21 Electromagnetism

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CHAPTER 21

Electromagnetism

The terms "electric" and "magnetic" were introduced in Volume I with the understanding that they were to be used as synonyms for "scalar one-dimensional" and "scalar two-dimensional" respectively, rather than being restricted to the relatively narrow significance that they have in common usage. These words have been used in the same senses in this volume, although the broad scope of their definitions is not as evident as in Volume I, because we are now dealing mainly with phenomena that are commonly called "electric" or "magnetic." We have identified a one-dimensional movement of uncharged electrons as an *electric* current, a one-dimensional rotational vibration as an *electric* charge, and a two-dimensional rotational vibration as a *magnetic* charge. More specifically, the magnetic charge is a two-dimensional rotationally distributed scalar motion of a vibrational character. Now we are ready to examine some motions that are not charges, but have some of the primary characteristics of the magnetic charge; that is, they are two-dimensional directionally distributed scalar motions.

Let us consider a short section of a conductor, through which we will pass an electric current. The matter of which the conductor is composed is subject to gravitation, which is a three-dimensional distributed inward scalar motion. As we have seen, the current is a movement of space (electrons) through the matter of the conductor, equivalent to an outward scalar motion of the matter through space. Thus the one-dimensional motion of the current opposes the portion of the inward scalar motion of gravitation that is effective in the scalar dimension of the spatial reference system.

For purposes of this example, let us assume that the two opposing motions in this section of the conductor are equal in magnitude. The net motion in this scalar dimension is then zero. What remains of the original three-dimensional gravitational motion is a rotationally distributed scalar motion in the other two scalar dimensions. Since this remaining motion is scalar and two-dimensional, it is *magnetic,* and is known as *electromagnetism*. In the usual case, the gravitational motion in the dimension of the current is only partially neutralized by the current flow, but this does not change the nature of the result; it merely reduces the magnitude of the magnetic effect.

From the foregoing explanation it can be seen that electromagnetism is the *residue* of the gravitational motion that remains after all or part of the motion in one of the three gravitational dimensions has been neutralized by the oppositely directed motion of the electric current. Thus it is a two-dimensional scalar motion perpendicular to the flow of current. Since it is the gravitational motion in the two dimensions that are *not* subject to the outward motion of the electric current, it has the *inward* scalar direction.

In all cases, the magnetic effect appears much greater than the gravitational effect that is eliminated, when viewed in the context of our gravitationally bound reference system. This does not mean that something has been created by the current. What has happened is that certain motions have been transformed into other types of motion that are more concentrated in the reference system, and energy has been brought in from the outside to meet the requirements of the new situation. As pointed out in Chapter 14, this difference that we observe between the magnitudes of motions with different numbers of effective dimensions is an artificial product of our position in the gravitationally bound system, a position that greatly exaggerates the size of the spatial unit. From the standpoint of the natural reference system, the system to which the universe actually conforms, the basic units are independent of dimensions; that is, $1^3 = 1^2 = 1$. But because of our asymmetric position in the universe, the natural unit of speed, s/t, takes the large value 3×10^{10} cm/sec, and this becomes a dimensional factor that enters into every relation between quantities of different dimensions.

For example, the c^2 term (the second power of 3×10^{10}) in Einstein’s equation for the relation between mass and energy reflects the factor applicable to the two scalar dimensions that separate mass (t^3/s^3) from energy (t/s). Similarly, the difference of one dimension between the two-dimensional magnetic effect and the three-dimensional gravitational effect makes the magnetic effect 3×10^{10} times as great (when expressed in cgs units). The magnetic effect is less than the one-dimensional electric effect by the same factor. It follows that the magnetic *unit* of charge, or emu, defined by the magnetic equivalent of the Coulomb law is 3×10^{10} times as large as the electric unit, or esu. The electric unit 4.80287×10^{-10} esu is equivalent to 1.60206×10^{-20} emu.

The relative scalar directions of the forces between current elements are opposite to the directions of the forces produced by electric and magnetic charges, as shown in Figure 23, which should be compared with Figure 22 of Chapter 19. The inward electromagnetic motions are directed *toward* the zero points from which the motions of the charges are directed outward. Two conductors carrying current in the same direction, AB or A’B, analogous to like charges, move toward each other, as shown in line (a) of the diagram, instead of repelling each other, as like charges do. Two conductors carrying current in the direction BA or B’A, as shown in line (c), also move toward each other. But conductors carrying current in opposite directions, AB’ and BA’, analogous to unlike charges, move away from each other, as indicated in line (b).

Figure 23

B’ A B A’

(a) | | => | <= |

(b) | <= | | => |

(c) | => | <= |

These differences in origin and in scalar direction between the two kinds of magnetism also manifest themselves in some other ways. In our examination of these matters we will find it convenient to consider the force relations from a different point of view. Thus far, our discussion of the rotationally distributed scalar motions—gravitational, electric, and magnetic—has been carried on in terms of the forces exerted by discrete objects, essentially point sources of the effects under consideration. Now, in electromagnetism, we are dealing with continuous sources. These are actually continuous arrays of discrete sources, as all physical phenomena exist only in the form of discrete units. It would therefore be possible to treat electromagnetic effects in the same manner as the effects due to the more readily identifiable point sources, but this approach to the continuous sources is complicated and difficult. A very substantial simplification is accomplished by introduction of the concept of the field discussed in Chapter 12.

This field approach is also applicable to the simpler gravitational and electrical phenomena. Indeed, it is the currently fashionable way of handling all of these (apparent) interactions, even though the alternate approach is, in some ways, better adapted to the discrete sources. In examining the basic nature of fields we may therefore look at the gravitational situation, which is, in most respects, the simplest of these phenomena. As we saw in Chapter 12, a mass A has a motion AB toward any other mass B in its vicinity. This motion is inherently indistinguishable from a motion BA of atom B. To the extent that actual motion of mass A is prevented by its inertia or otherwise, the motion of object A therefore appears in the reference system as a motion of object B, constituting an addition to the actual motion of that object.

The magnitude of this gravitational motion of mass A that is attributed to mass B is determined by the product of the masses A and B, and by the separation between the two. as is the motion of mass B, if the scalar motion AB is regarded as a motion of both objects. It then follows that each spatial location in the vicinity of object A can be assigned a magnitude and a direction, indicating the manner in which a mass of unit size *would move* under the influence of the gravitational force of object A *if it occupied that location*. The assemblage of these locations and the corresponding force vectors constitute the gravitational field of object A. Similarly, the distribution of the motion of an electric or magnetic charge defines an electric or magnetic field in the space surrounding this charge.

The *mathematical* expression of this explanation of the field of a mass or charge is identical with that which appears in currently accepted physical theory, but its *conceptual* basis is entirely different. The conventional view is that the field is "something physically real in the space"[32] around the originating object, and that the force is physically transmitted from one object to the other by this "something." However, as P. W. Bridgman concluded, after carrying out a critical analysis of this situation, there is no evidence at all to justify the assumption that this "something" actually exists.[29] Our finding is that the field is not "something physical." It is merely a mathematical consequence of the inability of the conventional reference system to represent scalar motion in its true character. But this recognition of its true status as a mathematical expedient does not negate its usefulness. The field approach remains the simplest and most convenient way of dealing mathematically with magnetism.

The field of a magnetic charge is defined in terms of the force experienced by a test magnet. The field of a magnetic pole—one end of a long bar magnet, for example—is therefore radial. As can be seen from the description of the origin of electromagnetism in the foregoing paragraphs, the field of a wire carrying an electric current would also be radial (in two dimensions) if it were defined in terms of the force experienced by an element of the current in a parallel conductor. But it is customary to define the electromagnetic field on the magnetostatic basis; that is, by the force experienced by a magnet, or an electromagnet in the form of a coil, a solenoid, which produces a radial field similar to that of a bar magnet by means of its geometrical arrangement. When the field of a current-carrying wire is thus defined, it circles the wire rather than extending out radially. The force exerted on the test magnet is then perpendicular to the field, as well as to the direction of the current flow.

Here is a direct challenge to physical theory, an apparent violation of physical principles that apply elsewhere. It is a challenge that has never before been met. The physicists have not even been able to devise a plausible hypothesis. So they simply note the anomaly, the "strange" characteristics of the magnetic effect. "The magnetic force has a strange directional character," says Richard Feynman, "at every instant the force is always at right angles to the velocity vector."[90] It is likely, however, that this perpendicular relation between the direction of current movement and the direction of the force would not seem so strange if magnets interacted only with magnets and currents with currents. In that event, the magnetic effect of current on current would still be "at right angles to the velocity vector," but it would be in the direction of the field, rather than perpendicular to it, as the field would have to be defined in terms of the action of current on current. When there is interaction between current and magnet, the resultant force is perpendicular to the magnetic field; that is, to the field intensity vector. A test magnet in an electromagnetic field does not move in the direction of the field, as would be expected, but moves in a perpendicular direction.

> *Notice how strange the direction of this force is. It is not in line with the field, nor is it in the direction of the current. Instead, the force is perpendicular to both the current and the field lines.*[91]

The use of the word "strange" in this statement is a tacit admission that the reason for the perpendicular direction is not understood in the context of present-day physical theory. Here, again, the development of the theory of the universe of motion provides the missing information. The key to an understanding of the situation is a recognition of the difference between the scalar direction of the motion (force) of the magnetic charge, which is outward, and that of the electromagnetic motion, which is inward.

The motion of the electric current obviously has to take place in one of the scalar dimensions other than that represented in the spatial reference system, as the direction of current flow does not normally coincide with the direction of motion of the conductor. The magnetic residue therefore consists of motion in the other unobservable dimension and in the dimension of the reference system. When the magnetic effect of one current interacts with that of another, the dimension of the motion of current A that is parallel with the dimension of the reference system coincides with the corresponding dimension of current B. As indicated in Chapter 13, the result is a single force, a mutual force of attraction or repulsion that decreases or increases the distance between A and B. But if the interaction is between current A and magnet C, the dimensions parallel to the reference system cannot coincide, as the motion (and the corresponding force) of the current A is in the inward scalar direction, while that of the magnet C is outward.

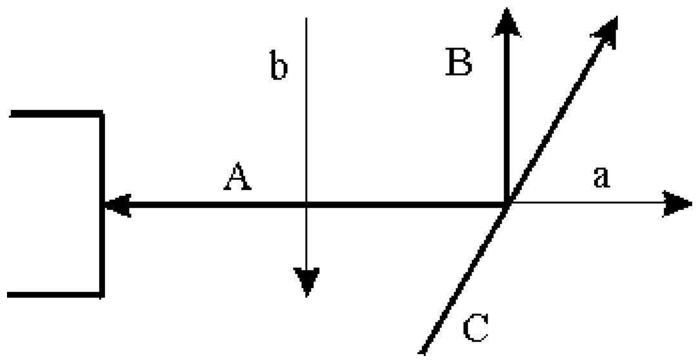
It may be asked why these inward and outward motions cannot be combined on a positive and negative basis with a net resultant equal to the difference. The reason is that the inward motion of the conductor A toward the magnet C is also a motion of C toward A, since scalar motion is a mutual process. The outward motion of the magnet is likewise both a motion of C away from A and a motion of A away from C. It follows that these are two separate motions of both objects, one inward and one outward, not a combination of an inward motion of one object and an outward motion of the other. It then follows that the two motions must take place in different scalar dimensions. The force exerted on a current element in a magnetic field, the force aspect of the motion in the dimension of the reference system, is therefore perpendicular to the field.

These relations are illustrated in Figure 24. At the left of the diagram is one end of a bar magnet. This magnet generates a magnetostatic (MS) field, which exists in two scalar dimensions. One dimension of any scalar motion can be so oriented that it is coincident with the dimension of the reference system. We will call this observable dimension of the MS motion A, using the capital letter to show its observable status, and representing the MS field by a heavy line. The unobservable dimension of motion is designated b, and represented by a light line.

We now introduce an electric current in a third scalar dimension. As indicated above, this is also oriented coincident with the dimension of the reference system, and is designated as C. The current generates an electromagnetic (EM) field in the dimensions a and b perpendicular to C. Since the MS motion has the outward scalar direction, while the EM motion is directed inward, the scalar dimensions of these motions coincident with the dimension of the reference system cannot be the same. The dimensions of the EM motion are therefore B and a; that is, the observable result of the interaction between the two types of magnetic motion is in the dimension B, perpendicular to both the MS field A and the current C.

The comment about the “strange” direction of the magnetic force quoted above is followed by this statement: “Another strange feature of this force” is that “if the field lines and the wire are parallel, then the force on the wire is zero.” In this case, too, the answer to the problem is provided by a consideration of the distribution of the motions among the three scalar dimensions. When the dimension of the current is C, perpendicular to the dimension A of the motion represented by the MS field, the EM field is in scalar dimensions a and B. We saw earlier that the observable dimensions of the inward EM motion and the outward MS motion cannot be coincident. Thus the EM motion in dimension a is unobservable. It follows that the motion in scalar dimension B, the dimension at right angles to both the current and the field has to be the one in which the observable magnetic effect takes place, as shown in Figure 24. However, if the direction of the current is parallel to that of the magnetic field, the scalar dimensions of these motions (both outward) are coincident, and only one of the three scalar dimensions is required for both motions. This leaves two unobservable scalar dimensions available for the EM motion, and eliminates the observable interaction between the EM and MS fields.

Figure 24



As the foregoing discussion brings out, there are major differences between magnetostatics and electromagnetism. Present-day investigators know that these differences exist, but they are unwilling to recognize their true significance because current scientific opinion is committed to a belief in the validity of Ampère's nineteenth century hypothesis that all magnetism is electromagnetism. According to this hypothesis, there are small circulating electric currents—"Ampèrian currents"—in magnetic materials whose existence is assumed in order to account for the magnetic effects.

This is an example of a situation, very common in present-day science, in which the scientific community continues to accept, and build upon, hypotheses which have been revised so drastically to accommodate new information that the essence of the original hypothesis has been totally negated. It should be realized that there is no empirical support for Ampère's hypothesis. The existence of the Ampèrian currents is simply assumed. But today no one seems to have a very clear idea as to just what is being assumed. Ampère's hypothetical currents were miniature reproductions of the currents with which he was familiar. However, when it was found that individual atoms and particles exhibit magnetic effects, the original hypothesis had to be modified, and the Ampèrian currents are now regarded as existing within these individual units. At one time it appeared that the assumed orbital motion of the hypothetical electrons in the atoms would meet the requirements, but it is now conceded thai something more is necessary. The current tendency is to assume that the electrons and other sub-atomic particles have some kind of a spin that produces the same effects as translational motion. The following comment from a 1981 textbook shows how vague the "Ampèrian current" hypothesis has become.

> *At the present time we do not know what goes on inside these basic particles [electrons, etc.]. but we expect their magnetic effects will be found to be the result of charge motion (spinning of the particle, or motion of the charges within it).*[92]

Ampère's hypothesis was originally attractive because it explained one phenomenon (magnetostatics) in terms of another (electromagnetism), thereby apparently accomplishing an important simplification of magnetic theory. But it is abundantly clear by this time that there are major differences between the two magnetic phenomena, and just as soon as that fact became evident, the case in favor of Ampère's hypothesis crumbled. There is no longer any justification for equating the two types of magnetism. The continued adherence to this hypothesis and use of Ampèrian currents in magnetic theory is an illustration of the fact that there is inertia in the realm of ideas, as well as in the physical world.

The lack of any theory—or even a model—that would explain *how* either a magnetostatic or electromagnetic effect is produced has left magnetism in a confused state where contradictions and inconsistencies are so plentiful that none of them is taken very seriously. A somewhat similar situation was encountered in our examination of electrical phenomena, particularly in the case of those issues affected by the lack of distinction between electric charge and electric quantity, but a much larger number of errors and omissions have converged to produce a rather chaotic condition in the conceptual aspects of magnetic theory. It is, in a way, somewhat surprising that the investigators in this field have made so much progress in the face of these obstacles.

As noted earlier, many of the physical quantities involved in electromagnetism are the same as those that enter into magnetostatic phenomena. These are quantities applicable to two-dimensional scalar relations, irrespective of the particular nature of the phenomena in which they participate. The electromagnetic units applicable to these quantities are therefore the same ones defined for magnetostatic phenomena in Chapter 20. Some of the relations between these quantities are also those of two-dimensional motions in general, rather than being peculiar to either magnetostatics or electromagnetism. More commonly, however, the relations involved in electromagnetism are analogous to those encountered in current electricity, as electromagnetism is a phenomenon of current flow rather than of magnetic charges.

One example is the force between currents. There is no electromagnetic relation analogous to the Coulomb equation. The theorists commonly use "current elements" for purposes of analysis, but such units obviously cannot be isolated. A simple interaction between two units, analogous to the interaction between two charges, therefore does not exist. Instead, the simplest electromagnetic interaction, the one that is used in defining the unit of current, the ampere, is the interaction between the magnetic forces of parallel wires carrying currents. Making use of the field concept, the advantage of which is quite evident in dealing with currents, we first define the magnetic field of one current in terms of the flux density, B. This quantity B has been found to be equal to $\mu_0 I/(2\pi s)$. The space-time dimensions of this expression are $t^3/s^4 \times s/t \times 1/s = t^2/s^4$, the correct dimensions of the flux density The force exerted by this field on a length l of the parallel current-carrying wire is then BIl, dimensions $t^2/s^4 \times s/t \times s = t/s^2$.

The expressions representing the two steps of this evaluation of the force can be consolidated, with the result that the force on wire B due to the current in wire A is $\mu_0 I_A I_B l/(2\pi s)$. If the currents are equal this becomes $\mu_0 I^2 l/(2\pi s)$. There is some resemblance between this and an expression of the Coulomb type, but it actually represents a different kind of a relation. It is a magnetic (that is, two-dimensional) relation analogous to the electric equation V = IR. In this electric relation, the force is equal to the resistance times the current. In the magnetic relation the force on a unit length is equal to the permeability (the magnetic equivalent of resistance) times the square of the current.

The energy relations in electromagnetism have given the theorists considerable difficulty. A central issue is the question as to what takes the place of the mass that has an essential role in the analogous mechanical relations. The perplexity with which present-day scientists view this situation is illustrated by a comment from a current physics textbook. The author points out that the energy of the magnetic field varies as the second power of the current, and that the similarity to the variation of kinetic energy with the second power of the velocity suggests that the field energy may be the kinetic energy of the current. "This 'kinetic energy' of a current's magnetic field," he says, "suggests that it has something like mass."[93]

The trouble with this suggestion is that the investigators have not been able to identify any electric or magnetic property that is "something like mass." Indeed, the most striking characteristic of the electric current is its immaterial character. The answer to the problem is provided by our finding that the electric current is a movement of units of space *through* matter, and that the effective mass of that matter has the same role in current flow as in the motion of matter through space. In the current flow we are not dealing with "something like mass," we are dealing with mass.

As brought out in Chapter 9, electrical resistance, R, is mass per unit time, t^2/s^3. The product of resistance and time, Rt, that enters into the energy relations of current flow is therefore mass under another name. Since current, I, is speed, the electric energy equation, $W = RtI^2$, is identical with the equation for kinetic energy, $W = ½mv^2$. The magnetic analog of resistance is permeability, with dimensions t^3/s^4. Because of the additional t/s term that enters into this two-dimensional quantity, the permeability is the mass per unit space, a conclusion that is supported by observation. As expressed by Norman Feather, the mass "involves the product of the permeability of the medium and a configurational factor having the dimensions of a length."[94] In some applications, the function of this mass term, dimensions t^3/s^3, is clear enough to have led to its recognition under the name of inductance.

The basic equations employed in dealing with inductance are identical with the equations dealing with the motion of matter (mass) through space. We have already seen (Chapter 20) that the inductive force equation, F = L dI/dt, is identical with the general force equation, F = m ds/dt, or F = ma. Similarly, magnetic flux, which is dimensionally equivalent to momentum, is the product of inductance and current, LI, just as momentum is the product of mass and velocity, mv. It is not always possible to relate the more complex electromagnetic formulas directly to corresponding mechanical phenomena in this manner, but they can all be reduced to space-time terms and verified dimensionally. The theory of the universe of motion thus provides the complete and consistent framework for electric and magnetic relationships that has heretofore been lacking.

The finding that the one-dimensional motion of the electric current acting in opposition to the three-dimensional gravitational motion leaves a two-dimensional residue naturally leads to the conclusion that a two-dimensional magnetic motion similarly applied in opposition to gravitation will leave a one-dimensional residue, an electric current, if a conductor is appropriately located relative to the magnetic motion. This is the observed phenomenon known as *electromagnetic induction*. While they share the same name, this induction process has no relation to the induction of electric charges. The induction of charges results from the equivalence of a scalar motion AB and a similar motion BA, which leads to the establishment of an equilibrium between the two motions. As indicated above, electromagnetic induction is a result of the partial neutralization of gravitational motion by oppositely directed scalar motion in two dimensions.

This induction process is another of the aspects of electricity and magnetism that is unexplained in conventional science. As one textbook puts it,

> *Faraday discovered that whenever the current in the primary circuit 1 is caused to change, there is a current induced in circuit 2 while that change is occurring. This remarkable result is not in general derivable from any of the previously discussed properties of electromagnetism.*[95]

Here, again, the advantage of having at our disposal a *general* physical theory, one that is applicable to all subdivisions of physical activity, is demonstrated. Once the nature of electromagnetism is understood, it is apparent from the theoretical relation between electricity and magnetism that the existence of electromagnetic induction necessarily follows.

Since there is no freely moving magnetic particle corresponding to the electron, there is no magnetic current, but magnetic motion can be produced in a number of ways, each of which is a method of inducing electric currents or voltage differences. For example, the magnetic motion may originate mechanically. If a wire that forms part of an electrical circuit is moved in a magnetic field in such a way that the magnetic flux through the wire changes (equivalent to a magnetic motion), an electric current is induced in the circuit. A similar effect is produced if the magnetic field is varied, as, for instance, if it is generated by means of an alternating current.

The force aspect of the one-dimensional (electric) residual motion left by the magnetic motion in the electromagnetic induction process can, of course, be represented as an electric field, but because of the manner in which it is produced, this field is not at all like the fields of electric charges. As Arthur Kip points out, there is an "extreme contrast" between these two kinds of electric fields. He explains,

> *An induced emf implies an electric field, since it produces a force on a static charge. But this electric field, produced by a changing magnetic flux, has some properties which are quite different from those of an electrostatic field produced by fixed charges… the special property of this new sort of electric field is that its curl, or its line integral around a closed path, is not zero. In general, the electric field at any point in space can be broken into two parts, the part we have called electrostatic, whose curl is zero, and for which electrostatic potential differences can be defined, and a part which has a nonzero curl, for which a potential function is not applicable in the usual way.*[96]

While the substantial differences between the two kinds of electric fields are recognized in current physical thought, as indicated by this quotation, the reason for the existence of these differences has remained unidentified. Our finding is that the obstacle in the way of locating the answer to this problem has been the assumption that both fields are due to electric charges—static charges in the one case, moving charges in the other. Actually, the differences between the two kinds of electric fields are easily accounted for when it is recognized that the processes by which these fields have been produced are entirely different. Only one involves electric charges.

The treatment of this situation by different authors varies widely. Some textbook authors ignore the discrepancies between accepted theory and the observations. Others mention certain points of conflict, but do not follow them up. However, one of those quoted earlier in this volume, Professor W. J. Duffin, of the University of Hull, takes a more critical look at some of these conflicts, and arrives at a number of conclusions which, so far as they go, parallel the conclusions of this work quite closely, although, of course, he does not take the final step of recognizing that these conflicts invalidate the foundations of the conventional theory of the electric current.

Like Arthur Kip (reference 96), Duffin emphasizes that the electric field produced by electromagnetic induction is quite different from the electrostatic field. But he goes a step farther and recognizes that the agency responsible for the existence of the field, which he identifies as the electromotive force (emf), must also differ from the electrostatic force. He then raises the issue as to what contributes to this emf. "Electrostatic fields cannot do so,"[13]he says. Thus the description that he gives of the electric current produced by electromagnetic induction is completely non-electrostatic. An emf of non-electrostatic origin causes a current I to flow through a resistance R. Electric charges play no part in this process. "No charge accumulates at any point," and "no potential difference can be meaningfully said to exist between any two points."[97]

Duffin evidently accepts the prevailing view of the current as a movement of charged electrons, but, as indicated in a previously quoted statement (reference 13), he realizes that the non-electrostatic force (emf) must act on the "carriers of the charges" rather than on the charges. This makes the charges superfluous. Thus the essence of his findings *from observation* is that the electric currents produced by electromagnetic induction are non-electrostatic phenomena in which electric charges play no part. These are the currents of our ordinary experience, those that flow through the wires of our vast electrical networks.

In the course of the discussion of electricity and magnetism in the preceding pages we have identified a number of conflicts between the results of observation and the conventional "moving charge" theory of the electric current, the theory presented in all of the textbooks, including Duffin's. These conflicts are serious enough to show that the current *cannot* be a flow of electric charges. Now we see that the ordinary electric currents with which the theory of current electricity deals are definitely non-electrostatic; that is, electric charges play no part in them. The case against the conventional theory of the current is thus conclusive, even without the new information made available by the development reported in this work.