Beyond Newton

Preface

In my previous publication *The Structure of the Physical Universe*, I found it necessary to discuss a very wide range of phenomena in order to get a broad enough coverage to establish the validity of the fundamental postulates on which the work is based. This, of course, limited the space that could be devoted to each subject and precluded any attempt at a detailed examination of specific areas. I have had in mind, therefore, that when the opportunity presented itself, I would follow the original work with some supplementary discussions that would carry the development into more detail in some areas of particular interest. This present volume is a work of this kind, directed primarily at the subject of gravitation: one of the basic phenomena of the universe.

I should perhaps explain why the title is *Beyond Newton* and not *Beyond Einstein*, since Einstein's work is generally regarded as occupying the more advanced position. My findings indicate that Newton's Law of Gravitation is correct, so far as it goes, and that the functions of such a work as this are first, to clarify the application of this gravitational Iaw án those areas where its validity is now in question, and second, to furnish an explanation for each of the characteristics of gravitation, including particularly the two items which Newton made no attempt to determine: the origin of the gravitational force which he postulated and the mechanism whereby this force is exerted.

In the course of this development it has become apparent that Einstein's theory of gravitation is not on the main line leading to the defined objectives; it branches off on a side track that leads ta a dead end. It has therefore been necessary to retrace the steps that have been taken under Einstein's guidance, and to go forward along a new route from the point where Newton stopped to the new destination Beyond Newton.

DEWEY B. LARSON
August,1963

Part One
The Problem

GRAVITATION: STILL A MYSTERY
(Title of article by Paul R. Heyl, *Scientific Monthly*, May 1954)

GRAVITATION: AN ENIGMA
(Title of article by Robert H. Dicke, *American Scientist,* March, 1959)

Here is an unintentional but graphic commentary on the progress that has been and is being made toward an understanding of one of the most Conspicuous and most fundamental of all physical phenomena. At the time Heyl wrote his article, almost three hundred years after Newton first grasped the significance of the falling apple and formulated the mathematical expression which represents the gravitational force and enables us to calculate its magnitude with extreme precision, the nature and origin of the phenomenon could still be described as a "mystery." Five more years of effort by scientists of the highest caliber sufficed only to raise this mystery to the status of an "enigma": a rather imperceptible advance, to say the least. "It (gravitation) may well be the most fundamental and least understood of the interactions,"[1] Dicke tells us.

Of course, some scientists disagree with this evaluation, and Dicke concedes in his article that many of his colleagues would take exception to the use of the term "enigma" in this connection. However, the record clearly corroborates the opinions of these two specialists in gravitational research. Some progress has been made in the experimental field since Newton's day, but aside from the accurate measurement of the gravitational constant, the experimental gains have been largely of a negative character; that is, they consist of increasingly precise measurements which demonstrate the absence of certain effects that might be expected, or at least suspected. Progress toward a theoretical understanding has been meager; indeed the growing disillusionment with Einstein's General Relativity Theory indicates that progress along this line is practically non-existent.

This General Theory is the only major theoretical step taken since Newton, which can even claim to have any factual backing, and while it achieved widespread acceptance initially, doubt as to whether the claims made on its behalf are justified has been increasing as time goes on. As Dicke appraises the situation, "In addition to dissatisfaction with the scanty observational evidence supporting Einstein's theory of gravitation, there are certain conceptual difficulties which are a source of doubt concerning the complete correctness of the theory in its present form."[2] Similar expressions of skepticism are currently being voiced by many other observers. H. Bondi tells us, for example, "The very few and minor points of discrepancy (between Newton's gravitational theory and Einstein's) are observationally not too firmly established."[3] Louis de Broglie elaborates this same thought: "The new phenomena predicted by it (the General Theory) are indeed very small and, even when they are actually observed, it can always be asked if they really have their origin in the cause which the theory of Einstein attributes to them, or rather in some other very small perturbation which was neglected in the analysis."[4] Werner Heisenberg adds, "For the theory of general relativity the experimental evidence is much less convincing... this whole theory is more hypothetical than the first one (the Special Theory)."[5] G. J. Whitrow concurs in this appraisal of the observational evidence: "... the General Theory has a far less impressive list of crucial empirical tests to its credit," and he comments further, "... there is an ambiguity latent in this method (of reducing gravitation to geometry)... Indeed, in developing the theory this ambiguity continually arises."[6] Martin Johnson tells us that Einstein followed up his 1905 success with a "less certifiable sequel in 1915 which has in some of its implications led science astray.[7] Even Henry Margenau, one of the strong supporters of the Relativity doctrine, admits that General Relativity has "suffered a certain loss of glory."[8]

E. A. Milne may be regarded as somewhat prejudiced on this score, as he is the author of a competing theory, but the mere fact that competent investigators such as Milne see a necessity for some other approach is itself a serious reflection on the adequacy of the General Theory, and Milne's comments are therefore of interest in this connection. General Relativity, he says, "in the writer's opinion, is of a nature alien to the main tradition in mathematical physics."[9] Bondi sums up the situation: "It (the General Theory) is considered to be correct by a majority of theoretical physicists, but there is a substantial minority that considers it to be wrong or, at least, not established."[10] The existence of this "substantial minority" is all the more significant when we note the kind of individuals who are included in the group: specialists in gravitational research such as Dicke and Heyl, world-renowned leaders in the field of physics such as Bridgman, de Broglie and Heisenberg, active investigators in the areas where General Relativity should be most applicable, such as Bondi, Whitrow, Johnson and Milne, and so on.

A factor that has contributed heavily to this increasing skepticism as to the validity of the General Theory is that it seems to have arrived at a dead end. One of the criteria by which we are able to recognize a sound physical theory is the manner in which it fits in with existing knowledge in related fields and sheds new light on phenomena other than that for which it was originally constructed. The failure of Einstein's gravitational theory to accomplish anything of this nature or to show the normal amount of improvement of its own internal structure during the half century that has elapsed since its inception therefore weighs heavily against it. Freeman J. Dyson describes the situation in this manner: "... the view of the world (given by General Relativity)... has remained since 1929 almost totally sterile ".[11]

But in any event, whether or not these increasing doubts are justified, this theory does not carry gravitational knowledge very far beyond the point where Newton left it. The contributions of the General Theory to an understanding of gravitational processes are greatly overestimated in current scientific thinking. Even if the assertions of the theory were correct, which the succeeding pages will demonstrate that they are not, they do not furnish actual explanations for the things which they purport the explain; they merely push the need for explanation farther into the background where it is less obvious and can more conveniently be disregarded.

Such a statement may seem rank heresy today, at a time when, in spite of the doubts expressed by the more critical observers, Relativity Theory has been elevated to the status of an article of faith on a par with or even superior to the established facts. The textbooks tell us that Newton's gravitational theory is grossly deficient in that it merely assumes the existence of a gravitational force without giving us any explanation of how such a force originates, and Einstein's work is hailed as a great theoretical advance that provides us with the explanation which Newton was unable to supply. Typical of the positive and explicit statements to this effect that can be found throughout present-day scientific literature is the following: "Strange as Einstein's idea (General Relativity) seemed, it was able to explain something which the Newtonian law of gravity had not been able to explain."[12]

But neither Einstein nor his fellow relativists make any such claim. What *they* say they have done is to furnish us some good reasons why we *should not ask* for an explanation.

Willem de Sitter is very explicit about this situation in his book *Kosmos.* He points out that no one, Einstein or anyone else, has actually *explained* gravitation, in spite of all the effort that has been devoted to the task: "In the course of history a great number of hypotheses have been proposed in order to 'explain' gravitation, but not one of these has ever had the least chance, they have all been failures."[13]

De Sitter then goes on to say that Einstein's actual accomplishment is to make gravitation identical with inertia, which *eliminates the need* for an explanation, as "Inertia has from the beginning been admitted as one of the fundamental facts of nature, which have to be accepted without explanation, like the axioms of geometry."

Einstein himself admits that he cannot give any explanation for the properties with which he is endowing the "space" in which the physical processes represented by his theories take place. "Our only way out," he says, "seems to be to take for granted the fact that space has the physical property of transmitting electromagnetic waves, and not to bother too much about the meaning of this statement."[14]

In the light of this half-apologetic admission by the originator, some of the present-day encomiums of the theory are nothing short of ridiculous. "... the (general) theory of relativity is a step of almost conclusive power," says one modern author, "It banishes from physics that occult force of gravity which Newton would not defend, reaching instantaneously across the equally occult idea of void."[15]

How much "conclusive power" can we legitimately attribute to anything that we are asked to "take for granted" without inquiring too closely into its meaning? Is this any less "occult" than the unexplained aspects of Newton's theories?

At the same time, the inability of existing gravitational concepts, whether connected with General Relativity or not, to account for some of the observed characteristics of gravitation has had the very curious effect of convincing the physicists that the observations give us the wrong picture of the gravitational phenomenon. No one has been able to conceive of a mechanism whereby one mass can exert an influence on another distant mass instantaneously, and hence it is generally assumed by the physicists that there must be some kind of propagation of the gravitational effect at a finite velocity, even though there is not the slightest evidence that this is true. Similarly, there is a general tendency to accept the existence of some sort of a gravitational unit--a graviton, or some such thing--as a fact, without any experimental or observational evidence to back up the assumption, merely because this facilitates setting up certain kinds of gravitational theories.

In all practical applications the picture of the situation inferred from the results of observation is accepted as correct. All astronomical calculations and other computations involving gravitation are made on the assumption that the effect is instantaneous, and so far as we are aware, no inconsistencies result from this procedure. But the theorists then turn around and repudiate all of this, simply because they have been unable to discover any satisfactory theory that fits the observed facts. Max van Laue, explains, on their behalf, "Nowadays we are also convinced that gravitation progresses with the speed of light. This conviction, however, does not stem from a new experiment or a new observation, it is a result solely of the theory of relativity."[16]

When taken in conjunction with the grave doubts now being entertained as to the validity of General Relativity by some of today's foremost physicists, this necessity for adjusting the facts to the theory rather than the theory to the facts, has some very definite implications that deserve serious consideration, irrespective of whether or not a satisfactory alternative theory is available. The presentation of a new theory of gravitation in this work merely emphasizes a serious weakness in the structure of current scientific thought that should have been evident in any event.

The objective of this present work is to show that gravitation *can* be explained and therefore we do not need to try to convince ourselves that we must accept it as an "unanalyzable." It will be demonstrated in the subsequent pages that a simple and logical theory of gravitation can be constructed without the necessity of explaining away any of the known characteristics of this phenomenon: a theory which accounts for each of these characteristics in the exact form in which it is revealed by observation, and which goes on from there to provide a great deal of information in collateral fields, as a valid gravitational theory should do. This presentation will show that gravitation *can* act instantaneously, without an intervening medium, and in such a manner that its effects cannot be screened off or modified in any way, and can do all of this in a perfectly natural and logical way, without the necessity of utilizing any philosophically unacceptable assumptions such as that of action at a distance.

As a background against which to set up the new gravitational theory, it will be desirable to outline briefly just what is known about the gravitational phenomenon at the present time. In this respect we are, of course, limited by the accuracy of existing methods of measurement. For instance, if the available instruments allow us to measure a certain effect to within one part in 10^{10}, and we find no indication of such an effect with these instruments, this creates a strong presumption that there is no effect of this kind. It must be conceded, however, that a theory which predicts an effect amounting to less than one part in 10^{10} is not inconsistent with the experimental results and therefore *could* be correct, but any theory which depends primarily on assumed effects that are beyond the reach of the extremely accurate instruments now available is certainly highly speculative, to say the least.

The following paragraphs summarize what is now known to the degree of precision of the measurements. In order to be satisfactory, a theory must either agree with these conclusions derived from experiment, or at least must not predict any deviations large enough to be detected by existing methods.

General. There is no question but that a gravitational *effect* actually exists. Newton attributed this effect to the existence of a gravitational *force*, but this interpretation has been challenged by some of the more recent investigators, notably Einstein, whose contention is that the gravitational effect is produced by a distortion of the space-time structure in the vicinity of a mass, and that there actually is no such thing as a gravitational force. However, if we analyze this conflict from a critical standpoint, it becomes apparent that what we have here is not a physical question but a question of semantics. The word "force" normally suggests some kind of a pull or a push and Einstein's contention, in essence, is that his explanation attributes the gravitational effect to something that is not in the pull-push category. But Newton did not limit his concept of gravitational force in this manner; in fact, he specifically refused to express any opinion as to the nature of the force. So far as Newton's theory is concerned, force is simply a quantity which relates mass to acceleration, and if we set up our definition of force on this basis (that is, define it by means of the equation F = ma) the consequences of the postulated space-distortion constitute a gravitational force, and can be treated as such. Einstein does this himself in his mathematical treatment of gravitation.

Relation to mass. The gravitational force between two masses is proportional to the product of the masses involved, and acts in the direction of the line joining the centers of the masses.

Relation to distance. The gravitational force between two masses is inversely proportional to the square of the distance between the centers of the masses.

Gravitational constant. The numerical constant in the gravitational equation based on the mass and distance relationships just stated is 6.67×10^{-8} when expressed as dynes x cm^2 x g^{-2}

Relation to chemical composition. The gravitational force is independent of the chemical composition of the masses involved.

Relation to crystal orientation. The gravitational force is independent of the direction of the crystallographic axes.

Relation to temperature. The gravitational force is independent of temperature.

Relation to physical state. The gravitational force is independent of the physical state of the masses involved.

Velocity of propagation. So far as is known at this time, the effect of gravitation is instantaneous, and in all practical applications of the gravitational equation the calculations are made on this basis, even at galactic distances. Many theories of gravitation, including the Einstein theory, assume a finite velocity of propagation of the gravitational effect, but there is no experimental or observational evidence to support this assumption.

Screening. The gravitational force cannot be screened off or modified in any way by any means now known.

In addition to listing the things that we *know* about gravitation, as a preliminary to a critical study of the phenomenon, it will be helpful to list some of the things that we do *not* know, because there is a general tendency to confuse fact with fancy when the consideration of a problem extends over such a long time and involves so much speculation. The speculative hypotheses of a century or half-century ago are likely to have acquired the standing of axioms by this time where they have remained unchallenged in the interim.

Curved space. There is no evidence that space is, or can be, curved or deformed in any way. It is true that Einstein has set up a system wherein some of the characteristics of gravitation are explained on the *assumption* that space is deformed by the presence of matter, but the phenomena which an assumption was specifically designed to fit cannot be used as proof of the validity of that assumption, and there is no other evidence of an independent character to verify the existence of a deformation of space.

Gravitational fields. There is no evidence that a gravitational field exists in any physical sense. All that we know is that a test particle placed in a particular location experiences a gravitational force due to the proximity of a mass. So far as we have any actual knowledge, the only participants in this phenomenon are the two masses; any theory that calls for an intermediate effect on or by a field, a medium or space itself, is purely speculative.

Mediums. There is no evidence of the existence of a medium of any kind through which gravitational effects could be propagated. Furthermore, there is no evidence that space has the properties of such a medium.

Gravitational units. There is no evidence of the existence of "gravitons" or any such gravitational unit.

Variability with time. There is no evidence that the strength of the gravitational effect has varied or is varying with time.

On the basis of the foregoing, a satisfactory theory of gravitation must produce an explanation of how two masses can exert a force on each other instantaneously, without an intervening medium, and in such a manner that the effects cannot be screened off or modified in any way, or alternatively, if one or more of these requirements is not met, the theory must provide an acceptable explanation of the observed facts which now appear to lead to these requirements.

Before undertaking to present all explanation of gravitation, it is first necessary to define what we mean by the term "explanation." This is one of those words whose significance seems perfectly obvious in ordinary usage, yet proves rather difficult to down when we attempt to be more specific, and current literature is full of discussion and controversy over the various philosophic aspects of the explanation process. A recent book by R. B. Braithwaite, for example, devotes its entire 376 pages to this one subject of *Scientific Explanation.*

As is so often true under similar circumstances, much of this debate is actually meaningless, since it is essentially a discussion of the question as to what significance *ought* to be assigned to the word "explanation." This question assumes that the word has an inherent meaning and that the identification of this true meaning is a task for the philosopher or the scientist with philosophical interests. The truth is, however, that no word has an inherent meaning; it has only the meaning that we choose to assign to it. Of course, the object of language is communication, and in order to accomplish that objective it is necessary to have some sort of a general agreement as to the significance that is to be attached to the words that are utilized in that language, and we have compiled dictionaries to keep a record of the meanings that are agreed upon. It does not follow, however, that a particular word must necessarily be used in exactly the same way by everyone, nor even that it always be used in the identical manner by the same individual. Eddington, for example, makes it very clear that he has no intention of restricting himself to a single meaning for every word. He remarks, "A correspondent has pointed out to me that in various places in *The Nature of the Physical World* the word "space" occurs with four different meanings. I think he expected me to feel penitent. But the word *has* these meanings..."[17]

In order to be intelligible, the word "explain" must be used in the same *general* sense specified in the dictionary; that is, to make clear. But clarification can be accomplished in more than one way, and there is no compelling reason why one way should be any more official than another is. Each individual therefore has the option of selecting the type of explanation which he wishes to offer, and the proper criterion that should be applied in evaluating the explanation is not whether it conforms to some particular philosophical idea of what constitutes an explanation, but whether it actually does clarify the situation in one way or another. The first aim of the present discussion will therefore be to describe the kind of explanation, which will be offered in this work.

All explanations must necessarily be based on certain specified premises and if the phenomena to be explained are of a basic nature, these premises cannot be other than assumptions. Braithwaite regards the explanation of a law or principle as a process of deducing it from some more general law or principle (the validity of which must, of course, be assumed) and since this process can conceivably continue endlessly, he concludes, "... there is no ultimate end to the hierarchy of scientific explanation, and thus no completely final explanation."[18]

R. E. Peierls expresses the same point of view: "All explanations of natural phenomena therefore consist in reducing them to some basic laws. To ask for an explanation of these laws would merely mean reducing them to some other laws."[19] This is orthodox positivist doctrine--it can be found almost word for word in the writings of Comte but, with all due respect to the positivist philosophers, unless we define the term "law" in an unusually broad manner, this assumption that a law can only be explained by reducing it to some other law is not correct. If we pursue our quest for an explanation long enough we should ultimately be able to account for the law in terms of some basic *property* or properties of the universe. This is something quite different from what Peierls and Braithwaite envision. Braithwaite admits that in some other fields of activity we can have "a complete explanation in the sense that no further question can be asked of the same sort."[20] When we reach the point in scientific research where the next question must ask why the universe has a certain specific property, no "further question of the same sort" is possible in the physical field either.

Let us consider, for example, the relation of the intensity of illumination to the distance from the source of light. We start from the premises that such a light source exists, and that it emits photons, which are distributed uniformly in all directions and move linearly outward at a constant velocity. We then want an explanation of the fact that under such circumstances the intensity of the illumination at any distance *d* from the light source is inversely proportional to d^2. Here we can see that a complete explanation is provided by geometry alone, since the surface area of a sphere of radius *d* is proportional to d^2, and under the conditions specified in the initial assumptions the total illumination striking such a spherical surface must necessarily be constant irrespective of the radius. If we then assume! that the universe is three-dimensional and Euclidean, both of which assumptions are supported by observational evidence independent of the behavior of light, these assumptions explain the observed relationship.

From a purely physical standpoint, this is as far as we can go. So far as we know, a four-dimensional universe or a five-dimensional universe may be possible, but the question as to why our particular universe is restricted to three dimensions is a "question of a different sort": one that cannot be answered by means of any information that we can obtain within our three-dimensional universe. In order to consider such a question at all, we must leave physics and enter the domain of metaphysics. When we have carried our explanation to the boundaries of the physical realm in this manner we therefore *do* have a "completely final explanation" in the sense that Braithwaite is using the term. (Of course, it is possible that the explanation might be wrong, and hence not "completely final" in this sense.) Such an explanation which relates the phenomenon in question directly to some simple inherent property or properties of the universe, the existence of which can be independently confirmed, constitutes what we may call an explanation of the first order.

Newton's Law of Gravitation falls considerably short of this status; in fact, on this same basis, we will have to classify it as an explanation of the third order, since it leaves two *physical* issues unresolved, in addition to the metaphysical question that we cannot avoid. The essence of Newton's theory is the assumption that a force of attraction exists between each mass and every other mass. But merely *assuming* the existence of such a force leaves us with two unanswered questions: (1) How does the force originate? and (2) How does it work?

Einstein's gravitational theory still leaves us in essentially the same position. This theory rests on the assumption that the existence of mass causes a deformation of the space-time structure which, in turn, accounts for the gravitational attraction. Here again we have the same two unanswered questions: (1) How does the deformation originate; that is, what is there about the property of mass that deforms space or space-time? and (2) What is the mechanism of the deformation; that is, how does it operate? Thus, whether or not Einstein's theory is superior to that of Newton from other standpoints, it is not an explanation of a higher order, it is still a third order explanation.

At this point it is necessary to call attention to the fact that the classification of scientific explanations outlined and discussed in the foregoing paragraphs does not indicate how satisfactory the explanations may be, as this involves some additional factors. It is quite possible that an explanation of the third order might be quite satisfactory as far as it goes, whereas some first order explanation might be wholly unsatisfactory. The optimum, of course, is a fully satisfactory first order explanation.

The most important requirement of a *satisfactory* explanation, irrespective of the class to which it belongs, is that it should satisfy the tests that any physical theory must meet in order to be considered valid; that is, it must be internally consistent, and in agreement with all of the pertinent facts as revealed by observation or measurement, or at least not inconsistent with any of these facts. Next the explanation must be complete. It must not only account for the existence of the phenomenon itself, but must also account for the known characteristics of that phenomenon, both qualitatively and quantitatively. Finally a truly satisfactory explanation must contribute toward fittings the phenomenon into the general fabric of physical theory by enlarging its field of application or by relating it to other physical phenomena.

In relatively recent years a new twist has been introduced into the question of what constitutes a satisfactory explanation of a physical phenomenon. The entities with which modern science has had to deal--phenomena of the very small, the very large, and the high velocity regions--have been extremely difficult to describe and explain in the terms of reference provided by knowledge of physical relations in the more familiar regions, but a reasonable degree of success has been attained in the construction of mathematical expressions to represent these phenomena. Under such conditions, the normal conclusion would be that formulation of the mathematical expression simply represents the first step on the way to a complete explanation. This is, in fact, a very common sequence of events in scientific research. For example, Planck's results on the distribution of frequencies in black-body radiation first took the form of a mathematical equation which achieved the agreement with experimental results that the previous expressions of Wien and Rayleigh failed to attain. *After* the mathematical relationship was discovered and verified, Planck turned his attention to finding an explanation of this radiation equation and, as he tells us in his account of his discoveries, a great deal of hard work was required before the quantum idea emerged.

We would naturally expect that any other mathematical expression which correctly represents some physical relationship could likewise be translated into physical terms if sufficient study is applied to the problem, but many of the basic mathematical relations of modern physical science have thus far resisted explanation, even though these matters have been given long and intensive study. If our assumption as to the existence of a physical explanation for any correct mathematical relation of this kind is valid, we are forced to conclude either (1) that these mathematical expressions are not correct representations of the physical relations to which they are supposed to apply, or (2) that the amount of effort applied to the task of finding the explanations has been insufficient, or (3) that the abilities of those who have attacked these problems are not equal to the task. All of these alternatives are definitely distasteful, and to avoid facing them the scientist of the present day has resorted to one of the ingenious techniques which modern science has devised to cope with this kind of a situation: a principle of impotence. The theorist who fails to solve such a problem simply meets the issue by postulating that the problem is inherently incapable of solution.

In order to soften the impact of this dictum to some degree, it is now customary to accompany this postulate that a physical explanation is impossible with an argument to the effect that such an explanation is unnecessary anyway, since a purely mathematical explanation is entirely adequate for those who accustom themselves to thinking in mathematical terms. "To him (the modern scientist) the algebraic law of gravitation, for example, is the satisfying explanation for a host of phenomena, whereas to many nonscientists the very same law would be regarded as an additional unexplained mystery."[21]

There is a bit of Chinese philosophy which asserts that if one cannot get what he wants, he can arrive at exactly the same result by persuading himself to want only what he can get. Whether those who are attempting to persuade us to accept the mathematical equations as ultimate explanations of physical phenomena are deliberately employing this ancient philosophy, or are doing so unconsciously, this is certainly the direction that the arguments take. When Eddington tells us, "We do not ask how mass gets a grip on space-time and causes the curvature which our theory postulates. That would be... superflous,"[22] he is enunciating exactly this point of view. Philipp Frank gives us the same thing in the form of a general proposition: "The task of physics is only to find symbols among which there exist rigorously valid relations, and which can be assigned uniquely to our experiences."[23]

But regardless of any validity that this renunciatory idea may have in application to purely personal desires, it does not hold water when applied to scientific research. In the case of gravitation, we want to know how the gravitational force, or gravitational effect, originates and how it operates, not only because we have an innate desire for knowledge, but also because we are confident on the basis of past experience that this additional knowledge of the gravitational phenomenon will open the door to further advances in related fields. The mathematical expression of gravitation, the "algebraic law" which Holton and Roller, the authors of the statement quoted in the preceding paragraph, are asking us to accept as a "satisfying explanation" gives us no help of this kind. In the words of Paul F. Schmidt, "mathematical propositions tell us nothing about the character of nature; they are uninterpreted formalisms."[24]

We can get an idea of where this currently popular "Be satisfied with a mathematical explanation" philosophy leaves us if we consider what would have happened to Planck's discoveries if he had stopped with his mathematical expression for black-body radiation, and had not gone on to formulate his explanation of this equation in terms of quanta. In this event progress would have ceased with black-body radiation; it would not even have been possible to take the next step, Einstein's extension of the theory to the photoelectric effect, to say nothing of all the subsequent development that has taken place in this area. Planck recognized this situation clearly. He explains, "But even if the absolutely precise validity of the radiation formula is taken for granted, so long as it had merely the standing of a law disclosed by a lucky intuition, it could not be expected to possess more than a formal significance. For this reason, on the very day when I formulated this law, I began to devote myself to the task of investing it with a true physical meaning." [25]

If we accept the Confucian viewpoint of the "modern scientist" who wants us to be content with the mathematical expression of the gravitational law, we are deliberately restricting ourselves to the limited field in which we now know this law to be applicable, and we are closing the door to any increase in scientific knowledge that might be possible through a more complete understanding of the gravitational phenomenon. Of course, the physicist who champions the mathematical equation as the ultimate explanation of gravitation can justify this stand only on the basis of the contention that this equation expresses the full range of the phenomenon, and that there are no other pertinent facts which could be revealed by a physical explanation. No attempt will be made to refute this contention at this point, as the entire work from here on constitutes such a refutation. The subsequent pages will show that a complete and satisfactory explanation of a higher order *can* be found, and that with the benefit of this more adequate and comprehensive explanation, the gravitational relations can be extended to a much wider field. Part Two of this volume will raise Newton's theory to the status of a second order explanation by deriving his assumption of the existence of a gravitational force from a more general set of basic assumptions which will have the effect of reducing force to motion. This still leaves us with a question as to the origin of the motion, but it eliminates one of the two questions that are unanswered in both Newton's and Einstein's treatment of the subject, since we do not have to ask how motion works. Part Three will extend this to a first older explanation by showing that the gravitational assumptions utilized in Part Two can be deduced from certain independently confirmed postulates as to the general nature of the physical universe.

The great dilemma that has faced gravitational theory ever since its inception is the fact that in order to account for the gravitational attraction it seems to be necessary either to postulate the existence of a medium capable of transmitting the gravitational effect from one mass to another or else to concede the possibility of action at a distance. There is no evidence of any medium, and the properties which such a medium would have to possess in order to account for the observed effects are fantastic. On the other hand, the idea that one mass can exert an influence on another mass at a distance without the benefit of any connecting medium is philosophically unacceptable to most scientists. Newton himself called it "absurd."

It is commonly contended that Einstein resolved this dilemma by devising an explanation of gravitation based on geometry rather than on force, but if we examine his gravitational theory carefully, it is apparent that he has merely moved the dilemma to a new location; he has not eliminated it. Newton's problem in this connection was to account for the existence of the gravitational force. Einstein accounts for the force (or the equivalent of such a force) by a distortion of the space-time structure, but if we subject this explanation to a critical examination instead of just following the currently fashionable practice and accepting it on trust, it is obvious that Einstein faces exactly the same problem in accounting for the space-time distortion that Newton does in accounting for the gravitational force. In order to explain how mass A is able to influence the structure of space-time at the location occupied by mass B. we either have to postulate the existence of a medium connecting location A with location B (postulating that space-time has the properties of a medium is, of course, equivalent to postulating a medium) or else we have to postulate action at a distance: some mechanism whereby mass A can exert an influence on the space-time structure at a remote location B without any connection between the two.

The general attitude of the scientific profession toward these problems is a very strange phenomenon: one that might well serve as the basis for an interesting study in psychology. Bridgman suggests that it "may some day become one of the puzzles of history."[26] In spite of the fact that Newton refused to commit himself to any specific explanation of the gravitational force which he postulated, and took the eminently sound position that the existence of this force should be accepted as an empirical fact pending the discovery of some satisfactory explanation at some future date, the scientific profession in general has refused to concede that any possibilities can exist beyond its current range of vision and has taken the stand that Newton's system *necessarily* involves the assumption of action at a distance. "Newton's mechanics assumed action at a distance between the different bodies," says Max Von Laue, "His law of gravitational attraction shows this very distinctly."[27] At the same time, the attitude toward action at a distance has been one of strong distaste. Pascual Jordan expresses the general sentiment in these words:

> But even in Newton's day there were physicists who looked with

> misgivings on this idea. That two bodies in the cosmos should exert a reciprocal force which leaps, as it were, over the vast empty space between them--that each of these bodies should exert a force where it is not, on a body far removed from it--struck these critics as incredible. They desired an explanation of how the energy emanating from one body spreads or propagates itself through space, until it finally reaches the other, remote body [28]

In such an atmosphere, where the great majority of physicists were firmly convinced that Newton's theories were solidly tied to this thoroughly unpalatable concept of action at a distance, Einstein's General Theory came as a welcome relief from an intolerable situation, and under the circumstances most scientists were quite content to accept Einstein's conclusions at face value without any very serious attempt to inquire into their validity. As Eddington admonishes us in the statement previously quoted, "we do not ask" about such matters, and Einstein's theory has therefore been incorporated into the current dogma of the scientific profession substantially on the terms which he laid down; that is, on the basis that we should "take for granted" the properties which he assigns to space, and not "bother too much" about their meaning.

There are, it is true, a few prominent members of the scientific community who have refused to accept on trust these explanations that do not explain. G. C. McVittie is outspoken: "To say instead that gravitation is a manifestation of the curvature of four-dimensional geometrical manifolds is to account for a mystery by means of an enigma "[29] Bridgman says essentially the same thing: "I believe, however, that an analysis of the operations that are used in specifying what the field is will show that the conceptual dilemma (connected with the difficulty of imagining any 'mechanism' by which action at a distance occurs) has by no means been successfully met, but has merely been smothered in a mass of neglected operational detail."[30] As these observers indicate, what Einstein has actually accomplished, so far as the great dilemma of gravitation is concerned, is not to resolve it, but to push it farther into the background where its existence is less obvious.

The salient fact here is that the substitution of a hypothetical finite velocity of propagation for action at a distance is purely a matter of wishful thinking; there is no experimental evidence of such propagation--"... it certainly cannot be measured at the present time, even if it does exist,"[31] reports Bryce S. De Witt in a review of the present gravitational situation--and there is no evidence of any kind which conflicts with the hypothesis that the effect is instantaneous. All practical gravitational calculations are carried out on this instantaneous basis by means of Newton's equation. Einstein himself admits, "Newton's law (of gravitation) still remains the basis of all astronomical calculations."[32] Most scientists accept the General Theory of Relativity but no one uses it except as a mental and mathematical exercise; indeed it is doubtful if anyone knows *how* to use it in anything other than an artificially simplified situation.

The impetus for the acceptance of this purely hypothetical finite velocity of propagation comes almost entirely from a pronounced distaste for what appears to be the only alternative. It is, of course, easy to understand why the scientific community is reluctant to accept the concept of action at a distance. There would be little reason for making any attempt to comprehend nature unless we have some underlying philosophical convictions as to the rational character of the relationships with which we are dealing, and action at a distance does not come within our usual definition of rationality. What is not so easy to understand is why this particular concept should be singled out as so overwhelmingly objectionable that it must be avoided *at all costs.* What have we gained if we dispense with action at a distance only by admitting such a concept as that of distortion of space? We object to action at a distance mainly because we cannot conceive of any mechanism whereby this can take place, but can anyone explain the mechanism whereby space can be distorted? The relativists have no explanation to offer. Eddington says "we do not ask." Einstein tells us that we should "take it for granted." Margenau gives us the same answer: "At the present stage of science we cannot ask why the law of the metric is true."[33]

After all, what is wrong with Newton's attitude toward this question: a frank admission that he did not know how the gravitational force originates? Of course, we cannot be *satisfied* with this situation; we must continue to search for an explanation. But as long as we have no explanation, the best thing that we can do is to say so. Here is one of the most serious faults of present-day scientific practice: an almost psychopathic unwillingness to admit ignorance. Where the truth is unknown, present-day scientists seem unable, in most instances, to resist the temptation to present their opinions, or those of the "authorities" in their respective fields, in the guise of established facts.

There is no lack of warning as to the dubious character of this kind of "knowledge"; clear-sighted observers are continually sounding the alarm. For example: from Louis de Broglie, "... many research workers take a number of contemporary theories as fully proven simply because they do not realize on what shaky foundations these theories rest";[34] from Paul Freedman, "... existing scientific knowledge is not nearly so complete, certain and unalterable as many textbooks seem to imply";[35] from Sir Edmund Whittaker, a caution aimed particularly at General Relativity, "It is unwise to accept a theory hastily on the ground of agreement between its predictions and the results of observation in a limited number of instances: a remark which perhaps is specially appropriate to the investigations of the present chapter (title: Gravitation)";[36] from P. W. Bridgman, "But it seems to me that our present theories, even the successful ones, are not yet constructed so completely in accord with sound principles but that in this day and generation criticism is a most necessary and useful enterprise for the physicist."[37] But this wise counsel is for the most part unheeded.

A collateral factor that has had some influence toward encouraging the assumption that the gravitational effect is propagated at a finite velocity is an analogy with electromagnetic radiation. The line of reasoning in this case is as follows:

1. Electromagnetic radiation travels at a finite velocity.
2. Under appropriate conditions this radiation produces electric and magnetic effects.
3. This suggests that the effects due to the existence of electric charges and magnets are propagated by similar electromagnetic disturbances traveling with a finite.
4. This, in turn, suggests that gravitational effects, which resemble the effects of electric charges in some respects, such as following the inverse square relation, arc also propagated at a finite velocity.

Even a minimum of consideration of this reasoning is sufficient to make it clear that there is only a very tenuous connection between the initial premise (1) and the final conclusion (4). The need for a very careful and thorough evaluation of the evidence is therefore definitely indicated, but here we find that the conclusion that has been reached is so highly satisfactory to a scientific world desperately anxious to have something--anything--which can replace the unwelcome concept of action at a distance that the usual processes of critical scrutiny and verification have been waived.

For present purposes, however, it is essential to have a realistic appraisal of the merits of this analogy. Let us therefore review the characteristics of electromagnetic radiation. It has been found that this radiation consists of discrete units of an oscillating character--photons--which originate from matter at specific locations and travel outward from these points at a constant velocity, which we recognize as the velocity of light. In empty space these photons travel in straight lines, but when they encounter matter their direction is subject to various modifications such as reflection, refraction, etc.

Each photon has a definite frequency of vibration and a corresponding energy content, hence these photons are essentially traveling units of energy. The emitting agency loses a specific amount of energy whenever a photon leaves. This energy travels through the intervening space until the photon encounters a unit of matter with which it is able to react, whereupon the energy is transferred, wholly or in part, to this unit of matter. At either end of the path the energy is recognizable as such, and at either location it is readily interchangeable with any other type of energy. The radiant energy of the impinging photon may, for instance, be converted into kinetic energy (heat), or into electrical energy (the photo-electric effect), or into chemical energy (photochemical action). Similarly, any of these other types of energy which may exist at the point of emission of the radiation may be converted into radiation by appropriate processes.

Now let us ask, are these the characteristics of gravitation? The answer must be an unequivocal *No!* They have no resemblance at all to the characteristics of the gravitational phenomenon. Gravitational energy *is not* interchangeable with other forms of energy. At any specific location with respect to other masses, a mass unit possesses a definite amount of gravitational (potential) energy, and it is impossible to increase or decrease this energy content by conversion from or to other forms of energy. It is true that a change of location results in a release or absorption of energy, but the gravitational energy which the mass possesses at point A cannot be converted to any other type of energy at point A, nor can the gravitational energy at A be transferred unchanged to any other point B (except along equipotential lines). The only energy that makes its appearance in any other form at point B is that portion of the gravitational energy which the mass possessed at point A that it can no longer have at point B: a fixed amount determined entirely by the difference in location.

This behavior is totally different from that of the electromagnetic photon. The photon carries its total complement of radiant energy undiminished up to the point of action, and at that point there is complete freedom as to the disposition of the energy. The photon may he reflected or refracted, retaining the full energy with which it originated, or it may transfer part or all of its energy to the matter with which it reacts. If the radiant energy at point A is x at time t_1, this does not in any way determine the energy which will exist at time t_2. The same is true of the energy at point B. Both of these values depend on the relation of the amount of radiant energy produced to the amount radiated in the interim. But if a quantity y of energy is radiated from point A and travels through free space to point B. it is still y when it reaches point B. Radiant energy thus remains constant in magnitude while traveling in free space, but it can vary almost without limit at any specific location.

The behavior of gravitation is exactly opposite. The gravitational effect remains constant at any specific location but varies if the mass moves from one location to another, unless the movement is along an equipotential line. If the gravitational energy at point A is x at t_1, it remains x indefinitely (providing that no changes take place in the masses responsible for the gravitational effect). If the mass is allowed to fall to point B it arrives there with a gravitational energy z, which is determined solely by the conditions existing at point B and is completely independent of the magnitude of the original gravitational energy x and also independent of the nature of the events that have taken place along the route.

Energy is defined as the capability of doing work. Kinetic energy, for example, qualifies under this definition, and hence any kind of energy that can be converted to kinetic energy also qualifies. But gravitational energy is not capable of "doing work" as a general proposition. It will do one thing and one thing only: it will move masses inward toward each other. If this motion is permitted to take place, the resulting decrease in gravitational energy makes its appearance as kinetic energy and the latter can then be utilized in the normal manner, but unless gravitation is allowed to do this one thing which it is capable of doing, the gravitational energy is completely unavailable; it cannot do anything itself, nor can it be converted to any form of energy that *can* do something.

Gravitational energy, or potential energy, is purely energy of position; that is, for any two specific masses, the mutual gravitational energy is determined solely by their spatial separation. But *energy* of *position in space cannot be propagated in space;* the concept of transmitting this energy from one spatial location to another is totally incompatible with the fact that the magnitude of the energy is *determined by* the spatial location. Propagation of gravitation is therefore inherently impossible. The gravitational action is necessarily instantaneous as Newton's Law indicates, and as has always been assumed for purposes of calculation.

Although these energy considerations are sufficient in themselves to demonstrate that there can be no such thing as a propagation of the gravitational effect analogous to the propagation of electromagnetic radiation, there are many other points of difference between these two phenomena which show that they are entities of a totally different character. For example, the emission and the absorption of light, or any other electromagnetic radiation, are two separate and distinct events. Although matter usually absorbs the emitted photons sooner or later, the absorption is not a *necessary* consequence of the emission and it is theoretically possible that some photon might *never* be absorbed. Gravitation, on the other hand, is a cooperative phenomenon. The gravitational attraction exerted by mass A upon mass B is never independent of the attraction exerted by mass B upon mass A; the gravitational effect is a *mutual* attraction of the two masses toward each other (or more properly, as we will see in Part Two, the *equivalent* of a mutual attraction).

Likewise, the behavior of gravitation in its action upon matter is altogether different from the behavior of electromagnetic radiation. The property of transparency, for instance, is entirely unknown so far as gravitation is concerned. Many substances are transparent to light, many more to x-rays; that is, the radiation passes through these substances more or less readily and to the extent of the transparency the behavior of these substances toward radiation is that of empty space. But so far as we have been able to determine, no material substance is in any degree transparent to the gravitational force. Then again, if a body is not transparent the electromagnetic radiation that falls upon it is absorbed or reflected and the space beyond the opaque body is shielded from this radiation, but there is no known way of screening off gravitation or of modifying it in any respect. When the earth comes between the sun and the moon, for instance, the solar radiation is intercepted by the earth and there is an eclipse of the moon, but observations of the moon's orbit show that the gravitational effect of the sun upon the moon is not altered in the least by the presence of the earth in the intervening space. All of the available information indicates that the gravitational force between mass A and mass B is completely independent of the environments in which the two masses are located and unaffected by anything that may be present in the intervening space.

All in all, gravitation and electromagnetic radiation are about as dissimilar as any two physical phenomena can be, and the attempts that have been made to draw conclusions from an assumed analogy between the two are simply meaningless. There is no support anywhere for the idea that gravitation is propagated at a finite velocity and, however painful it may be, the scientific profession would be better off if it faced this issue squarely. Burying the head in the sand and refusing to recognize the facts accomplishes nothing. If no acceptable explanation of these facts is currently available, the only logical course of action is to take a stand alongside Newton and look upon the gravitational laws simply as empirical findings until such time as we are able to discover a satisfactory theoretical explanation.

Of course, the present-day contention is that three hundred years of intensive effort by scientists of the highest caliber have failed to produce any alternatives other than the two possibilities--action at a distance or propagation through a medium--which have been recognized from the start, and that this experience is sufficient to demonstrate that there is no other alternative. From a logical standpoint this contention is completely untenable, since it can be valid only if the scientists who have attacked the problem are, or were, infallible, but it has a strong appeal nevertheless, particularly to the baffled investigators and their colleagues, and it is a difficult argument to combat. However, it is a very vulnerable argument, since it is Immediately and utterly demolished when the allegedly non-existent alternative is actually produced, as will be done in the pages that follow.

In undertaking to present a complete and satisfactory explanation of gravitation it is not only necessary to show how and why the gravitational force acts as it does, but also why it does *not* do some things that would naturally be expected to result from whatever causes produce the observed effects. If we accept Newton's concept of gravitation, either with or without Einstein's modification, we would expect to find all particles of matter everywhere in the universe moving inward toward each other and Continuing in this motion until they eventually join, either by actual consolidation or by the establishment of stable orbital motion. Observation shows, however, that the behavior of matter in certain regions of the universe deviates very decidedly from this pattern which should theoretically be produced, and since there is no independent evidence, in any of these regions, of any counter force that could cause the abnormal behavior, a complete gravitational theory must necessarily explain why the individual particles do not move toward each other in these particular regions, as well as why they do exhibit a mutual attraction in what is generally considered the normal situation

Looking first at the far distant regions of the universe that have been brought within observational reach in relatively recent years by the giant new reflecting telescopes, particularly the 200-inch Hale telescope on Mount Palomar, we find that the distant galaxies not only show no evidence of any gravitational motion toward our own location but, according to the testimony of their spectra, are reversing the gravitational direction and are receding from us at enormous speeds which increase proportionately with the distance. Of course, it is easy to assume a force of "cosmic repulsion" to account for this galactic recession, but no independent evidence of the existence of any such force has been produced by those who advance this hypothesis, and a purely *ad hoc* assumption can hardly be regarded as a satisfactory explanation. Gravitational theory therefore faces the problem of accounting for the recession of the distant galaxies in one way or another.

There is a possibility, to be sure, that the spectral red-shift, which is generally interpreted as a Doppler effect and hence as evidence of motion, is actually due to some other cause, but no other explanation that is anything more than an unsupported speculation has thus far been offered and the prevailing opinion at the moment is that the red-shift indicates a real recession. As matters now stand, therefore, this is a part of the general gravitational problem.

Moving inward toward the regions of shorter distances, the next discrepancy that we encounter is in the inter-stellar relationships. Here again, both the Newton and Einstein theories require the stars to move continually inward toward each other and eventually to join either by consolidation or by the establishment of stable orbital systems. We do find many relatively large stars, which conceivably could have resulted from consolidation of smaller masses, and we do find some small orbital systems, binary stars and a small proportion of more complex systems, the largest now known having six or eight components. We would expect to find more and larger stellar aggregates in a universe in which Newtonian gravitation had been operative for a long period of time, but the existing situation could be plausibly explained on the assumption that we are still in the early stages of gravitational agglomeration. On this basis the existing star systems are not inconsistent with existing gravitational theories.

If we accept this explanation, however, there should be a distribution of stars throughout the entire distance range from the radius of the largest orbital system to the radius of the galaxy: stars which are on their way to the eventual consolidation that must be the end result of the postulated gravitational attraction. But the observed distribution is totally different from this expectation. Beyond the orbits of the multiple star systems, which are comparable in dimensions to the planetary orbits and involve distances that, in terms of the velocity of light, are measured in *minutes* or *hours,* there are no stars at all until we get out to distances measured in *years.* The star nearest the earth is 4.2 light years distant and there is no evidence that any two stars in the solar neighborhood, aside from those in multiple star systems, are appreciably closer together. The average separation of the stars in this region is estimated at 2 parsecs or 6.5 light years.

Even where conditions would be expected to be the most favorable for the development of powerful gravitational forces, in the interiors of the globular clusters and the nuclei of the giant spiral galaxies, the weight of evidence indicates that the minimum separation must still be measured in light years. The average density of the globular clusters is estimated at only about five times the density of the local star system, and although the central regions of the spiral galaxies are too far away for detailed observations there are indications that they are no more densely populated than the globular clusters. "The average density of matter in the nuclear region (of our galaxy) is probably about twice that for the vicinity of the sun..."[38] reports Bok.

The existence of this immense gap from light hours to light years completely void of stars is completely inconsistent with the theories of Newton and Einstein in their existing forms, regardless of what assumptions may be made as to the age of the universe or the elapsed time since gravitation first took effect. The fact that stars do not enter this immense region, which should be well populated on the basis of existing gravitational theory, strongly suggests that they *can not* enter, and that unless stars have a common origin (as those in multiple star systems presumably do) the gravitational pattern is such that they cannot approach each other within a distance of the order of light years. A satisfactory gravitational theory must therefore contain such a pattern, or alternatively, must provide some other plausible explanation of this very peculiar star distribution.

Again moving inward toward the shorter distances, we find another major discrepancy when we get to the point where we are dealing with individual atoms. There is nothing in gravitational theory, as it now stands, to indicate that the gravitational force is any less applicable to atoms than to any other masses, but the observed behavior at interatomic distances comparable to those existing in the solid state is totally different from that envisioned by existing theory. On the basis of either the Newton or the Einstein version of the theory the atoms should continue to move toward each other under the influence of the gravitational forces until they are in actual contact, after which they should be held together by these same forces. Until rather recently it was assumed that the atoms *are* actually in contact in the condensed states, but this concept is no longer tenable in the light of present-day knowledge, and as matters now stand it is evident that the interatomic distance in the solid state merely represents a point of equilibrium at which the attractive and repulsive forces acting between the atoms are in balance. Furthermore, it is now clear that the gravitational force, if it follows the same mathematical pattern as at greater distances, is far too small to account for the observed cohesion in the solid structure. At this level, then, existing gravitational theory contributes nothing toward an explanation of the observed situation.

We thus find that Newton's "Law of Universal Gravitation," with or without Einstein's modification, is far from being universal. There are at least three important regions in the universe where the actual behavior of matter is entirely different from that specified by the allegedly "universal" law, and a complete and correct theory of gravitation must necessarily explain the gravitational pattern in these regions as well as the more conventional behavior.

Part Two
The Answer

In Part Three of this work an entirely new theory of gravitation which meets all of the requirements of a complete and comprehensive first order explanation of the gravitational phenomenon outlined in Part One will be developed from some new assumptions as to the basic nature of space and time. These assumptions, however, not only require a rather drastic revision of present-day ideas concerning space-time itself, but also lead to major changes in the theoretical background of almost all branches of physical science. There will, of course, be considerable reluctance to accept any such sweeping revision of current thought, and since the most essential features of the new gravitational theory can be developed from two less general postulates that do not necessarily conflict with the existing theoretical structure of science outside of the gravitational area, it appears advisable to approach the subject from this direction first, leaving the underlying theory for subsequent treatment in Part Three.

By way of establishing a background for the first of these two new postulates, let us consider the currently accepted concept of the progression of time. According to this viewpoint we are presently occupying a location in time which we call "now," but we regard "now" as continually progressing, so that if we designate the current "now" as x we will be located at point x + 1 in time when another unit of time has elapsed. These lines are being written at a time location which we designate as 1963 AD When another year has elapsed we will consider ourselves as occupying time location 1964. We usually think of our own location as remaining stationary with time flowing past us, but the essential point is that in one unit of time a situation in which "now" is at time x changes to a situation in which "now" is at time x + 1. It is clear that this same result would be achieved if time, instead of flowing past us, moves from x to x + 1 in this interval, carrying us with it. In terms of the "River of Time" analogy, we may either visualize ourselves as located on a rock in midstream and measuring the river flow relative to our own position, or we may visualize ourselves as located in a boat floating freely with the stream, in which case we measure the flow by reference to the river bank.

The human race is strongly inclined to regard its own location as fixed and to interpret any relative motion with reference to another object as an actual motion of the other object, and much of the history of science during its first few millennia is concerned with the slow and painful progress toward freeing scientific thought from the handicap of this ingrained error. By this time, however, the scientific world has learned its lesson through costly experience and scientists are now wary of any theory or concept that portrays the abode of man as occupying any fixed or privileged position. The prevailing idea that we remain in a fixed location while time flows past us is actually an anachronism: an isolated corollary of the geocentric theory of the universe that has managed to survive only because it has never been subjected to a serious challenge.

The alternate viewpoint in which the rate of flow or progression of time is independent of us and of our position not only frees this phenomenon from the anthropomorphic aspects of currently popular concepts but also eliminates the necessity of providing an explanation for our motion relative to time. It is, of course, easy to visualize time itself as an entity that has an inherent flow or progression, but it is not so easy to understand why this flow should be a flow past us. This is not implicit in the concept of a progression of time; it is something that is introduced only when *we* enter the picture, and the mechanism responsible for the motion of time relative *to us* or, what amounts to the same thing, our motion relative to time, must be connected with us, not with time itself. If we regard time as flowing past us we are therefore faced with the problem of finding some mechanism whereby we can move relative to time. On the other hand, if we adopt the alternative viewpoint that we are being carried along by the flow or progression of time, this problem is eliminated. On this basis we always remain at the same location in time, but this location itself progresses and corresponds to constantly changing coordinates if viewed from the standpoint of an arbitrary reference system that theoretically does not progress.

The first of the postulates of the new theory adopts this latter viewpoint as to the progression of time, and extends the concept to space-time as well. On this basis there exists a progression of space-time such that each location in space-time moves outward from all other locations at a constant velocity. This means, of course, that the observed progression of time is simply one aspect of a more general phenomenon, another aspect of which is a similar progression of space. At first glance this latter concept seems absurd, since we have never recognized any evidence, in our everyday experience, of a progression of space that bears any resemblance to the observed progression of time. As we will see shortly, however, evidence of this kind can be found if we know what to look for.

During one unit of time, according to this postulate, location x not only progresses to x + 1 in time, but also progresses to x + 1 in space, since space-time as a whole is progressing. Any object without independent motion of its own which occupies location x in space at time x will therefore be found at location x + 1 in space at time x + 1, simply because space location x + 1 at time x + 1 is the *same* space-time location as space location x at time x. The hypothetical object remains permanently at the same location in space-time, but it moves with respect to a coordinate system that does not progress in space or a coordinate system that does not progress in time.

In the era of Newton space and time were regarded as independent entities but it has been apparent for the last half century that they are not independent, and that basically we must deal with space-time, not with space alone or with time alone. The currently popular Minkowski concept, which was adopted by Einstein in his work, recognizes this fact and portrays space-time as a four-dimensional continuum made up of three space dimensions and one time dimension. But only time progresses in a Minkowski universe, and hence an object that has no independent motion of its own remains stationary in Minkowski space, whereas the progression of space-time specified by the new gravitational postulate carries such an object outward in space as well as in time. This view of a location in space-time as an entity in motion is something new and unfamiliar but it should not present any serious conceptual difficulties. If we can visualize a progression of time we should certainly be able to visualize a corresponding progression of space. In this connection it should be noted that the concept of a relationship between space and time which is implied by the use of the expression "space-time" naturally suggests motion, since motion is the only relation between space and time of which we have any actual knowledge.

It has been emphasized in the preceding discussion that assumptions of a purely *ad hoc* nature with no confirmation from independent sources are essentially nothing more than speculations until some confirmation of this kind is forthcoming. The next thing that we will want to do, therefore, is to see what independent confirmation of the postulate of space-time progression can be obtained. If this assumption of a progression of space-time is valid, then we should be able to recognize some phenomena in which identifiable objects without inherent motion of their own are being carried along in space by the progression of space-time. In order to simplify the question of a reference system, let us assume that a large number of such objects originate at the same space-time location, which means that they originate at the same space location simultaneously. Due to the progression of space-time these objects immediately begin moving outward, but outward in space-time is a scalar direction, whereas the corresponding spatial motion is vectorial and can have any direction in three-dimensional space. Inasmuch as there is no reason why any particular direction should be preferred, the motions of the individual objects will be distributed over all possible directions in accordance with the probability principles, hence if the postulate of space-time progression is valid we should observe objects of this kind originating at various spatial locations and moving away from the points of origin in all spatial directions and at a constant velocity.

We do not have to look very far in order to find physical entities, which display exactly this behavior. Throughout the universe there are sources of light or other electromagnetic radiation from which photons emanate in all directions and recede from the points of emission at a constant velocity. Furthermore, these photons, so far as we know, have no motion of their own other than a vibratory motion which, because of the constant reversal of direction, has no net resultant in any spatial direction. Thus these photons not only behave in the manner theoretically appropriate for objects with no inherent motion, but they also answer the description of such objects. The radiation phenomenon therefore provides the definite independent evidence that is necessary in order to demonstrate the reality of the postulated space-time progression.

Further confirmation of the validity of the postulate is provided by the behavior of the very distant galaxies. The galaxies nearest our own have spectra which indicate relatively slow motions of a random character, but outside the local group all galactic spectra indicate that the galaxies are moving away from us at high velocities. Furthermore, these velocities increase with distance, apparently in linear proportion, and at the extreme limits reached by the giant optical telescopes they are in the neighborhood of half of the velocity of light. A reasonable extrapolation of this trend leads to the conclusion that not far (astronomically speaking) beyond the present observational limits the galaxies are receding from us at the velocity of light, which is just what would be expected on the basis of the space-time postulate as stated, providing that these galaxies have no appreciable independent motion of their own in our direction. This is almost certainly true, as our observations indicate that the random velocities of the galaxies are too small to be significant in this connection and at these extreme distances any gravitational motion toward our galaxy would be attenuated to the point where it would be negligible.

Thus the recession of the distant galaxies not only provides us with an additional verification of the postulate of space-time progression but also gives us a clear indication of how gravitation fits into the picture. Gravitation is normally visualized as a *force,* but in the case of the isolated galaxies, where no opposing forces are present, it is obviously a *motion,* and since the gravitational motion of each galaxy is directed *inward* toward all other galaxies, this gravitational motion is directly opposed to the motion of the space-time progression, which carries each *galaxy outward* away from all others. The gravitational motion evidently must be a property of the matter of which the galaxies are composed, and the second of the two postulates of the new gravitational theory will therefore be that each unit of matter has an inherent motion in the direction opposite to that of the space-time progression. In order to account for both the gravitational attraction at the shorter distances and the recession of the more distant galaxies it will, of course, be necessary to include the assumption that the gravitational motion of any unit of matter toward any other unit is equal to the space-time progression at some finite distance. Since the motion of the progression is constant irrespective of location, the inverse square relationship which applies to gravitation results in a net inward motion at the shorter distances, while beyond the equilibrium point the net notion is outward, increasing toward the velocity of light as the effective gravitational motion weakens.

A consideration of the situation existing at this equilibrium point shows how the concepts of gravitational force and gravitational motion are related. At this point there is no apparent motion in either direction. According to the gravitational postulates both the gravitational motion and the motion of the space-time progression actually exist, but there is no net resultant as one cancels the other. It is also possible, however, to consider both gravitation and the space-time progression as forces tending to *cause* motion, and to take the stand that no motion actually exists because the opposing forces are equal and there is no net force in either direction. The concept of force is quite legitimate and it is very convenient for many applications, but it has certain limitations simply because it is not exactly a true representation of the physical facts. One of the postulates of Einstein's General Theory, for instance, is the so-called "Principle of Equivalence" which asserts that a gravitational force is equivalent to an accelerated motion. Actually, on the basis of the theory now being presented, gravitation is not *equivalent* to motion; it *is* motion. Under most circumstances these two concepts amount to the same thing, but the boundary conditions are different and Einstein's formulation leads to erroneous results under some conditions: a situation which will be discussed in detail in the pages to follow.

From a space-time standpoint gravitation, as defined in this new system, is a uniform motion. This uniform motion is, however, distributed equally in all spatial directions in accordance with the probability principles, and the fraction of the total motion, which is directed toward any specific point in space, is therefore inversely proportional to the square of the intervening distance. In spite of the fact that it is uniform in space-time, the gravitational motion is thus an accelerated motion in space.

For present purposes it is not actually necessary to inquire into the question of the origin of the gravitational motion, but it is quite evident from the foregoing discussion that a rotational motion of the units of matter--the atoms--in, the direction opposite to that of the space-time progression would produce just such a result. From a spatial standpoint rotational motion produces no net effect as the motions in the different directions cancel each other, but since the space-time aspect of this rotational motion is scalar (that is, it is outward only, without any other directional specification), the rotational motion of the atoms can have a constant space-time direction and for present purposes a constant space-time direction opposite to that of the space-time progression will be assumed. The theoretical necessity for this constant direction will be demonstrated in Part Three. Unlike the space-time progression, which originates everywhere here and thus has a constant magnitude irrespective of location, the rotational motion of an atom originates at the specific location which that atom happens to occupy. Since the direction in space corresponding to an inward motion in space-time is indeterminate, the rotational motion is distributed over all spatial directions, and the magnitude of the effective component of this motion directed toward any other unit of matter therefore decreases with distance, following the inverse square law.

The two gravitational assumptions may now be expressed as follows:

1. There exists a progression of space-time such that each location in space-time moves outward from all other locations at the velocity of light.

2. Each atom of matter has an inherent motion of rotational origin opposite to the motion of the space-time progression in direction and equal in magnitude at a finite distance.

Let us now see what kind of a gravitational picture will result from these two assumptions. First, we note that on this basis gravitation is not an action of one mass upon another; it is a relation between each mass individually and the general space-time structure. In the absence of gravitation, each mass would move outward from all other masses by reason of the ever-present progression of space-time. Gravitation, being opposite in direction and greater in magnitude than the progression inside the equilibrium distance, reverses this behavior and causes each mass to move inward toward all other masses.

Here we have a situation in which each mass *appears* to be exerting a force of attraction on all other masses (within the distance limit) but in reality each is pursuing its own course completely independent of the masses with which it appears to be interacting. Under these circumstances the apparent force of attraction is exerted instantaneously, no medium is necessary, and there is obviously no way in which the effect could be screened off or modified by anything interposed between the masses. This is just the kind of behavior that is indicated by observation: a behavior which previous gravitational theories have been unable to account for.

As an aid in visualizing this gravitational situation, let us assume that a violent explosion has taken place and that we are looking at the results shortly thereafter without any knowledge of what has happened. We will see a cloud of flying particles apparently exerting a force of repulsion upon each other, and with a reasonable amount of ingenuity we can formulate a mathematical expression to represent the magnitude of this force. But we will find it very difficult to account for the origin of the force and to explain how it operates, as long as we remain under the Impression that it is a force exerted by one particle upon another, since we will find that this hypothetical force has some very peculiar characteristics: it acts instantaneously, without an intervening medium, and in such a manner that it cannot be screened off or modified in any way.

Judging by past experience, we can expect our leading physicists to deny the validity of the results of our observations of these happenings, on the grounds that they imply action at a distance, and to contend that there must be some kind of propagation of the repulsive force between the particles of debris, notwithstanding the physical facts that testify to the contrary.

Of course it can be anticipated that the foregoing statement will be taken as merely a bit of pleasantry; the idea that anyone would react to the situation in such a manner seems absurd in this case. But actually these *are* the conclusions which the great majority of the theoretical physicists of the present day have reached with respect to gravitation, on the strength of an almost identical set of observed facts. It is true that gravitation acts in the opposite direction--inward rather than outward, but it should not take much of a mental effort to visualize an explosion in reverse.

This new concept of gravitation not only explains the mechanism of the apparent attraction of one mass toward another, but also explains the unusual characteristics of the gravitational action at the same time, and eliminates the necessity of postulating phenomena or behavior characteristics for which there is no experimental or observational evidence: deformation of space, a finite propagation velocity, etc. The most impressive feature of this performance is that the entire theoretical structure is an integral unit; the same assumptions that lead to the *existence* of gravitation also define the *characteristics* of the gravitational action and no supplementary or collateral assumptions are required.

Furthermore, these assumptions also account for the general behavior of electromagnetic radiation and for the recession of the distant galaxies, as already indicated. The first of the three major deviations from the normal gravitational pattern which were discussed in Part One, that which is observed at extreme distances, is thus explained. Then when we turn our attention to the second area of deviation, the unexpectedly great distances between the stars, we find that this is simply another manifestation of exactly the same combination of factors that is responsible for the galactic recession.

Since the gravitational assumptions specify that the inward-directed gravitational motion of each atom is equal to the outward-directed motion of the space-time progression at a finite distance, this distance constitutes a *gravitational limit* for the atom, a limit within which the gravitational motion exceeds that of the progression, and beyond which the motion of the progression is the greater. Where a number of atoms are associated in a material aggregate the total gravitational motion, or force, increases proportionately with the mass, and since the space-time progression is constant this means that the gravitational Iimit moves outward as the mass increases. Each mass aggregate therefore has an individual gravitational limit that depends on the magnitude of the mass. The gravitational limit of a large spiral galaxy such as our own or M31 has been found empirically to be in the neighborhood of a million light years. The Magellanic Clouds, which are about 200,000 light years distant from the Milky Way, are therefore within the gravitational influence of our galaxy and have a small gravitational motion in our direction; M31 and M33, the principal exterior members of our local group of galaxies, are outside our gravitational limit and therefore have a small outward motion due to the net space-time progression. The velocities of these local galaxies due to the net excess of gravitation or progression are so small that they can easily be masked by the random motions which the galaxies have acquired in the course of their development, but all other galaxies beyond the local group have a relatively large outward velocity due to the excess of the progression over the gravitational motion: a quantity which increases with distance, as has been explained.

Aside from the globular star clusters, which for present purposes can be considered as junior size galaxies, the next smaller independent unit of mass is the star. Since the only difference between the galactic aggregate and the stellar aggregate from a gravitational standpoint is in magnitude, the points that were brought out with reference to the gravitational behavior of the galaxies also apply to the stars. Here again there is a gravitational limit, within which there is a net inward motion and beyond which there is a net outward motion. From Newton's relationship between mass, distance and gravitational force, we find that if the gravitational limit of a galaxy whose mass is equal to that of the Milky Way is approximately one million light years, the gravitational limit for a mass equal to that of the sun is about two light years. This, then, is the explanation of the immense distances between the stars. All matter within the gravitational limit of an existing star is pulled in to the star by the gravitational forces, and this prevents the accumulation of enough material to form a new star. If there ever was a "creation" period, and if some different situation prevailed at that time so that stars did come into existence within the gravitational limits of other stars, such new stars have long since consolidated with their predecessors or formed multiple star systems. Any star initially outside the gravitational limit of another star can never get inside, as the net motion in the region beyond the limit, is outward.

We do not observe a "recession of the stars" similar to the recession of the galaxies, but this is obviously due to the fact that the stars, unlike the galaxies, are under the gravitational control of larger aggregates. The stars in the vicinity of the sun, for example, are moving outward from the sun and from each other but at the same time they are being pulled inward toward the center of the galaxy by the gravitational force of the galaxy as a whole. The net result is an equilibrium in which the stars maintain reasonably constant relative positions just outside the gravitational limits of their neighbors.

The globular star clusters provide a particularly interesting example of this kind of equilibrium. The structural relationships in these clusters have long been a major astronomical problem. It seems quite obvious that each cluster is held together by gravitational forces, but if current gravitational ideas are valid some counter force must be operative to maintain the existing distances between the stars and prevent collapse of the structure. Unfortunately for the theorists it has not been possible to find such a force. From analogy with other astronomical systems it is natural to think of rotation in this connection, but all available evidence indicates that there is little or no rotation of the clusters. An attempt has been made to formulate an alternative theory on a basis somewhat similar to the kinetic theory of the motion of gas particles, but here again the observed facts prove to be recalcitrant. Such an explanation would require a high random velocity of the individual stars and frequent collisions or near collisions, neither of which is substantiated by observation.

Again, as in the case of the galactic recession, the new theory provides a ready answer in terms of gravitation in conjunction with the space-time progression. There is a force of repulsion between the individual systems (separate stars and multiple star systems) because each is outside the gravitational limits of its neighbors. The cluster is held together by the gravitational effect of the total mass on the individual units but the local repulsion between these individual units prevents the star density from exceeding a certain limiting value. This theory based on the two gravitational assumptions of this work thus requires just the kind of a situation which, according to the observations, actually exists.

The mere existence of clusters of this kind is a powerful argument in support of the new theory, as this is a case where the consequences of the basic assumptions of this theory see in sharp contrast to the results obtained from any other gravitational theory. No theory heretofore proposed could explain the existence of structures with the characteristics of these globular clusters, but they do exist and they are not freak phenomena; they exist in enormous numbers. One galaxy (M87) is estimated to have over a thousand associated clusters. The abundance of these objects in the visible universe is a strong point in favor of the only theory, which explains why they hold together but do not collapse.

Likewise, the fact that individual stars or multiple star systems are never observed less than one or two light years distant from each other, either in the clusters or elsewhere, strongly supports the conclusions of this work to the effect that a closer approach is impossible and that any astronomical theory which postulates stellar collisions or near misses is erroneous.

The most striking fact about the gravitational theory outlined in the foregoing description is that it sidesteps the dilemma that has hitherto seemed inescapable; that is, it explains the gravitational effect without postulating either a medium or action at a distance, and without any "semantic trick" such as that employed by Einstein to create the appearance of having eliminated the medium without actually doing so. It is now apparent that this dilemma was not inherent in the gravitational problem itself, as had been thought; it was introduced by means of a totally unnecessary assumption that slipped into the line of reasoning without being recognized for what it actually is.

It is generally understood that the existence of concealed assumptions in a line of reasoning is one of the serious hazards that attends any attempt to apply logic to a problem, and great care is customarily taken to avoid introducing such assumptions. Unfortunately, however, it is usually necessary to formulate some kind of a theoretical viewpoint before a physical question can be approached at all and it is always possible that the concepts which enter into this viewpoint may contain some kind of a hidden assumption that is totally or partially erroneous, and this may invalidate the entire chain of thought, just as has happened in the gravitational case. The assertion that the gravitational effect is an action of one mass upon another is not a fact of observation, as has been believed; it is purely an assumption, and recognition of this fact opens the way to a clarification of the whole situation.

It should be emphasized that the new gravitational theory not only resolves this long-standing dilemma, but also agrees with *all of* the observed characteristics of the gravitational phenomenon; something that no other theory has ever done. All previous theories have had to assume that the gravitational observations do not mean what they seem to mean; that they are misleading and that the true characteristics of gravitation are something other than what the observations would indicate. This present work offers, for the first time, a system in which the theoretical characteristics of gravitation are in full agreement with the picture that we get from observation; that is, gravitation acts instantaneously, without an intervening medium or any substitute for a medium, and in such a way that it cannot be screened off or modified.

This is only one of several instances where the new theory provides simple and logical explanations of items for which no plausible explanations have been forthcoming on the basis of previous theories. The globular cluster problem previously discussed is another striking example. No previous theory has been able to explain, in any way that is consistent with the observed facts, why these clusters hold together but do not collapse into one massive aggregate.

The general situation involved in accounting for the extraordinary magnitude of the minimum distance between stars (or multiple star systems) is a case where previous theories have not only failed to supply an explanation, but have been unable to provide enough insight into the situation to enable recognition of the fact that there is an anomaly here which *requires* an explanation. Serious consideration is currently being given to many theories involving collisions or near collisions of stars, both in the clusters and elsewhere, although even the most elementary analysis indicates that if the stars were free to approach each other to within collision distance, there would necessarily be a distribution of stars throughout the zone extending from this collision distance outward, whereas observations indicate that there is an immense region out to a radius of one or two light years completely devoid of stars. The observed star distribution is thus totally inconsistent with current astronomical thought and in this instance, therefore, the new theory supplies the answer to a problem before the scientific community has recognized that such a problem exists.

Summarizing the foregoing, for three hundred years it has been accepted as an incontrovertible fact that there are only two possible explanations of the gravitational phenomenon: action at a distance or propagation of the effect at a finite velocity through something with the properties of a medium (ether, field or deformable space). This work has now presented a third alternative that has been completely overlooked by previous investigators: a process analogous to the inverse of an explosion, in which the individual mass units merely act as if they are exerting attractive forces on each other, whereas in truth each is pursuing its own course completely independent of all others. The mere fact that this development lies produced an entirely new concept of a logical and self-consistent nature in a field, which has been exhaustively studied for centuries by the best scientific minds, is, in itself, a noteworthy achievement. But this is much more than just another hypothesis comparable to the original two, neither of which is at all satisfactory. This new theory meets all of the requirements of a complete and satisfactory explanation of the gravitational mechanism.

Furthermore, the explanation provided by the new development is not the difficult and esoteric concept that might be expected in view of the fact that it remained undetected for three hundred years; it is something readily intelligible in terms of ordinary human experience. The gravitational action as explained by this new theory is the very essence of simplicity. There is no action at a distance, no medium, no propagation of a force, no distortion of space; simply an inherent motion of the atoms of matter in the direction opposite to the ever-present outward progression of space-time. These atoms appear to exert mutual forces of attraction only because they are in constant motion toward each other. Such an explanation seems quite strange on first acquaintance, to be sure, but this is merely because it is unfamiliar; anyone can visualize the behavior of the particles of debris that seem to be exerting a "force of repulsion" on each other after an explosion, and no great feat of the imagination is required in order to envision an inverse process. We could even get a visual demonstration of a process somewhat analogous to gravitation by taking a motion picture of an explosion and then running it backward.

Then, additionally, this same simple hypothesis which explains the general nature and mechanism of gravitation also explains the observed characteristics of this phenomenon, including not only the curious, but well-known, properties that have been so difficult to account for in terms of previous theories, but also the gravitational behavior in other fields such as the recession of the galaxies where the role of gravitation has hitherto been largely a matter of conjecture.

In spite of these achievements, however, the theory as here set forth cannot claim to be anything more than an explanation of the second order, on the basis of the classification set up in Part One, since it still leaves the question of the *origin of* the gravitational motion unanswered. Part Three, which follows, will answer this question, and in so doing will also supply the additional information that we need in order to clear up the gravitational situation in the atomic region: the only one of the regional gravitational anomalies that is being left unexplained in Part Two.

Part Three
The Theory

As pointed out in Part One, any explanation of a primary physical phenomenon must necessarily rest upon assumptions or postulates of some kind, and the ultimate in physical explanation is reached when these assumptions refer to simple inherent properties of the universe, the existence of which can be independently confirmed. The origin and development of the postulates on which this work is based, and the nature of the confirmatory evidence that is available were described in a previous publication *The Structure of the Physical Universe*[39] and the full text will not be repeated here, but it may be helpful to show briefly how the principal conceptual innovation involved in these postulates can be derived from very elementary considerations.

Let us assume that we are undertaking a study of basic physical relationships. Both past experience and theoretical considerations indicate that it is sound practice to begin with the most fundamental relation of this kind and then to build the superstructure of theories and principles on this foundation. There is, of course, no definite signpost to indicate just what this most fundamental relationship is, but few would gainsay the statement that if we wish to select the two most basic entities in the universe, the most likely candidates are space and time. The logical starting point for the study is therefore an investigation to determine the general relation between space and time.

At this point it is interesting to note that although we arrive immediately and almost inevitably at this conclusion that we should begin our study by examining the relation between space and time, this question that should logically take first place in such a project has never heretofore had any consideration *as a part of the original development of any basic physical theory*. Newton never even realized that there was any such relation, and in his system space and time are completely independent. Einstein ultimately picked up and utilized Minkowski's hypothesis of a four-dimensional continuum with three space dimensions and one time dimension, but this hypothesis played no part in his original formulation; in fact, Minkowski did not even publish it until several years after Einstein's 1905 paper. The procedure suggested by an elementary analysis of the situation therefore represents a new avenue of approach to the problem. This, in itself, augurs well for the undertaking. The odds against accomplishing anything significant by following previous routes in areas which have had as much attention as this one are tremendous, but the availability of a new approach to the problem makes the situation very much more favorable.

In order to utilize this new line of attack to the best advantage, it will be advisable to consider first the general situation in which we are examining the relation of any quantity y to any other quantity x. Let us illustrate this situation by the diagram, Fig. 1, in which the values of x and y are represented in the usual coordinate manner. In the general situation there will be a

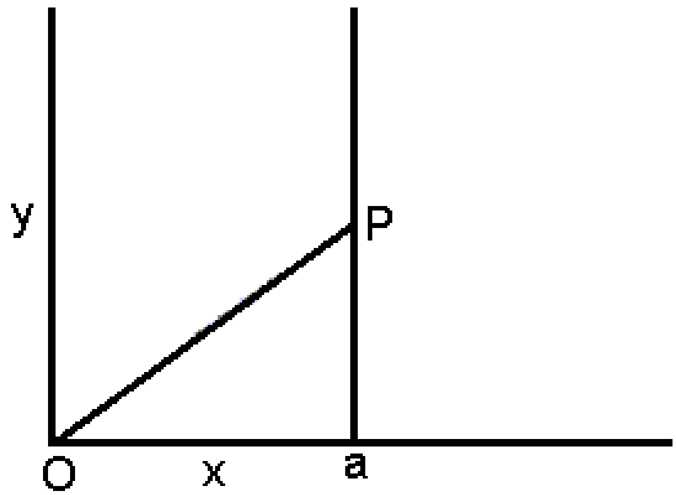

Fig. I

known region, which we will represent by the area to the left of the vertical line *a-a*, and an unknown region, which will be represented by the area to the right of this line. The first step, obviously, is to determine the relation existing in the known region, which we will represent by the line O-P. The problem then reduces to a question of determining the corresponding relation existing in the unknown region.

Since the relations in this region are, by definition, not capable of being determined in any direct manner by the means now at our command, our procedure must be to *assume* some relationship, then develop the consequences of this relationship, select those of the consequences which fall into the known region, and finally compare these particular consequences with the corresponding known facts. If we find an agreement, this verifies the assumption to a degree that depends on the number and variety of the correlation's available; if there is a disagreement, the assumption is invalid and we must discard it. The problem therefore becomes a matter of deciding what assumption should be tried first.

Inasmuch as the relation in the unknown region is necessarily unknown, it could be almost anything. When we consider this general situation, however, without the distracting influences that normally interfere with a clear view of any *particular* physical situation, it is obvious that there is one possible assumption that is inherently far superior to all others: an assumption which has so much greater probability of being a true representation of the physical facts that we are never justified in even considering any other possibility until we have given the consequences of this assumption a complete and thorough examination. This greatly superior assumption is, of course, the hypothesis that the same relation which prevails in the known region also holds good in the unknown region; that is, it is an extrapolation from the known to the unknown.

Our analysis of the general situation along these lines thus tells us that the first move in investigating the relation between space and time in the universe as a whole should be to test the consequences of extrapolating the relation that we find existing in the known region of the universe. In this known region the relation between space and time is motion, and in motion space and time are reciprocally related. The analysis thus indicates that we should postulate a general reciprocal relation between space and time effective throughout the universe.

This reciprocal postulate is the keystone of the new system of thought of which the gravitational theory herein described constitutes an integral part, and in order to place it in the proper perspective it should be emphasized that this is essentially the *only* conceptual innovation introduced into physical theory by this new system. It is true that a great many novel ideas, some of them surprising, perhaps even startling, emerge from the development of the consequences of this one basic innovation, but this is simply a result of the fact that this one new concept is introduced at the very base of the theoretical structure and it therefore has some kind of an effect on almost every part of that structure. In recognition of this major role which the reciprocal postulate plays in the system as a whole, this system will be designated as the *Reciprocal System* for the purpose of convenient reference in the subsequent pages. The word "system" is used rather than "theory" because the full development of the consequences of the postulates on which it is based leads to a whole network of physical relationships, each of which is comparable in scope to the gravitational theory which is the primary subject of the present discussion. This new development is not merely a theory but an interconnected system of theories.

It is evident that the reciprocal postulate necessitates the further assumption that space and time have the same dimensions, since quantities of different dimensions cannot stand in a reciprocal relation to each other. We can recognize three dimensions of space, and the simplest assumption that is consistent with both the reciprocal postulate and these observed properties of space is that both space and time are three-dimensional. Equally necessary in order to permit a reciprocal relationship of anything other than a purely formal character is the limitation of space and time to discrete units. Neither of these additional assumptions involves any great departure from current scientific thought. The possible existence of -dimensional time is a frequent subject of speculation in theoretical circles, and the continual extension of the property of discreteness to more and more physical phenomena, first to matter, then to electricity, then to radiant energy, then (somewhat tentatively) to magnetism, makes the further extension of the same concept to the basic entities, space and time, practically inevitable in the long run, irrespective of the requirements of this present work.

These three postulates constitute the definition of space-time as formulated on the basis of the considerations discussed in the preceding paragraphs. Together with the further assumption that space-time as thus defined is the *sole* constituent of the physical universe, they can be combined into one comprehensive postulate which may be expressed as follows:

> *First fundamental Postulate:* The physical universe is composed entirely of one component, space-time, existing in three dimensions, in discrete units, and in two reciprocal forms, space and time.

In addition to this First Postulate which defines the physical nature of the universe, it will be necessary to make some further assumptions as to its mathematical behavior, in order that we may utilize mathematical processes in developing the consequences of the First Postulate. Until comparatively recently the validity of the mathematical relations which will be assumed in this work was generally considered axiomatic, but it has since been discovered that other more complex and unconventional relations are also theoretically possible, and although the existence of any physical realities corresponding to these unorthodox mathematics has never been definitely verified, these recent inventions are widely employed in present-day physical theory. In setting up a new theory, however, it is obviously advisable to return to the simpler and more manageable concepts of earlier days, unless and until this policy encounters obstacles. We therefore have the

> *Second Fundamental Postulate:* The physical universe conforms to the relations of ordinary commutative mathematics, its magnitudes are absolute and its geometry is Euclidean.

It was demonstrated in the previous work that these postulates are sufficient in themselves, without the aid of any supplementary or subsidiary assumptions, to define a complete theoretical universe, but for present purposes we will confine the discussion to those aspects of the theoretical universe which are relevant to the subject of gravitation and we will limit the development of the consequences of the postulates to those items which are required for a complete understanding of the gravitational relations.

On examination of the Fundamental Postulates it is immediately apparent that they *require* a progression of space-time identical with that which was *assumed* as a basis for the development in Part Two. Let us consider some location A in space-time. When one more unit of time has elapsed this location has progressed to A + 1 in time. According to the First Postulate the one unit of time is equivalent to one unit of space, since the postulate specifies that space and time are reciprocal, hence this location also progresses to A + 1 in space.

It is also evident that the reciprocal postulate requires something beyond this equivalence of the single unit of time and the single unit of space. If this were the extent of the relationship we would postulate that time and space are equivalent; not that they are reciprocal. In order to make the relation reciprocal there must be certain conditions, under which associations of n units of one component exist, in which case the sense of the postulate is that these n units of the one component are equivalent to 1/n units of the other.

Next we will want to know how these associations originate; that is, how it is possible to modify the 1 to 1 ratio of space to time which exists in the general space-time progression. It is evident that such a modification cannot take place in space-time itself, as space and time are equal in any unit of space-time and are therefore equal in any number of units or any succession of units. The modification must be accomplished by some alteration in the factors affecting space or time individually, and in order to permit such an alteration there must be a difference between space (or time) individually and space (or time) as a component of space-time: the capacity in which it participates in the space-time progression. The only such difference for which where is any provision in the postulates is a difference in direction, and we therefore arrive at the conclusion that space-time as such is scalar and that direction is a property of space and time individually.

On this basis, if we replace an individual unit of one component by a multiple unit so that this multiple unit of the one component is associated with a single unit of the other, the direction of the progression of the multiple component must reverse at the end of each unit. Inasmuch as space-time is scalar, this reversal of space direction or time direction means nothing from a space-time standpoint and the regular rate of progression, one unit of space per unit of time, continues just as if there were no reversals. From the standpoint of space and time individually, the progression involves n units of one kind but only one of the other, the latter being traversed repeatedly in opposite directions. It is not necessary to assume any special mechanism for the reversal of direction. In order to meet the requirements of the First Postulate the multiple units must exist, and they can only exist by means of the directional reversals. It follows that these reversals are required by the postulate itself.

Because of the periodic reversal of direction a multiple unit replaces the normal unidirectional space-time progression with a progression which merely oscillates back and forth over the same path. But when the translatory motion in one dimension of space is eliminated, the oscillating unit is confined to a single space unit, and this unit of space then progresses in the normal manner in another dimension, carrying the oscillating unit with it. When viewed from the standpoint of a reference system that does not progress, the combination of an oscillating progression in one dimension and a unidirectional progression in a dimension perpendicular to that of the oscillation takes the form of a sine curve.

Obviously this feature of the theoretical universe defined by the Fundamental Postulates can be identified as *radiation.* Each oscillating unit is a *photon,* and the space-time ratio of the oscillation is the *frequency* of the radiation. Since space-time is scalar the actual spatial direction in which any photon will be emitted is indeterminate, and where a large number of photons originate at the same location the probability principles whose validity was assumed as a part of the Second Fundamental Postulate require that they be distributed equally in all directions. We find, then, that the theoretical universe defined by the postulates includes radiation consisting of photons traveling outward in all directions from various points of emission at a constant velocity of one unit of space per unit of time.

Another possible motion of the oscillating photon is a rotation. Let us consider next the factors involved in rotational motion of these units. Rotation differs from translation only in direction and this difference has no meaning from a space-time standpoint since space-time is scalar. Rotation at unit velocity is therefore indistinguishable from the normal space-time progression: that is, from the physical standpoint it is essentially the equivalent of no rotation at all. In order to produce any physical effects there must be what we will call a *displacement:* a deviation from unity. The deviation is necessarily upward, as fractional units do not exist, and the magnitude of any rotational motion of the photons is therefore greater than that of the space-time progression.

A second necessary characteristic of the rotational motion of the photons is that its direction must be opposite to that of the space-time progression, because any added displacement in the positive direction would result in a directional reversal and would produce a vibration rather than a rotation, as previously explained. This means that when the photon acquires a rotation it travels back along the line of the space-time progression, and since this retrograde motion is greater than that of progression (at unit distance) these rotating units are reversing the pattern of free space-time and are moving inward toward each other, either in space or in time, depending on the direction of the displacement.

For present purposes we will consider only those photons which are moving inward in space. Like the photons that are moving transitionally, the rotating photons of this type which exist in the theoretical universe defined by the Fundamental Postulates are readily correlated with observed physical entities. With the exception of a few that are dimensionally incomplete, they can be identified as atoms. Collectively the atoms constitute *matter,* the inward motion resulting from the rotational velocity *is gravitation,* and the incomplete atoms are *sub-atomic particles.*

At this point, then, it is clear that the two gravitational assumptions of Part Two are necessary and direct consequences of the two Fundamental Postulates; that is, the postulates lead directly to a progression of space-time and to an inherent motion of the atoms of matter in the direction opposite to the progression. All of the conclusions and relations derived from the gravitational assumptions in Part Two can therefore be incorporated en bloc into the theoretical system that is here developed *from* the Fundamental Postulates.

A very significant point about the theory outlined in the foregoing paragraphs is that the same feature of the theory, which leads to the existence of matter--rotation of the oscillating photons in the direction opposite to the space-time progression--also, causes matter to *gravitate.* This is, of course, a major step toward simplification of the basic physical relationships. It brings within the scope of one general theory two important items, which have hitherto required completely separate treatment. But this is by no means the full extent of the unification of the theoretical structure that has been accomplished. The developments in Part Two, which are also part of the new theoretical structure, since the assumptions of Part Two have now been shown to be necessary consequences of the Fundamental Postulates of the Reciprocal System, go on to derive from the *same* initial premises the *major characteristics* of gravitation, the instantaneous action, the absence of a medium and the impossibility of modification, and in addition they explain the *principal deviations* from what we may consider the "normal" pattern of gravitational action in two of the three regions in which such deviations occur. The somewhat abbreviated view of the situation given by the two gravitational assumptions of Part Two was not capable of explaining the deviations in the third of these regions, the region of atomic and molecular interaction, but a more complete development of the consequences of the Fundamental Postulates brings the relationships in this region within the scope of the gravitational theory.

Ordinarily the effect of the space-time progression is to move physical objects farther apart. Any two objects which are initially separated by x units of space-time will be separated by x + *n* units of space after *n* additional units of time have elapsed, as each unit of time is equivalent to a unit of space. However, if there is a space-time displacement of such a nature that the two objects are initially separated by x units of time in association with one unit of space (that is, by the equivalent of less than one unit of space) the result is quite different. In this case the progression takes place entirely within one unit of space and consequently space remains constant at one unit while time is free and progresses in the normal manner. In view of the reciprocal relation between space and time, the increase in time due to the unilateral progression is equivalent to a decrease in space, hence the effect of the progression on two objects initially separated by the equivalent of less than one unit of space is to decrease the equivalent space separation.

At first glance it appears inconsistent for the same space-time progression to move objects farther apart in one region and to move them closer together in another region. As emphasized in the previous publication, however, the seeming inconsistency is due to the use of the wrong datum in evaluating the situation. Because of the equivalence of the unit of space and the unit of time, the initial point of all physical activity is at unity, not at the mathematical zero. When we recognize this fact, the apparent inconsistency disappears. Now the progression always proceeds in the same *natural* direction: away from unity. Above unit distance, away from unity is outward; below unit distance it is inward.

Inasmuch as gravitation, by reason of its inherent nature, always acts in the direction opposite to that of the progression, a similar reversal occurs in the gravitational direction. Above unit distance, the gravitational motion is inward toward unity. Below unit distance it acts in the same natural direction, toward unity, but in this case toward unity is outward. Gravitation therefore exerts a force of attraction between two masses which are initially more than one space unit apart, but it exerts a force of repulsion between two masses which are initially less than the equivalent of one space unit apart.

With the benefit of this information, the nature of the inter-atomic force equilibrium now becomes clear. In the region outside unit distance there can be no equilibrium, as any motion resulting from an unbalanced force accentuates the unbalance. If the inward-directed gravitational force exceeds all outward-directed forces, for example, an inward movement takes place, which strengthens the already dominant gravitational force. In the region inside unit distance, on the other hand, any movement due to an unbalanced force reduces the unbalance and tends toward equilibrium. Here an excess gravitational force causes an outward movement, which weakens that force, and ultimately reduces it to equality with the constant force of the space-time progression, whereupon the motion ceases and the two objects take up equilibrium positions.

This explanation accounts for the existence of cohesion in solids and liquids and thus extends the application of gravitational theory to another major physical field for which a completely separate theoretical structure has hitherto been necessary. With this addition, the scope of the theory now includes the entire range of space intervals from the shortest interatomic distance to the separation between the most distant galaxies.

Throughout this entire immense region, the concept of a progression of space-time outward from unity provides the *additional* effect of a general nature, which is necessary in order to account for various phenomena that have hitherto resisted explanation. Physicists are understandably very reluctant to accept any such idea. It is quite distasteful to be compelled to admit that an unrecognized force of general applicability can still exist after the many centuries that they have devoted to intensive study of physical relations, and consequently they are strongly inclined to close their eyes to the fact that many existing situations are wholly inexplicable unless such a force is effective. But occasionally an admission is encountered in the literature. Gold and Hoyle, for example, tell us candidly, "Attempts to explain both the expansion of the universe and the condensation of galaxies must be very largely contradictory so long as gravitation is the only force field under consideration. For if the expansive kinetic energy of matter is adequate to give universal expansion against the gravitational field it is adequate to prevent local condensation under gravity, and vice versa. That is why, essentially, the formation of galaxies is passed over with little comment fin most systems of cosmology.[40]

The analogous problem of the globular clusters is "passed over" with even less comment. Examination of one after another of the available textbooks and dissertations on astronomy gives us no indication that there is any difficulty in accounting for the existence of these numerous and conspicuous objects. But if we search diligently through the astronomical journals we will find a few papers in which attempts have been made to analyze this problem, and almost invariably these papers begin with an admission such as the following from E. Finlay-Freundlich: "All attempts to explain the existence of isolated globular star clusters in the vicinity of the galaxy have hitherto failed."[41]

Here again the difficulty arises from the fact that at least *two* forces are required in order to explain the existing situation, whereas the astronomers have only one force to work with. "Their structure must be determined solely by the gravitational field set up by the stars which constitute such a cluster," says

Freundlich, and he goes on to admit that on this basis, "The main problem presented by the globular star clusters is their very existence as finite systems..." In view of the absence of any evidence of rapid rotation, the only theory which the astronomers have been able to produce is that the behavior of the stars in the cluster is analogous to that of the molecules in a gas. "But the analogy is useless," says R. v. d. R. Woolley, the Astronomer Royal, "unless collisions among the stars are sufficient to set up equipartition of energy, and not very valuable unless the mean free path for stellar encounters is small compared with the dimensions of the stellar aggregation considered. Calculation shows that the mean free path is probably large compared with the effective diameter of a cluster, so that in clusters the analogy with a gas is an idea that cannot be pushed very far."[42]

All that we actually know about these clusters indicates that they are very stable structures and have probably existed in approximately their present forms for billions of years. This implies that they are in a state of equilibrium: a condition that existing theory cannot explain. Both Woolley and Freundlich concede that an isothermal equilibrium similar to that, which would be the final result in a gaseous system, would involve dispersion of the cluster. "The isothermal gas sphere' is not a finite object," Wooliey admits. Those astronomers who attempt to approach this problem are thus forced either to assume that the clusters are not in equilibrium. In the face of the observational evidence indicating that they are among the most stable and permanent of all astronomical objects, or else to modify the gas relations in an arbitrary and *ad hoc* manner, which destroys the cogency of the argument in favor of using the gas analogy.

Resort to such tactics is not necessary in the theoretical universe of the Reciprocal System, as this system provides the additional force that is necessary for equilibrium. Here each individual star (or multiple star system) is outside the gravitational limits of its neighbors and hence is moving away from them because of the space-time progression. At the same time, however, the gravitational effect of the cluster as a whole is pulling the individual stars in toward the center of the cluster. The net effect is equilibrium between these opposing motions (or forces).

When we turn to the inter-atomic situation, we find essentially the same thing. Here again the gravitational force and the postulated electrical force of attraction between the atoms are not sufficient to account for the equilibrium that actually exists, but the complete inadequacy of the currently accepted theories in this particular respect is simply ignored by all but a very few of the physicists. One of the few authors that has recognized and conceded the true nature of this problem is Karl Darrow, who examined the whole situation in 1942 in an article entitled *Forces and Atoms.*[43] Darrow points out that both gravitation and the electrical force of cohesion (the existence of which he assumes, in accordance with current theory) are forces of attraction, and in order to produce an equilibrium there must be a third force: an "antagonist" to the attractive forces. "This essential and powerful force has no name of its own," Darrow explains, "This is because it is usually described in words not conveying directly the notion of force." By this means the physicist "manages to avoid the question."

Darrow concludes his discussion of the problem with the comment, "This combination of a short-range attraction with a repulsion still shorter in range cries out for explanation. Could one but somehow reduce it all to inverse-square forces, one would be more contented." This comment is particularly apropos at the moment, since what the Reciprocal System has accomplished is essentially what Darrow envisions: a reduction of the whole problem to equilibrium between an inverse-square force and a force of constant magnitude. In this system the constant space-time progression provides the inward force that is responsible for cohesion, while the gravitational force, reversed at the unit level, is the "antagonist" that accounts for the equilibrium.

The validity of this definition of the inter-atomic force system can be verified by an examination of the response of the system to external forces impressed upon it; that is, by a study of solid and liquid compressibility's. A comprehensive study of this kind has been carried out in connection with the investigation on which this present work is based, and it is planned to include a summary of the results in a new and more complete edition of *The Structure of the Physical Universe* to be published in the near future. This data will show that the theoretical compressions derived from the equations of the Reciprocal System are in agreement with the measured values, within the probable experimental error, over the entire range of the experimental work, up to 100,000 atm.. static pressure and to several million atmospheres by the recently developed shock wave techniques.

In our ordinary experience space and time appear to be altogether different in character. Space is the kind of a phenomenon that we intuitively feel that we can understand: a well-behaved entity with a comfortable sort of permanence that makes observation and measurement relatively simple. It is true that there are some basic philosophical questions concerning its ultimate nature that have been controversial issues ever since man first began to speculate about such subjects, but nevertheless space can be broadly classified as one of the more familiar features of our physical universe.

On the other hand, time has always been mysterious and elusive. It undoubtedly exists; there is certainly something that distinguishes the present from the past and from the future, and there is certainly some physical meaning attached to the symbol t that enters into so many of the mathematical expressions that we; use for the purpose of expressing physical relationships. But when we attempt to be more specific and to develop a more tangible concept to replace these rather hazy ideas, we encounter some extraordinary difficulties. We have not even been able to devise any direct measurement of time; the best we can do is to select some type of periodic motion and to assume that successive coincidences of identifiable spatial points connected with this motion distinguish intervals of time.

The most striking and prominent feature of time, as we observe it, is the continuous flow or progression. This is, in fact, just about *all* that we know about time. The most prominent feature of space is its extension in three dimensions. According to the Fundamental Postulates of the Reciprocal System, however, space and time are absolutely symmetrical and all of the properties now observed in either space or time individually are actually applicable to both. On the basis of this new viewpoint the great dissimilarity in the observed characteristics of the two entities is not due to any real difference between the two, but is a result of the gravitational motion of matter in the direction opposite to that of the space-time progression. This oppositely directed motion in space cancels the effect of the space progression in the local region and the results of the progression are visible only at the extreme range of our giant telescopes. The existence of this phenomenon has therefore remained unrecognized.

In our observations of time we recognize the progression but not the three-dimensional extension. A modification of the normal space-time ratio by substitution of an association of units for a single unit of one of the components produces a motion either in space or in time, but not in both. The inherent motion of matter is in space (because it is the units whose motion is in space that we call matter) and so far as matter is concerned, the progression of time continues as in free space. Since the velocity of the progression is so high, 186,000 miles per second, the differences in time location comparable to the differences, which we observe in spatial location, are, in most instances, relatively minor, and they are so over-shadowed by the progression that their true nature has not been perceived. Here again, there actually is a noticeable effect under extreme conditions (motion at very high velocities) but it has not hitherto been realized that this discrepancy is chargeable to a misconception of the properties of time.

As an aid in visualizing this situation, let us consider the motion of a distant galaxy. In the constellation Hydra there is a faint galaxy which, according to the red shift in its spectrum, is receding from us at a velocity of over 35,000 miles per second, one-fifth of the velocity of light. So far as we are able to determine t his galaxy is moving directly away from our location and, except for the somewhat lower velocity, the recession of this and other distant galaxies has exactly the same characteristics as the progression of time: that is, it is a scalar motion which always proceeds in the same direction: linearly outward. According to the findings of this work, this galactic recession not only *appears* similar to the progression of time; it actually is the same kind of a phenomenon. It is the space equivalent of the time progression. The only reason why the galactic velocity is lower than that of light is that the Hydra galaxy, in spite of the enormous distance which separates it from our location in space, is still close enough to be subject to a small gravitational effect. At greater distances there undoubtedly are galaxies which are receding from us at practically the full velocity of light.

In Fig. 2 the Hydra galaxy was at point A at time to. During a time interval t the recession carries it from point A to point B. The intervening distance AB is the space equivalent of a time interval resulting from the constant progression of time, and since we refer to the latter as *clock time*, we may utilize the same terminology and call the distance AB the *clock space.* From our far distant location, this movement from A to B in clock space is the only movement of the Hydra galaxy that we can distinguish, but we know from observation of less distant galaxies that these galactic aggregations also have random motions in space, and we can therefore deduce that the Hydra galaxy will not actually be found at point B when t units of clock time have elapsed; it will be found at some other point C. The random motions of the galaxies are not restricted to the dimension of the recession; that is, the distance BC, which represents the random motion during time t is not necessarily a prolongation of AB, but may have any direction in three-dimensional space. The total distance traveled by the Hydra galaxy during time t is therefore the vector resultant of the clock distance AB and the distance BC due to the random motion, the latter being a distance in the familiar three-dimensional space of our everyday experience. In order to distinguish this kind of space from the clock space, we may call it *coordinate space*, since we usually define it by means of some coordinate system. Summarizing the foregoing, we may say that the total space traversed by the Hydra galaxy in any specified interval of clock time consists of two separate components: the *clock space,* which is the distance covered by the galactic recession (the progression of space) and the *coordinate space,* which is the distance covered in three-dimensional space by the random motion of the galaxy. Inasmuch as there is no reason to believe that this particular galaxy is

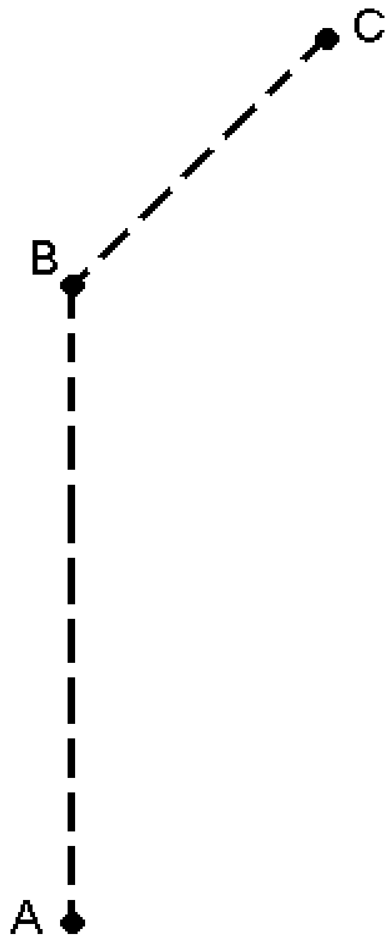

Fig 2.

exceptional or privileged in this respect, we may apply the same conclusion to *all* galaxies, including our own. In the case of the far distant galaxies, such as Hydra, we can detect only the motion in clock space; in observation of our own or other galaxies of our local group the motion in clock space is masked by the gravitational motion, and we see only the motion in coordinate space. But it is clear that these are merely observational deficiencies; the two separate components exist in all cases whether we can detect them or not.

In view of the reciprocal relation between space and time it is evident that exactly the same conclusions apply to time. The total time interval in any physical situation includes not only the *clock time* due to the constant time progression, a one-dimensional movement analogous to the galactic recession, but also another component, the *coordinate time,* due to random movement in three-dimensional time. Normally we detect only the clock time because the coordinate time component is negligible (relatively), but under extreme conditions, such as very high velocities, the coordinate time may be quite significant. As in the analogous case of the receding galaxy, the actual point c in time occupied by an object at a particular stage of the progression is something other than the clock time b, and since many values of c may correspond to the same value of b, the true time interval cannot be expressed in terms of the clock system of reference (that is, in clock time) except in certain special cases, such as that in which b and c are practically coincident (which is true at low velocities) or where the local motion follows a pattern of a restricted type, such as uniform transnational velocity.

This is the basic error in all previous theories of motion. All theories that have enjoyed any substantial degree of support have assumed a one-dimensional, one-valued time. "...we shall assume without examination... the unidirectional, one-valued, one-dimensional character of the time continuum,"[43]44 says Tolman. But this is clock time, not the total time that actually enters into physical processes.

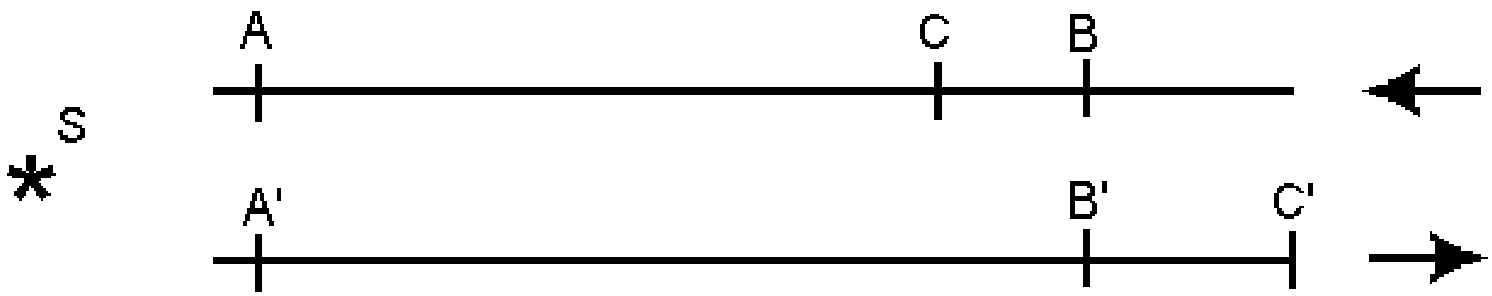

Fig. 3

Newton's Laws of Motion are based on the primitive concepts of space and time: a three-dimensional Euclidean space (coordinate space) and a one-dimensional time progressing uniformly and having the same value at all points in space at each stage of the progression (clock time). For two hundred years these laws met every test, with nothing more than minor discrepancies which were not regarded very seriously. Then in 1887 the Michelson-Morley experiment shattered the foundations of Newton's structure. Fig. 3, adapted from Tolman,[43]45 shows the nature of the problem introduced by the results of this experiment. Let us assume that a ray of light from a distant source S passes from A to B and from A' to B' in two parallel systems. Then let us assume that the systems AB and APB' are in motion in opposite directions as shown, and are in coincidence as the light ray passes A and A'. Because of the motions of the respective systems, point B will have moved to some point C closer to A by the time the light reaches it, whereas B' will have moved to some more distant point C'.

Yet if the results of the Michelson-Morley experiment are to be believed, the velocity of the incoming ray at C is identical with the velocity of the incoming ray at C'; that is, the velocity of light is independent of the reference system. As Tolman expresses it, the time required for the light to pass from A to C measures the same, as the time required to pass from A 'to C': a conclusion which, as he says, is "in direct opposition to the requirements of so-called common sense."[45]

This comment by Tolman shows very clearly just where and how the thinking of the scientific profession was diverted into the wrong channels. In reality the Michelson-Morley experiment does *not* indicate that the *time* ac is equivalent to the time a'c'; it merely shows that the *velocity* of light over the path AC is the same as the velocity over the path A'C'. The further conclusion that the two times are equivalent is not an experimental finding; it is an *interpretation* of the experimental findings in the light of the currently popular assumption as to the nature of time.

It is evident from the points brought out in the preceding paragraphs that we do not need to abandon common sense to explain this situation; all that we need to do is to get a broader view of time which will encompass all of its properties, not just the progression. The correct explanation of Tolman's diagram is that points A and B are not only separated by the coordinate distance AB; they are also separated by an equal amount of coordinate time, since each unit of space, according to the Fundamental Postulates, is equivalent to a unit of time. The movement of point B to location C not only reduces the space separation between the original location of A and the new location of B by the; amount of coordinate space BC, but also reduces the time separation by bc, the same amount of coordinate time. If the velocity of the system AB is relatively low, as most velocities are in the world of our everyday experience, the time bc is negligible in comparison with the time of the progression, but if the velocity is great enough to make it necessary to take the *distance* BC into account, then we must also take the equivalent time be into account. The Newtonian concept of time in conjunction with the results of the Michelson-Morley experiment leads to the relation AC/t = A'C'/t, which is absurd, as Tolrman tells us. But when we realize that the motion which reduces the distance from AB to AC also reduces the time from ab to ac, the relation of the velocities in the two systems becomes AC/ac = A'C'/a'c' which is fully in accord with both common sense and common mathematics.

The extreme condition is illustrated in Fig. 4. Here two light photons leave point O simultaneously and travel in opposite directions. Photon a moves one unit of space OA in one unit of time. Photon b moves one unit of space OB in one unit of time. (The system of space and time units is immaterial. Irrespective of the conventional units employed, we reduce them to the same proportionality by defining the velocity of light as unit velocity.) According to Newton, the relative velocity of the two photons is then 2/1 = 2, since the space separation at the end of one unit of time is AB, or two space units. But the experimental results show that the velocity of light is independent of the system of reference, and that the relative velocity is actually one unit, not two. Newton's system therefore gives us the wrong answer.

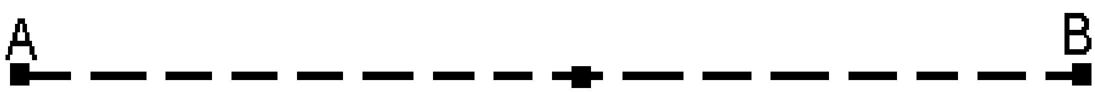

Fig. 4

Einstein met the situation by abandoning the concept of absolute space and time magnitudes and accepting the hypothesis, originally advanced by Fitzgerald, that space contracts in the direction of motion. On this basis the distance AB no longer has the value 2, as it does in Newton's system. The constant velocity of light is accepted as a fundamental property of nature, and it is assumed that the distance AB is automatically reduced to whatever value is necessary in order to make the quotient s/t equal to this constant velocity, generally represented by the symbol c or, as in the present discussion, defined as unit velocity. In the Einstein system the equation of motion for Fig. 4 becomes s/1 = 1, where s is arbitrary, or more generally s/t = 1, where both s and t are arbitrary, as for some purposes, at least, it becomes necessary to assume a dilatation of time as well as a contraction of space.

Einstein's concept of space as a purely relative magnitude, varying according to the location and velocity of the observer, is incompatible with the somewhat intuitive ideas synthesized from everyday experience and generally described by the term "common sense." The scientists of the early twentieth century were therefore very reluctant to accept it, but Newton's system, with its absolute time and space, had been invalidated by the experimental demonstration of the constant velocity of light, and since no plausible alternative was proposed (other than some variations of the Relativity Theory itself) this concept of a "rubber yardstick" won acceptance by default. A factor that contributed greatly to this acceptance was that the principal obstacle standing in its way, the prejudice against violation of common sense principles, was undermined by the fact that the experimental results appeared to be, as Tolman remarked in the statement previously quoted, "in direct opposition to the requirements of so-called common sense." Obviously if the facts themselves are in conflict with common sense, it is no longer consistent to demand that theory stay within common sense boundaries.

With the benefit of the information that has been developed in this work, however, it is clear that Einstein's drastic step in abandoning absolute space and time was neither necessary nor justifiable. Both Newton and Einstein failed to recognize that there are two components of physical time and both set up their theories on the assumption that we are dealing only with clock time. On this assumption the time required by photon a to travel from O to A is the *same* unit of time as the time required by photon b in traveling from O to B. But the unit of distance is separate and distance from the unit OA and since two separate units of distance are traversed by the photons, the equivalence of the individual units of space and time postulated in this work requires the corresponding units of time to be separate and distinct. In other words, when the photons are at points A and B respectively and are separated by two units of space they are also separated by two units of time. The equation of motion is then 2/2 = 1, which is completely in accord with the results of the experiments.

It is now apparent that Tolman misunderstood the nature of the message, which the Michelson-Morley experiment was trying to convey (as did Tolman's colleagues, including Einstein. Tolman's work is being used for purposes of illustration merely because it is a particularly clear presentation of the currently accepted viewpoint). The results of this experiment do not, as Tolman asserts, require us to contradict the "requirements of common sense" and accept the time elapsed between A' and C' as being the same as that between A and C. What these results actually tell us, if we read their message correctly, is that the concept of time which leads to this absurd conclusion, the concept that has hitherto been universally accepted, is wrong.

This orthodox concept of time is based on a narrow view which recognizes only one of its aspects, the progression, whereas the preceding pages have shown that a theoretical analysis of the situation, supported by observations of the motions of the distant galaxies and by the observed properties of radiation, leads to the conclusion that time also possesses all of the attributes that are recognized in space. When it is thus realized that space and time are completely symmetrical, it becomes apparent that all of the magnitudes applicable to time are commensurate with the corresponding magnitudes applicable to space. The individual locations are not necessarily coincident. In Fig. 3. for example, the time locations a, b and c, which now correspond to space locations A, B and C respectively, may be changed to d, e and f as a result of the progression of time, but the new time separation de then corresponding to the space separation AB will still be equal to AB and also to ate. This simplifies the problem of measurement of the time separation very materially, since we can readily measure the coordinate space separation between any two accessible objects, and this value, when expressed in appropriate units, is also the coordinate time separation between these objects.

Both the complexities and the limitations of Einstein's Relativity Theory arise from the fact that he was unable to see the broad picture and attempted to describe all physical events in terms of clock time only. As indicated in the preceding discussion, a revision of the basic concepts to take *all* of the properties of space and time into account eliminates the necessity for any arbitrary manipulation either of the mathematical relationships or the physical magnitudes. Everything then falls into line easily and naturally without any kind of artificial maneuvering or any conflict with common sense.

One of the most significant features of the Reciprocal System is that it is a purely theoretical construct. All of its elements are sharply and positively defined because they are derived from pure theory and have no empirical content (even though the theory itself was derived by inductive reasoning from empirical premises). This system is therefore completely untouched by most of the uncertainties and ambiguities that have troubled conscientious critics of previous theories. Bridgman points out; for example, that Relativity Theory is based in the first instance on the assumption of the existence of some kind of a physical framework defined by means of rigid measuring rods and clocks. But, as he says, there is no "very articulate analysis" of what is meant by "rigid," and he continues, "The specification of what is meant by a clock is usually even less articulate, and has been felt to be a matter of much difficulty by a number of critics... in practice it almost appears as though the only criterion for a clock is whether it functions in the way that the equations demand that a clock function."[45] [46]

Similar considerations apply to all of the concepts entering into physical theory, and a recognition of this situation has led to the emergence of the "operational" point of view, the adherents of which contend that physical concepts should be defined solely in terms of the operations by which they will be detected and measured. This is, of course, impossible for such elementary concepts as those of clocks and measuring rods, but once these basic elements have been defined, the methods by which they are utilized in observing and measuring other more complex entities can be used as bases for the physical definition of those entities. Such reasoning, applied to the concept of simultaneity, played a major role in Einstein's development of the Theory of Relativity and it has exerted a significant influence on modern physical theory as a whole.

Questions of this kind do not arise in the Reciprocal System. The universe developed from the Fundamental Postulates of this system is purely theoretical and any concept such as that of a clock can be specifically defined on a strictly theoretical basis. By means of the same structure of theory the kind of a physical entity that can qualify as a clock under this definition can also be specified unambiguously. Up to this point it is not necessary to take the actual physical world into consideration in any way, but once we have arrived at a conclusion which, for example, might be that any body in uniform rotational motion constitutes a clock, the next move is to examine the physical universe to determine whether or not we can identify any body in uniform rotational motion. If we can find such an entity, then we have a clock. In following this procedure we have actually used, on a rigidly correct theoretical basis, the practical criterion described by Bridgman; that is, we say that a rotating body is a clock because it functions in the way that a clock theoretically should function. If it functions *exactly* according to the theoretical requirements, then it is an *accurate* clock.

This is the same procedure that we apply to all physical phenomena when we utilize the Reciprocal System. We first determine what sort of thing should exist in the theoretical universe and then we look to see if we can find an entity in the observed physical universe, which conforms to the theoretical description. For instance, we do not put gravitation into our theoretical universe because we know that it exists in the real physical universe. We put *nothing* into the theoretical universe but the Fundamental Postulates, and gravitation is there only because its existence is a necessary and unavoidable consequence of those postulates. Similarly, the properties, which are attributed to gravitation in the theoretical universe, do not depend in any way on the properties that we find by observation of the physical phenomenon of gravitation; these theoretical properties are also necessary consequences of the postulates.

Of course, the theoretical development gives us no names; it simply gives us a description of the various components of the theoretical universe and, unless we wish to coin some new names for the theoretical entities, which would be confusing and would serve no useful purpose, we have to locate the physical entity corresponding to the theoretical description in each case before we arrive at a name. The theory merely tells us, for example, that a certain phenomenon exists in which oscillating units, with various frequencies of oscillation, originate at different points in space and travel away from these points in all directions at a constant velocity. When we turn to the actual physical universe, we find that a phenomenon with exactly the same characteristics also exists there. We are then justified in concluding that this physical phenomenon, which we call radiation, is the physical equivalent of the theoretical phenomenon deduced from the Fundamental Postulates, and we therefore apply the name "radiation" to both.

When we have thus identified a physical entity with its theoretical equivalent, we can carry over into the physical field all of the properties and relationships applying to the corresponding theoretical entity, irrespective of whether or not the available observational data are adequate for a physical verification of all of the theoretical conclusions. In the case of gravitation, for instance, we can confidently assert that the gravitational effect is instantaneous, because it is necessarily instantaneous in the theoretical universe, even though this point is contested by most theoretical physicists, including Einstein, not because of any evidence to the contrary, but because it is inconsistent with their theories.

In asserting that the gravitational effect is instantaneous, the Reciprocal System does not arrive at any *new* conclusion; it merely takes a position on one side of a long-standing controversy, but we are equally justified in going still farther and applying to the physical universe other features of the theoretical universe defined by this system which are completely new and in some cases totally foreign to current thinking. The reversal of direction of gravitation at unit distance is an item of this kind. Here is something that has never even been suspected, and which does not fit in very well with orthodox lines of thought. It will consequently meet with much resistance, but there is no logical or factual basis on which it can be rejected, since it is not inconsistent with any known fact, while on the affirmative side there is the very powerful argument that the explanation of the cohesion of solids provided by this gravitational reversal enables the inter-atomic distances in solids, and the changes in these distances under pressure, to be accurately calculated from pure theory.

This is the kind of a place where the immense advantage of a theory that is both *complete* and *correct* makes itself manifest. All that we know about solid and liquid cohesion form observation and experiment is that there must be two forces involved in the inter-atomic equilibrium: a force of attraction that holds the atoms together in the two condensed states, and a force of repulsion that limits the closeness of approach. (This is equally true whether or not the atoms are in contact. If they are in contact there must still be a force within the atom resisting deformation.) It does not appear likely that any more detailed information about these forces will be obtained from observation without some fairly specific clue as to what to look for, and in order to find such a clue we must first formulate a theory of the inter-atomic force system.

Heretofore there has been no available source of such a theory other than pure invention, and it is painfully obvious that the theorists' inventive capacity has been completely inadequate for this task. There is no doubt as to the existence of the repulsive force. If we apply external pressure to a solid or liquid aggregate, the atoms move closer together, and as they do so the resistance to the compression increases as a function of the displacement from the original equilibrium positions--up to the experimental limits of several million atmospheres, at least--but, as Darrow pointed out in the article previously quoted,93 the physicists have not even *attempted* to construct a theory which would account for anything other than the for ce of attraction. They have simply "managed to avoid the question" of the "essential and powerful force" that plays the role of an "antagonist" to the attractive force. A hypothesis which makes no attempt to account for more than one of the two participants in an equilibrium certainly cannot claim to be an explanation of the phenomenon in question, and present-day science therefore has nothing that can be legitimately called a theory of the inter-atomic forces.

In such a case, where the information obtainable from direct observation of the phenomenon itself is too meager to point the way to an adequate theory, there is an alternative possibility: the theoretical principles governing the situation may be deduced from relationships previously established in collateral fields. This is where the necessity for a complete and correct theory arises. An incomplete and approximate theory may be of considerable value in the field to which it is directly applicable, but it seldom accomplishes anything of any consequence outside of that field. Even the gravitational theory based on the two assumptions of Part Two, which is actually correct, as far as it goes gives us no help at all with the inter-atomic problem. But when these two gravitational assumptions are traced back to their source in the Fundamental Postulates of the Reciprocal System, and the further consequences of these postulates are developed in detail, we can obtain a complete and comprehensive picture of the interatomic forces in all of their manifestations and the acute questions concerning the nature of solid and liquid cohesion, including the identification of both the attractive and the repulsive forces, are answered as a part of the clarification of the general situation.

In the present state of physical knowledge it is not at all likely that a hypothesis such as that of a "natural" direction of gravitation-- always toward unity--would ever be formulated *ad hoc;* there is nothing elsewhere in the physical universe to suggest anything of this kind. On the other hand, when it develops that this constant direction toward unity, which involves a reversal of the gravitational force at unit distance, is a necessary and unavoidable consequence of principles firmly established in other fields, and on applying this conclusion to the cohesion problem we find that it accounts for the observed facts both qualitatively and quantitatively, it is in order to conclude that this hypothesis is a correct statement of the true physical situation. Throughout the many fields, which have thus far been covered in developing the details of the theoretical universe of the Reciprocal System, similar cases have been encountered frequently. In each of these instances the solution of a difficult problem of long standing was found to require some conceptual innovation or reversal of a habitual trend of thinking which by itself was almost inconceivable, yet proved to be fully in accord with the known facts when a careful and critical examination was finally undertaken because the need for such an innovation was established in the course of the development of the Reciprocal System.

Part Four
The Opposition

"The history of theoretical physics," says Jeans, "is a record of the clothing of mathematical formulae which were right, or very nearly right, with physical interpretations which were often very badly wrong."[47] The Special Theory of Relativity adds another page of the same kind of history. In essence this theory is simply a mathematical system of compensating for the error introduced into relations at high velocities by the failure to recognize the existence of coordinate time. It can easily be seen that a *generally applicable* mathematical scheme of this kind is impossible, since no conceivable mathematical system can accurately describe a three-dimensional relationship in one-dimensional terms. If we limit the field of application to unidirectional transnational velocities, however, we are dealing with only one of the three dimensions of coordinate time, and in this special situation a mathematical compensation for the conceptual error is possible. The Einstein theory is an ingenious and carefully developed system of this nature and in relatively simple applications it gives consistently accurate results, but because of its inherent limitations it quickly runs into complications as soon as it attempts to go beyond these simple applications.

In spite of its shortcomings, Relativity Theory has been the accepted physical doctrine in its field for more than a half century and consequently any new theory that is presented must indicate where and to what extent it differs from Relativity, as a matter of facilitating tile task of grasping the content of the new theoretical structure, if for no other reason. A general picture of this situation can be obtained by considering first, the postulates on which Relativity is based, and second, the experimental and observational evidence which is offered in support of the theory.

Relativity theory utilizes many principles and relations drawn from the general body of physical knowledge. Except in the one case of the basic concept of the nature of time, there is no point of conflict in this area, and a discussion of these items will not be necessary in the present connection. In addition, the theory sets up four postulates of its own. Two of these appear in the Special Theory: (1) a denial of the existence of absolute velocity, and (2) the constant velocity of light. The General Theory adds two more: (3) the equivalence of gravitational and inertial mass, and (4) the so-called postulate of "covariance."

The constant velocity of light is a necessary and direct consequence of the Fundamental Postulates of this present work. The same is true of the equivalence of gravitational and inertial mass. The Reciprocal System is therefore in full agreement with the Relativity Theory so far as postulates (2) and (3) are concerned. Furthermore, there is no definite disagreement concerning postulate (4). It is true that the implications of the Reciprocal System tend to reinforce the opinions of those who doubt whether there is any actual meaning in this postulate. Bridgman claims that "any assumed law of nature whatever can be expressed in covariant form,"[48] and states that this was admitted by Einstein in 1918. Bondi brings out the same point very forcibly: "Thus whereas the special principle has physical content, the general principle is void of all physical meaning and is merely a mathematical challenge, a challenge to the ingenuity of mathematicians to find the same form for the laws of nature in all systems of coordinates, however different the content of these laws might be. Given sufficient high ingenuity on the part of the mathematician the principle places no restriction whatever oil the laws."[49] But in any event, whatever physical significance the postulate does have in the Relativity Theory, if any, is equally valid in the Reciprocal System; indeed, the problem of maintaining the "form-invariance' is less acute in the new system as the theory itself and the mathematical expression thereof are both much simpler.

The area of disagreement between the Reciprocal System and the Relativity Theory, so far as the basic assumptions are concerned, therefore reduces to the difference in the respective concepts of the nature of time, and to a question as to the validity of postulate (1): the denial of the existence of absolute motion.

In setting up his Special Theory of 1905, Einstein took as his starting point the experimentally established constancy of the velocity of light, and expressed this as a postulate: a law of nature which we must accept, however strange and illogical it may seem in the light of preexisting thought. This immediately led to a direct conflict with the definition of velocity as s/t, space traversed divided by elapsed time, but Einstein found that the discrepancy, in the special case of uniform translational velocities, is a function of the velocity. He therefore deduced that the correct *mathematical* results could be obtained by denying the existence of absolute space and time and eliminating the discrepancy through an appropriate modification of the numerical values of the space and time terms.

This First Postulate which denies the existence of absolute motion, together with absolute space and time magnitudes, and thereby gives the Relativity Theory its name, is a purely negative proposition. It is sometimes stated in a positive manner; that is, the assertion is made that motion is relative rather than that it is not absolute. But absolute motion is also relative to any reference system which we may wish to set up, and the relativity assertion is therefore meaningless unless it is intended to signify that motion is relative *only,* which is just another way of saying that it is not absolute. As a negative proposition, this postulate cannot contribute anything positive to the theoretical structure. Herbert Dingle says flatly, "The principle of relativity in itself tells us nothing whatever about anything..."[50] It merely serves the purpose of evading the contradiction which would otherwise exist, and it is somewhat analogous to the legal principle that prevents a wife from testifying against her husband. This prohibition does not strengthen the husband's affirmative case in the least, but it may be extremely important in blocking the opposition. So it is with the First Postulate. When this postulate has eliminated the necessity of conforming to the space and time magnitudes determined by measurement, the way is left clear for the mathematical manipulation that is necessary in order to force an agreement with the constant velocity of light.

The First Postulate of Relativity is incompatible with the Reciprocal System described herein, as all physical magnitudes in this system are absolute, but as long as the only accomplishment of the postulate is to evade a contradiction, the new system arrives at exactly the same result without the postulate, since no contradiction develops in this system; the absolute space and time magnitudes on the new basis are in full agreement with the observed constant velocity of light.

We thus find that the Reciprocal System is in agreement with three of the four basic postulates of the Relativity Theory and it achieves the same results without the remaining postulate that Relativity Theory does with it. It is therefore appropriate to conclude that if these four postulates correctly represent the content of the theory, as Tolman and many others contend, any results which can *legitimately* be derived from the Relativity Theory will also be reached by the Reciprocal System. Other conclusions which result from attempts to apply the mathematical methods of Relativity to areas outside of their scope of applicability (that is, to areas in which the error due to the use of clock time rather than total time is not a function of the velocity alone) or which result from inferences drawn from the language in which the postulates are expressed will not be in agreement with the results obtained from the new system.

In this connection, it should be noted that there is no observational evidence to support the First Postulate, the only one of the basic postulates of the Relativity Theory with which the Reciprocal System is in conflict, whereas there *is* evidence that tends to contradict it. It is true that all attempts to measure a translatory velocity relative to a hypothetical ether or to the general framework of space have failed, but this does not necessarily mean that absolute motion does not exist; it is equally consistent with the hypothesis that such motion exists but our present facilities are incapable of detecting it. Heisenberg views the situation in this manner: "This is sometimes stated by saying that the idea of absolute space has been abandoned. But such a statement has to be accepted with great caution... The equations of motion for material bodies or fields still take a different form in a 'normal' system of reference from another one which rotates or is in a nonuniform motion with respect to the 'normal' one."[51] Bergmann expresses the same thought: "It. appears as if general relativity contained within itself the seeds of its own conceptual destruction, because we can construct 'preferred' coordinate systems."[52]

The most that can legitimately be contended, therefore, is that the experimental evidence leaves the question of the existence of absolute translational motion open. As indicated in the foregoing statements, absolute rotational motion *can* be detected. It is possible, for instance, to determine that the galaxies are rotating and even to get a rough idea as to the magnitude of the rotational velocity in each case simply by looking at them. All attempts that have been made to reconcile these facts with the First Postulate have been extremely awkward and far-fetched. In the words of Eddington, "We see at once that a relativity theory of translation is on a different footing from a relativity theory of rotation. The duty of the former is to explain facts; the duty of the latter is to explain away facts."[53]

The inapplicability of the First Postulate to rotational motion not only invalidates its claim to the status of a *general* physical principle; hut also creates a strong doubt as to its applicability to translational motion. The existence of absolute rotational motion and "preferred coordinate systems" strongly suggests that absolute translational motion also exists, since rotational and translational motion are interconnectertible, and it is rather difficult to accept the idea that absolute motion can be converted to motion which has no absolute magnitude. It is, in fact, just this point that has made the proponents of the Relativity Theory so desperate in their attempt to "explain away" the physical evidence of absolute rotation.

The findings of this present work make these considerations somewhat academic, however, as these findings not only eliminate the *reason for questioning* the existence of absolute motion, but also indicated that absolute translational motion *can* be detected and measured. We cannot regard our usual measurements relative to the earth as absolute, since we know that the earth revolves around the sun; we cannot regard measurements relative to the sun or the solar system as absolute, since we know that the sun takes part in the rotation of the galaxy; we cannot regard measurements relative to the galactic center or to the galaxy as absolute, since we know that the galaxies have random motions of their own and are also receding from each other. Up to now there has also been the possibility that the galaxies are in motion as component parts of some larger unit. An extensive development of the consequences of the Fundamental Postulates of the Reciprocal System indicates, how ever, that the galaxy constitutes the maximum aggregation of matter, the so-called clusters of galaxies being merely temporary associations of no major significance which will ultimately disappear either by dispersion or by agglomeration. An absolute system of reference can therefore be obtained by correcting the galactic positions for the effects of the recession and the random movements of the individual galaxies. Such a system constitutes the general spatial framework of our physical universe and since we know only one universe, motion relative to this general framework is absolute motion. The principal problem involved in establishing this absolute system of reference lies in evaluating the random movements, as the correction for the recession due to the space-time progression is a straightforward operation, but available statistical methods should he adequate for this purpose.

The ultimate test of the validity of any physical theory is agreement with the results of observation, and measurement. An actual *proof* of validity is, however, extremely difficult to achieve. In order to constitute a proof, the correlation between theory and observation must be comprehensive enough to reduce the possibility of a hidden conflict somewhere in the system to the point where it is negligible and, as previously pointed out, this means that there must be an exact correspondence in a large number of cases throughout the area affected, without exception, and without the use of contrived methods of evading contradictions or inconsistencies.

Because of the extraordinary difficulties that stand in the way of achieving a valid proof, it is necessary to relax the standards to some extent for practical purposes and to accept on a provisional basis a great many laws and principles which are far from qualifying as established truths under any reasonably rigid standards. Strictly speaking, such principles should be recognized as merely tentative, and in referring to them the words "We think..." should be used rather than "We know..." but the human mind is reluctant to admit ignorance and there is a very general tendency to regard today's best guess as the equivalent of established fact. The individual who is firmly convinced of the truth of the currently accepted doctrines in his field is inclined to take at face value anything which tends to reinforce the position to which he is committed, but to be very critical of anything to the contrary. As a result, the meaning of the word "proof" is badly distorted in current usage.

One very common practice, for instance, is to present evidence in favor of some particular portion of a theory as proof of the validity of the theory as a whole. A great deal of publicity has recently been given to some new "proofs" of the Relativity Theory that have been made possible by modern technological developments. One of the most significant of the recent experiments of this kind was carried out at Columbia University by C. H. Townes and associates; another at Harvard University by R. V. Pound and G. A. Rebka, Jr. The results of this work were immediately reported in the news journals of the scientific world with headlines such as "Year-Long Tests Confirm Einstein's Theory," followed by unequivocal statements that these tests "have confirmed... that Einstein's special theory of relativity is correct."[54] But when we look behind the facade to see just what was actually accomplished, we find that the Columbia group simply produced some additional verification of *one of the postulates* of the Relativity Theory: the constant velocity of light, whereas the Harvard investigators verified *another of the postulates:* the equivalence of gravitational and inertial mass.

To the extent that this additional evidence constitutes proof of anything, it is proof of these two postulates, not of the Relativity Theory as a whole. Furthermore, these particular postulates are not actually assumptions at all; they are experimental facts whose validity most physicists were willing to concede *before* Einstein incorporated them into his Relativity

Theory. When we get down to bedrock, there fore, we find that these widely publicized "proofs" of the Relativity Theory simply verify knowledge that existed before the theory was born; they tell us nothing about the new ideas that Einstein put into the theory.

An even more serious threat to the integrity of scientific knowledge is the widespread tendency to accept evidence, which is *consistent with* a theory as *proof of* that theory. The situation with respect to the First Postulate of Relativity has already been discussed. Teriestrial experiments of many kinds have failed to disclose any effects that can be attributed to absolute translational motion of the earth. This is consistent with the hypothesis that no such absolute motion exists, to be sure, but by no stretch of the imagination can it qualify as proof, since the contrary hypothesis that such motion exists but cannot be detected by available methods is equally consistent with the facts. But Relativity is the currently fashionable doctrine, and it is standard practice to accept contentions favorable to the orthodox doctrine at their face value hence, as Herbert Dingle states the case, "A theoretical demonstration that the theory contains no internal contradictions--that it *could* be right--has frequently been regarded as a proof that it *is* right."[55]

Another striking illustration of the current trend is furnished by the concept of an increase in mass at high velocities. Everywhere we turn, we find references to the "proof" of this relation derived from experiment, and to our "knowledge" of the rate of increase of the mass. Here again the evidence is clearly consistent with the popular hypothesis, but even a very casual consideration is sufficient to show that this evidence is equally consistent with any one of several other explanations, and hence is no proof of any of them. The almost universal habit of treating this evidence as proof of the hypothesis of an increase in mass is scientifically indefensible.

Equally common is the thoroughly unsound practice of accepting a hypothesis as an established truth simply because it happens to be the best explanation available at the moment, even if the confirmatory evidence is wholly inadequate This is the situation which exists today with reference to the Relativity Theory as a whole. In order to verify this statement, we will next proceed to summarize the evidence in favor of the theory and then to analyze the extent to which this evidence is sufficient to justify the two assertions that are now commonly made on behalf of Einstein's ideas: (1) that tile Relativity Theory is superior to the Newtonian system, and (2) that the Relativity Theory is a correct representation of the physical relationships.

The following are the points that are generally advanced in support of the theory:

1. It reduces to Newton's system at low velocities and hence is in agreement with all of the great mass of experimental and observational data that

supports Newton's generalizations.
2. It is in agreement with the observed fact that the velocity of light is constant and independent of the reference system.
3. It accounts for the advance of the perhelion of Mercury.
4. It predicts the interconvertibility of mass and energy and furnishes the correct mathematical expression for this conversion.
5. It supplies an explanation for the deviation from the Newtonian relation F = ma that is observed at high velocities.

Einstein proposed two other tests of the theory: bending of a light ray in passing a massive body and a shift of atomic spectra toward the red in a strong gravitational field. The first observations made after the original publication of the theory were interpreted as confirming these theoretical predictions, and for many years these correlations were accepted as proofs of the validity of the theory. More recently, however, skepticism has been growing, and what may be regarded as the "official" opinion at present is that the status of both of these tests is doubtful. A statement by H. P. Robertson at a conference on "Experimental Tests of Theories of Relativity" held at Stanford University in July 1961 contains the following conclusions, as reported by L. I. Schiff: "the deflection of light by the sun has not been measured with great precision," "the red shift follows from more elementary considerations and is not really a test of general relativity," and "only the precession of the perhelion of the orbit of the planet Mercury provides an accurate test of Einstein's theory."[56] In view of the existing uncertainties, we are not justified in taking the deflection of light and the gravitational red shift into consideration in the present analysis.

If we examine the five points listed in the foregoing tabulation from the standpoint of their relevance to the question as to the relative merits of Newton's and Einstein's theories, it is apparent that the verdict is definitely in favor of Einstein. Newton's theory gives the wrong answer in the case of item 2, the constant velocity of light and also item 5, the decrease in acceleration at high velocities, and it provides no explanation of the observed facts concerning item 3, the advance of the perhelion of Mercury. It is likewise silent on item 4. 'This latter cannot be counted against Newton, as this subject is not specifically within the scope of his theories, but the ability to cover a larger field is a point in favor of Einstein's theory. On the other side of the picture, Newton can claim no offsetting advantage over Einstein because of item 1, which means that all of the positive evidence in favor of Newton's system is equally favorable to the Relativity Theory. This statement should perhaps be qualified to some extent, as the ability of Einstein's theory (the General Theory, in particular) to achieve the same results as Newton's system cannot be definitely checked in the more complex applications because the mathematics become too difficult to handle by any means now available. Mc Vittie comments on this point as follows: "But whether it (General Relativity) can also embrace the phenomena associated with the idea of rotation--the tides, for example--which presented little difficulty to Newtonian theory, is still an unsolved problem."[57]

The early history of the Relativity Theory is commonly portrayed, in present-day writings, as a contest between Einstein and Newton in which the points outlined in the foregoing paragraphs were gradually recognized by the scientific profession, so that the decision ultimately went to Einstein. Actually, however, Michelson and Morley destroyed the validity of Newton's Laws as physical principles of general application in conjunction with existing ideas of space and time in 1887, not by Einstein, who first published his theory in 1905. As soon as the authenticity of the results of the Michelson-Morley experiment was conceded, the generality of Newton's Laws was automatically invalidated, even though it took some years to overcome the reluctance of the scientific profession to accept this distasteful fact. There was now a direct conflict between the Newtonian concept of motion and the experimentally verified constancy of the velocity of light. Something in the fabric of physical theory obviously had to be altered, and the issue facing the scientific community was essentially a question as to what this should be. Not recognizing the incomplete nature of the existing ideas of time, tile scientists of this era selected the concept of absolute magnitudes of space, time and motion as the item to be sacrificed. Fitzgerald first advanced the idea of a contraction of space in the direction of motion, Lorentz enlarged and improved the concept, and finally Einstein put the whole development on a firm mathematical and theoretical footing.

Between 1887 and 1905 there was no general theory of motion that could even *claim* validity. Thus the Relativity Theory did not attain its present position by triumph over an opposing idea; it simply filled a conceptual vacuum, and its general acceptance in spite of its many weaknesses is due primarily to this fact. Because of these numerous and serious weaknesses powerful voices were raised against it in its youth. P. W. Bridgman, for example, once predicted (referring particularly to the General Theory) that "the arguments which have led up to the theory and the whole state of mind of most physicists with regard to it may some day become one of the puzzles of history."[26] Paul R. Heyl was equally critical. "Here," he says, speaking of rotational motion, "the relativity concept shows plainly its nature: a hollow mathematical shell, with no real content; useful as far as it fits the facts, useless where it does not."[58] But the battle was won by default. Bridgman, Heyl and their fellow critics were ultimately silenced because they had no alternative to offer; they could only attack the shortcomings of the theory itself and, as the politicians so aptly put it, "You cannot beat something with nothing."

But when we turn to the second issue, the question as to whether the Relativity Theory is a correct representation of the actual physical relationships, all of the deficiencies and shortcomings pointed out by these early critics to no avail once more become pertinent. Here the theory has much more difficult requirements to meet; it must be so strongly supported that the *possibility* of an error of any consequence in the structure of the theory is negligible. As previously stated, this means that it must agree with the observed and measured facts in a large number of individual applications throughout the area affected, without exception, and without the use of contrived methods of evading inconsistencies or contradictions. Obviously the theory does not even begin to meet these requirements. Aside from the fact that it claims to incorporate Newton's low velocity relations, which are firmly established, the Relativity Theory can point to only a very few instances of agreement with the established facts, and in the most important of these, the situation with respect to the constant velocity of light, the agreement has been reached only by means of one of those evasive devices which vitiate any attempt at proof.

The use of principles of impotence or other evasive devices has become such a commonplace feature of present-day physical theory that their true character has been to a large extent obscured. What these devices actually accomplish is to dispose of a contradiction or inconsistency by postulating that this discrepancy shall not be counted as a discrepancy. It is, of course, possible that the device may be entirely legitimate; the universe may actually be constructed in some such weird manner. But there is no way in which we can determine whether or not it is legitimate in any particular case, and hence the use of such a device precludes any possibility of proof, irrespective of whether or not the contentions are well-founded. If we have to utilize a device of this kind to arrive at the truth, then we can never be certain that it is the truth. As Einstein himself has pointed out, "For it is often, perhaps even always, possible to adhere to a general theoretical foundation by securing the adaptation of the theory to the facts by means of artificial additional assumptions."[59]

Either of these deficiencies, the lack of adequate observational confirmation or the use of the unsupported assumption of the "rubber yardstick," is sufficient to stamp the Relativity Theory as unproved, hence our second question, the question as to whether the theory is a correct representation of the physical facts, will have to receive an inconclusive answer for the moment. There are no instances where the theory is definitely in conflict with established facts, aside from such bearing as the existence of absolute rotation may have on the issue, but the theory becomes more and more vague as it passes from general principles to details, and there is ample justification for a suspicion that it is only the concealment thus provided that prevents recognition of many conflicts with the physical facts. Einstein tacitly admits this when he speaks of "...the ever widening logical gap between the basic concepts and laws on one side and the consequences to be correlated with our experience on the other--a gap which widens progressively with the developing unification of the logical structure."[5960]

The development of the Reciprocal System now confronts the Relativity Theory with the kind of an acid test which it has never had to meet before: a direct item by item comparison with a new theoretical structure that agrees with the facts of observation and experiment in an easy and natural way, without the use of evasive devices such as the First Postulate of Special

Relativity or vague and obscure "artificial additional assumptions" of the kind that are employed so freely in the development of the General Relativity Theory. The presentation in this volume advances two contentions on behalf of the Reciprocal System similar to those, which have previously been offered on behalf of the Relativity Theory. These are (1) that the Reciprocal System is superior to the Relativity Theory, and (2) that this system is a correct representation of the physical facts. The second contention includes the first and it would actually be sufficient to establish this point alone, but it will help to clarify several significant issues if the two questions are considered separately.

In beginning an analysis of these two questions, let us first summarize the position of the Reciprocal System with respect to the five points raised in support of the Relativity

1. This system also reduces to Newton's system at low velocities.
2. It is also in agreement with the observed constant velocity of light.
3. It furnishes a different, but equally accurate, explanation of the advance of the perhelion of Mercury.
4. It arrives at the same mathematical expression for the interconversion of mass and energy.
5. It furnishes a different, but equally consistent, explanation of the deviation from the relation F = ma at high velocities.

From this tabulation it can be seen that the points which led to the triumph of Relativity over Newton's system are not available as arguments in the contest with the Reciprocal System. On the contrary, unless it can be shown that Relativity Theory furnishes a *better* explanation in one or more of those cases where the two theories arrive at the same results by different routes, the Relativity Theory has no argument at all to support a contention that it is superior to the Reciprocal System. Let us therefore examine the differences between the two theories in these particular areas.

So far as the agreement with Newton's Laws at low velocities is concerned, the Reciprocal System is in much the better position. The adherents of the Relativity Theory claim that the equations of this theory give the same results as Newton's Laws at low velocities but, as pointed out earlier, this claim cannot be vitrified in any other than the very simplest applications, as the mathematics of the theory are too complicated to be workable elsewhere. The Reciprocal System does not merely give *the same results as* Newton's Laws; at low velocities the equations of this system are Newton's expressions, hence there cannot be any question *as* to the kind of results which this system produces in the low velocity field.

The comparison in the field of motion at high velocities is also very definitely favorable to the Reciprocal System, as Relativity Theory is confronted with a contradiction between the constant velocity of light and the definition of velocity which the theory utilizes: a contradiction that is removed only by the use of an arbitrary assumption of a wholly unsupported nature. In the Reciprocal System, on the other hand, no such contradiction exists and no evasive assumption is required. The constant velocity of light emerges easily and naturally from the development of the basic postulates of this system.

Closely connected with this question of the constant velocity of light is the advance of the perhelion of Mercury. It has been known since the time of Leverrier that the orbit of this planet is constantly moving ahead of the position calculated on the basis of Newton's Laws, the unexplained increment being almost twenty miles per revolution or something over 40 seconds of arc per century. According to the Reciprocal System, this is merely another effect of the same factors that are responsible for the negative result of the Michelson-Morley experiment. As long as the orbital velocity is low, the difference between clock time and total time is negligible, but the velocity of Mercury is great enough to introduce an appreciable amount of coordinate time and during this added time the planet travels through an additional distance.

Einstein's mass-energy equation $E = mc^2$ is entirely in accord with the relations derived from the Reciprocal System. In the previous publication mass was identified as the reciprocal of three-dimensional velocity, t^3/s^3, and energy as the reciprocal of one-dimensional velocity, *t/s.* When reduced to the space-time terms of the new system, the mass-energy equation becomes $t/s = t^3/s^3 \times s^2/t^2$ As this is a valid equality, the equation $E = mc^2$ hold good in the Reciprocal System just as it does in the Relativity Theory.

But this agreement as to the mathematical *form* of the relationship does not signify agreement as to the *meaning* of the equation accepted l y both systems. Einstein claims that a body at rest possesses a quantity of energy equivalent to its mass, and that kinetic energy of motion likewise corresponds to an equivalent amount of mass. A body in motion therefore acquires an additional mass, which "varies with changes in its energy" and "becomes infinite when q (the velocity) approaches 1, the velocity of light."[61] "According to the theory of relativity," Einstein says, "there is no essential distinction between mass and energy. Energy has mass and mass represents energy."[62]

The Reciprocal System is in direct conflict with this *interpretation* of the equation. From the Fundamental Postulates of this system we find that energy is a one-dimensional displacement of space-time, whereas mass is a three-dimensional displacement (rotational). Under appropriate conditions the dimensions of the displacement can be altered, hence mass is convertible to energy and vice versa. The displacement can exist *either* as mass or as energy (that is, either in three dimensions or in one dimension) but obviously *not as both simultaneously.* Mass is not *associated with* energy; it *is convertible to* energy, and the mass-energy equation merely indicates the relation between the magnitudes involved *when and if* the conversion takes place. Energy is mass only if it is converted to mass, and when such a conversion takes place so that a quantity of mass makes its appearance, the equivalent quantity of kinetic energy ceases to exist.

As Bridgrnan has pointed out, many of Einstein's conclusions have been accepted without adequate critical scrutiny, and this mass-energy relation definitely falls in this category. If this relationship is examined from the standpoint of logic, it is apparent that Einstein's contentions are internally inconsistent and must eventually fall of their own weight, irrespective of what any other theory may say. Mass cannot be something that is associated with energy (and therefore increases as the energy increases) and at the same time something that is convertible to energy (and therefore decreases as the energy increases). But this obvious conceptual contradiction is one of the things that Relativity Theory expects us to accept. If "mass and energy, are only different expressions for the same thing,"[61] as Einstein declares, then we cannot have a conversion of one to the other; we cannot convert anything into itself. But such a conversion clearly *does* take place. An atomic explosion, for example, is not a mere alteration in terminology or a conceptual reorientation; it is an actual physical event, and hence Einstein's viewpoint cannot be correct. It does not meet the requirements of elementary logic.

It is generally believed that the hypothesis of an increase in mass accompanying increased velocity is firmly established by experiment, and scientific literature is full of positive statements to that effect: statements which emanate not only from rank and file physicists, but also from the most eminent leaders of science. Louis de Broglie states unequivocally, "...the variation of mass with velocity deduced by Einstein... is verified daily by observation of the motion of the high-speed particles of which nuclear physics currently makes such extensive use."[63] Planck was equally positive: "The theory of relativist mechanics was verified by experiment in the case of rapidly moving electrons, for this experiment showed that mass is not independent of velocity,"[64] and Eddington tells us flatly, "...the mass depends on the velocity--a fact unknown in Newton's day."[65]

Yet, oddly enough, while a host of scientific authorities of the highest rank are thus proclaiming that the postulated increase of mass with velocity has been proved by experiments with high-velocity electrons and verified by the successful use of the theory in the design and construction of the particle accelerators, almost every elementary physics textbook admits, explicitly or tacitly, that this hypothesis of an increase in mass is only an arbitrary selection from among several possible explanations of the observed facts. Richard Schlegel even manages to put both points of view into the same sentence. 'Even before Einstein's first paper on special relativity," he tells us, "W. Kaufmann had observed an increase in the mass of electrons moving with very high velocities--or more precisely he had found a decrease in the e/m ratio of electrons, where e is the electron charge, a magnitude unaffected by relative velocity."[66] Still more precisely, we may say that Schlegel's final comment about the effect of velocity on the magnitude of the charge is pure assumption. The truth is that the experiments with high velocity particles and the experience with the particle accelerators merely show that if a specific force is applied to a specific mass, the acceleration decreases at high velocities, following a pattern which indicates that it will reach zero at the velocity of light. II we are to maintain the relation a = *F/m* it then necessarily follows that either the mass increases or the force decreases, or both. Certainly the hypothesis of an increase in mass is *consistent* with the observed facts, but this is by no means the equivalent of the proof that is claimed. The door is wide open for ally alternative explanation which calls for a decrease in the effective force: either a decrease in the magnitude of the entity responsible for the force (an electric charge, in the usual case) or a reduction in the effective component of the force. The latter is the explanation that we obtain from the Reciprocal System.

In this system mass is absolute in magnitude, and it therefore remains constant irrespective of velocity. I Here, however, force is *not* constant. Force, according to the principles of the Reciprocal System, is simply a special way of looking at motion. If we assume a velocity v_1 acting in a certain direction and then superimpose an equal velocity v_2 acting in the opposite direction, the net velocity is $v_1-v_2 = 0$. In describing this situation we may take the stand that both velocities actually exist and that the null result is due to the fact that one cancels the other, or alternatively, we may say that there is a force F1 tending to produce velocity v1 and an oppositely directed force F_2 tending to produce velocity v_2, but that, since the resultant of the two forces is zero, no motion takes place.

It is clear from the development in Part Three that the motions actually do exist and that the concept of force is simply an artificial way of looking at the situation. This does not mean that there is anything inherently wrong in the use of such a concept. If there is an element of convenience in utilizing an artificial contrivance of this kind, as there certainly is in this particular case, it is perfectly legitimate to take advantage of this more convenient mode of expression, providing that the concept is recognized for what it really is, and its limitations are taken into account. But if this true status is not recognized and the limitations are ignored, it is inevitable that this artificial contrivance will lead us astray sooner or later.

From the standpoint of the force concept itself, the idea of a *constant* force seems entirely logical, and up to now the existence of forces of constant magnitude has not been questioned. On the basis of the explanation of the nature of force given in the preceding paragraphs, however, there can be no such thing as a constant force. The space-time progression, for instance, tends to cause objects to acquire unit velocity and we therefore say that it exerts unit force. But a tendency to impart unit velocity to a mass, which is already at a high velocity, is not equivalent to a tendency to impart unit velocity to a body at rest. The *effective* force is a function of the difference between the velocities, and the full effect of any force is only attained when that force is exerted on a body at rest. As velocity increases the velocity difference decreases and hence the effective force also decreases. In the limiting condition, when tile mass already has unit velocity, the force (the tendency to cause unit velocity) has no effect at all and the effective force component is zero. The acceleration is then also zero, as the experimental results indicate.

The foregoing discussion shows that the Reciprocal System provides a consistent and logical explanation for each of the five points on which Relativity Theory rests its case. Since this is true, there is no scientific basis on which Relativity can claim any superiority. On the contrary, whatever advantage does exist favors the Reciprocal System, since this system does not have to utilize any principle of impotence such as the First Postulate of Relativity, nor does it contain any internal inconsistency such as giving mass both the status of something associated with energy and the status of something convertible to energy. Even when it meets the Relativity Theory on that theory's own ground, therefore, the Reciprocal System makes a very favorable showing. But the facts brought out for this purpose represent only a minor portion of the evidence supporting the validity of the new system. Unlike the Relativity Theory, which can be checked against experiment and observation in only a few cases and which, as Einstein says, confronts us with an "ever widening gap" between the theoretical concepts and the facts of experience as the theory is extended into additional areas, the consequences of the Reciprocal System are clearly and sharply defined at all points, and they can be checked against experience in a multitude of applications, not only in the areas which Relativity Theory purports to cover, but also in many additional fields which have hitherto been considered totally unrelated to the gravitational phenomenon.

In presenting the case in favor of the broader contention that the gravitational theory derived from the Fundamental Postulates of the Reciprocal System is a correct representation of the physical facts, we will limit the discussion to gravitation, the specific subject under consideration in this present work, rather than dealing with the Reciprocal System as a whole. No attempt will be made, therefore, to present all of the immense volume of data confirming the validity of the system in general. Enough of these data were included in the previous publication *The Structure of the Physical Universe* to establish the solid factual status of the system, which may be described by the statement that the necessary consequences of the Fundamental Postulates of this system, without the aid of subsidiary or supplemental assumptions, and without the use of any contrived or artificial methods of evading contradictions, constitute a complete theoretical system of physical entities and relationships which is in agreement with observations and measurements in thousands of applications throughout the physical universe, and thus far has not been found inconsistent with the established facts in any instance. Just because of the validity of these postulates, and without the intervention of any other factor, radiation, matter, electrical and magnetic phenomena, and the other major features of the observed universe *must* exist in the theoretical universe, and the primary characteristics which these phenomena theoretically *must* have are identical with the characteristics of the corresponding observed phenomena.

In its general aspects, therefore, the Reciprocal System meets all of the requirements for proof of its validity; that is, it agrees with the observed and measured facts in a large number of individual cases throughout all of the general areas in which such facts are available, there are no known cases in which positively established facts are inconsistent with the theoretical conclusions, and no use has been made anywhere in the theoretical development of principles of impotence or other artificially contrived devices for evading such inconsistencies. It is true, of course, that the new system is in conflict with much of the currently accepted thought of the scientific profession, but in every case where such conflicts occur, it can be shown that the existing ideas, however firmly entrenched they may be, are not established facts; they are extrapolations of, interpretations of, or inferences drawn from these facts, or else they are pure assumptions not connected with the facts at all. If the issue is squarely faced, therefore, it must be conceded that the validity of the system in general has been established.

It does not follow, however, that every deduction, which may be made from the Fundamental Postulates of the Reciprocal System necessarily, participates in the proof of the validity of the system as a general proposition. As pointed out in Part One, once the validity of general principles of this kind has been established, it is possible to prove the validity of certain other conclusions by deductive methods; that is, by showing that these conclusions are necessary and unavoidable consequences of the principles already established, or of these principles taken together with certain known facts. The extent to which this kind of proof can be carried is somewhat limited; however, as one can rarely, if ever, be absolutely certain that a long line of reasoning is entirely free from error. Because of this situation the method of deductive proof is not ordinarily sufficient in itself; the purpose that it normally serves is reduce the number of correlation's with established facts that are required in order to bring the possibility of a concealed error down to the vanishing point. A theoretical relation that is definitely in conflict with positively established facts is wrong regardless of its derivation, but w here there is no contradiction or inconsistency, a relation that is derived in a straightforward manner from principles whose validity has already been proved is obviously in a much better initial position than a relation that is purely hypothetical. What we have done here is to reduce the general question of the possible existence of some contradictory fact to the more limited question of the validity of the deductive process, and hence a smaller number of factual correlation's is sufficient to reduce the probability of a hidden error to the neighborhood of zero.

The extent to which the deductive proof is effective in this respect naturally depends upon the length of the chain of reasoning involved in deducing the conclusion from the previously established principles. If the connection is immediate and direct, comparatively little factual corroboration should be required; the absence of any contradiction or inconsistency should be almost enough in itself under these circumstances. As the number and complexity of the steps in the process of deduction increases, the chance of a logical or mathematical error somewhere in the process likewise increases, and the need for more factual corroboration increases accordingly. In the limiting condition, where the deductive chain is extremely long and involved, the requirements for proof are essentially no different than in the case of a pure hypothesis.

On this basis, there is abundant proof of the validity of the gravitational theory presented herein. To begin with, this theory is an immediate and direct consequence of the Fundamental Postulates of the Reciprocal System, the validity of which, as has been stated, is confirmed by a great mass of evidence that meets all of the requirements of proof. In view of this status as a direct deduction from principles already established, a relatively small amount of factual corroboration should be adequate to complete the proof, and since everything that is actually known about gravitation is in full agreement with the theory, this should be sufficient for the purpose, even though it is true that the existing knowledge in this field is quite limited.

Furthermore, a very substantial amount of additional support is developed in fields, which have not hitherto been recognized as falling within the scope of gravitational theory. As the previous discussion has indicated, the new gravitational theory not only explains the origin of this phenomenon and the characteristics which it manifests in the generally recognized aspects of the gravitational action, but also goes on to provide explanations for other phenomena, such as the recession of the distant galaxies, the cohesion of solids, and the abnormal distances between the stars, which have heretofore been considered as totally unrelated to gravitation. The agreement between theory and established facts in these additional fields not only constitutes a major addition to the rather meager number of factual correlation's which it is possible to obtain in the narrow field hitherto connected with gravitation, but also has another very significant aspect, in that such an extension of the field of application is a recognized indication of merit in a new theory of any kind. In this case the extension that has been achieved is extremely far-reaching and it adds substantial additional weight to the already strong case in favor of the new gravitational theory.

The question as to just how far it is necessary to go before we can say that the remaining probability of the existence of a hidden error is essentially zero is a matter of opinion, but if the new gravitational theory does not actually qualify, it is certainly not far away from qualification. In any event, it is much closer to positive proof than most physical theories, and far superior in this respect to the current favorite, Einstein's General Theory of Relativity, which has not achieved its present standing on its own merits, but because of the fact that nothing better has hitherto been available.

In spite of the status of gravitation as the primary subject of this volume, the foregoing discussion of the Relativity Theory has been directed largely at the Special 'Theory since the General Theory, which actually deals with gravitation, is supposed to be an extension of the principles of the Special Theory to the wider field of nonuniform motion, and a full understanding of the true nature of the Special Theory gives us a better indication of the position of the General Theory than we can obtain by making a detailed analysis of the rather confused structure of the latter. It has been shown in the preceding pages that the Special Theory is simply a mathematical device which compensates for the error introduced into the relations of moving bodies by the failure to recognize the existence of coordinate time. The General Theory represents an attempt to extend this compensating mechanism into the field of non-uniform motion.

The Special Theory is mathematically correct even though it is expressed in terms of totally erroneous concepts, because its mathematical content is empirical and independent of the language in which it is described by the theory (in fact, this mathematical content antedates the theory itself). The validity of the empirical relations is dependent, however, on restricting their application to those cases where the error due to using clock time instead of total time is a definite function of the velocity. It is evident, therefore, that when the relations of the Special Theory are extended to rotational and other accelerated motion, where this error is normally *not* a specific function of the velocity, for reasons that have been detailed in the preceding discussion, the derived relations cannot be correct. Thus it is impossible for the General Theory to supply us with mathematical expressions which will serve the same purpose with respect to nonuniform motion that the equations of the special theory (the Lorentz transformations, etc.) do for uniform translational motion. No mathematical system, regardless of how complex and sophisticated it may be, can provide an accurate representation of the relations between quantities which, in truth, are not definitely related in any mathematical way. Any theory, which attempts to achieve this objective, must inevitably bog down in unworkable mathematical complexities and conceptual confusion, just as has actually happened in the case of the General Theory.

"In physics," said Herbert Dingle twenty-five years ago, "the name of Relativity is notorious: if one claims to understand it he is looked at askance, and his subsequent statements are received with suspicion."[67] Another quarter of a century in which Relativity has had the field all to itself without serious competition has silenced most of the critics, but it has not lessened the real force of their criticism. The General Theory is just as full of inconsistencies and loose ends today as it was in that earlier era; it has made no appreciable advance in the interim. If we examine the two postulates, which Tolman tells us contain the essence of the General Theory, the reason for this sterility is evident. The objective of the theory, its originator asserts, is an extension of the findings of the Special Theory into the area of non-uniform motion, particularly accelerated motion. Now let us ask, just what does the Principle of Equivalence contribute toward this objective? The answer must be--nothing. This postulated principle merely asserts that gravitational mass and inertial mass are equivalent, and hence gravitation can be treated as the equivalent of an accelerated motion. The present work has no quarrel with this conclusion; on the contrary, it goes a step farther and says that gravitation *is* an accelerated motion. But this simply means that we have only one problem--accelerated motion; we do not have two problems--gravitation and accelerated motion--as had been thought previously. All that the equivalence postulate does is to establish this point; it makes no contribution whatever to the solution of the one problem which does exist.

When we turn to the second of the two postulates of General Relativity, the postulate of covariance, we encounter a very odd situation. It was pointed out originally by Kretschmann, emphasized by Bridgman and others, and admitted both by Tolman and by Einstein, that this postulate actually imposes no restriction on physical theory, yet we find some of the most far-reaching conclusions of General Relativity ostensibly based upon it. This strange situation is the subject of a very penetrating comment by Bridgman: "It must, I think, strike one on reflection as paradoxical to attempt to get information about nature from the requirement of covariance, for this is at bottom merely an attempt to get information about nature from an analysis of the language in terms of which we describe it, whereas the fundamental idea back of the argument as it is worked out in detail is that the sort of language with which we describe nature must be a matter of indifference."[48]

The two postulates, which are supposed to express the content of General Relativity thus, turn out to have no bearing on the primary problem of extending the application of Special Relativity to accelerated systems. "The astonishing thing about Einstein's equations is that they appear to have come out of nothing,"[68] says one observer. Even the status of the General Theory as an extension of the Special Theory is open to serious question. Peter G. Bergmann states categorically, "It is quite true that the general theory of relativity is not consistent with the special theory any more than the special theory is with Newton's mechanics--each of these theories discards, in a sense, the conceptual framework of its predecessor."[69]

The question therefore arises, just how *does* General Relativity come to grips with this problem? Einstein himself supplies the answer to this question. He tells us that he had completed his analysis of the factors involved in gravitation and accelerated motion in general by 1908, and then goes on to say, "Why were another seven years required for the construction of the general theory of relativity? The main reason lies in the fact that it is not so easy to free oneself from the idea that co-ordinates must have an immediate metrical meaning."[70] He later defines this expression "a metrical meaning" as the existence of a specific relationship between differences of coordinates and measurable lengths and times.

Here we have the *real* essence of General Relativity. Special Relativity accomplished its objective of providing a mathematical correction for the conceptual error in the conventional view of time by abandoning the idea that the magnitudes of time and space intervals measured with respect to coordinate systems of reference have fixed values, and introducing a fictitious variability in these magnitudes. To meet the additional problem of accelerated motion, Einstein simply prescribed a bigger dose of the same medicine. It took him seven years to figure out where the additional flexibility could be introduced, but finally he created more latitude for numerical variation by depriving the coordinates themselves of any meaning so far as mensuration is concerned. As Moller sums up the new picture, "In accelerated systems of reference the spatial and temporal coordinates thus lose every physical significance; they simply represent a certain arbitrary, but unambiguous, numbering of the physical events."[71]

If the situation were one which *could* be reconciled with the conventional views of time by purely mathematical means, this strategy might have been successful (to the extent that constructing a theory that is mathematically right but conceptually wrong can be considered a success) just as Special Relativity is able to compensate for an error in its concept of the nature of time by introducing a counterbalancing error in its treatment of space. But since no general mathematical relationships of this kind exist once we get away from uniform translational velocity, General Relativity cannot expect to do anything in the field of motion beyond the little that has already been accomplished; that is, to provide complicated and rather vague solutions for certain very limited and mainly hypothetical problems.

Strangely enough, the reputation of the General Theory of Relativity, which is essentially, a theory of motion (gravitational and other) rests primarily on items which are only indirectly connected with motion. If this theory had to rely on its achievements in the field of motion alone (that is, on what it has accomplished in extending the relations of Special Relativity to accelerated motion) it would be in a very sorry state. But other, somewhat incidental, conclusions derived from or suggested by the Relativity Theory have had a spectacular success, and the success in these collateral areas has had the effect of sidetracking any critical scrutiny either of the extent to which the theory has accomplished its primary objective or the extent to which these widely publicized collateral derivatives are legitimate products of the Relativity Theory. "Though this treatment gets over some difficulties," says Sir George Thomson, "it does so at the cost of considerable violence to commonsense. It may be doubted if it would have received the full acceptance that it in fact has but for the remarkable applications to mechanics... leading to predictions concerning the identity of mass and energy which have been brilliantly verified in nuclear physics."[72]

When the originator of a new theory tells us that his theory leads to the (at that time) astonishing conclusion that mass and energy are equivalent and interconvertible, and subsequently the conversion of mass to energy is demonstrated in an awe-inspiring manner;

when he also tells us that the mass of a body in motion increases with the velocity, becoming infinite at the velocity of light, and that this mass increase will decrease the acceleration of high speed particles subjected to constant forces, and subsequently it is found that particles traveling at high velocities behave in exactly the manner predicted, this practically closes the door to any attempt at a critical analysis of the theoretical background. Few investigators are willing to attack such a strongly entrenched position, and little attention is paid to those who do have the temerity to make the attempt.

As a result, no one seems to have given any consideration to the fact that, while each of these two conclusions alleged to have been derived from the Relativity Theory makes an impressive showing by itself, they are mutually contradictory, and if either one is valid, the other is necessarily wrong. At least *one* of these impressive successes of the theory is fictitious. Mass cannot be an *accompaniment* of energy, as demanded by the aspect of the theory that explains the operation of the particle accelerators, and also something that can be *converted into* energy, as demanded by the aspect of the theory that explains the atomic bomb. These two concepts are incompatible and it is obvious that a theory, which claims to have derived both results from the same basic source, is in error somewhere. A thorough examination of the whole development is therefore very much in order.

Unfortunately, such an examination encounters major obstacles. One of the principal items of this kind, a factor that has played an important part in preventing the emergence of any full-scale attempts at a critical analysis of the alleged achievements of the Relativity Theory is the extreme difficulty of getting at the real essence of the theory. The situation that faces anyone who attempts to find out where the conclusions of the theory actually come from has already been mentioned. The mathematical basis of the theory is equally elusive. In the words of H. Bondi, "The equations describing general relativity are, in all but the simplest applications, exceedingly complex and difficult to unravel."[3] When it is extremely difficult to determine just what is *in* a theory, it is an almost hopeless task to arrive at a critical judgment as to the legitimacy of conclusions, which the originator and his supporters claim to have obtained *out of* the theory.

However, now that the Reciprocal System has provided us with a complete and consistent theoretical structure that is in agreement with the observed facts at all points, it is possible to examine the General Theory in the light of this new information and to get a more intelligible picture of the status of the points at issue, as has been done in the preceding pages. The conclusions of the foregoing analysis may be summarized as follows:

1. *As to the general objective*. The real, even though unrecognized, purpose of the theory (as interpreted in the context of the new information now available) is to provide a mathematical means of correcting for the error

introduced into calculations involving nonuniform motion by the failure to recognize the existence of coordinate time. However, the magnitude of the required correction, unlike that for uniform translatory motion, is not a specific function of the velocity, hence the primary objective of the General Theory is an impossible goal.

2. *As to the postulates of the theory*. The Principle of Equivalence is fully in accord with the newly developed information; indeed, the Reciprocal System goes a step farther and asserts that gravitation is an accelerated motion, not merely the equivalent of an accelerated motion. The Principle of Covariance is also accepted by the new system, although the significance of this principle is minimized. Most of the conclusions purporting to be derived from it have actually been introduced into the General Theory *ad hoc*.
3. *As to the correlation's with observation*. The equivalence of mass and energy (more properly the interconvertibility of mass and energy) deduced from the Relativity principles is verified by the Reciprocal System, but the hypothetical increase in mass accompanying an increase in velocity is inconsistent with the interconvertibility and is erroneous. The observed decrease in acceleration at high velocities is due to a decrease in the effective component of the presumably "constant" force, instead of an increase in mass. The advance of the perhelion of Mercury is a consequence of the same factors that are responsible for the negative result of the Michelson-Morley experiment and it is therefore related to the Special Theory, even though it involves non-uniform motion, rather than to the General Theory.
4. *General conclusion*. Unlike the Special Theory, which is mathematically correct, even though conceptually wrong, the General Theory must be considered erroneous in all of its basic aspects. The tangible achievements that it can claim, such as the prediction of the interconvertibility of mass and energy, have only a very tenuous connection with the theory itself, and rest primarily on *ad hoc* assumptions *suggested by* the theory. The widespread acceptance of the General Theory is based primarily on the achievements of the Special Theory, which is definitely superior to Newton's Laws of Motion in application to bodies moving at high velocities. The argument here is that if the Relativity principles are correct in application to uniform translatory motion, as the mathematical results seem to indicate, then they are probably also correct, and therefore superior to Newton's system, in application to non-uniform motion. In view of the admitted lack of consistency between the General Theory and the Special Theory this reasoning is clearly invalid, but in any event the issue being examined in this work is not between the Relativity Theory and Newton's system, but between the Relativity Theory and the newly developed Reciprocal System, and here the Relativity Theory is badly

> outperformed. The Reciprocal System is not only superior on an item by item basis in every instance where there is any significant difference between the too, but it also makes out a very good case when matched against the requirements for positive proof of its validity: something that the Relativity Theory cannot even approach.

The many glaring deficiencies and weaknesses that show up in the structure of the Relativity Theory as soon as it is subjected to a critical examination and judged on its own merits rather than merely on the basis of a comparison with Newton's system, indicate very clearly wily Bridgman was troubled by "the whole state of mind of most physicists with regard to it." We do not necessarily have to go along with his opinion that this will "some day become one of the puzzles of history," however, as it is actually quite evident that this is simply another manifestation of the psychological trait which makes the scientist (in common with his fellow human beings in other pursuits) unwilling to admit ignorance and leads him to treat today's best guess as the equivalent of an established fact, however weak and vulnerable that guess may be. Relativity has been, in reality, merely a makeshift: something to which the physicist could cling temporarily rather than drifting in a sea of uncertainty. It has survived only because of the lack of any serious competition, coupled with a general feeling that something is better than nothing: that even a poor theory is better than none at all.

Part Five
Discussion

Although the description of the new theory of gravitation given in Part Three is essentially complete as it stands, it may be helpful to show how the new concepts of the Reciprocal System affect some of the specific issues that have received special attention in previous studies of the subject.

The basic position occupied by the concept of a *clock* has already been mentioned. Since we have no means of making a direct measurement of time, we find it necessary to select some physical object with a uniform periodic motion and to utilize successive coincidences of identifiable spatial locations connected with this motion to distinguish intervals of time. Such an object then constitutes a clock. A very important point that has not been recognized heretofore, but which is brought out clearly in the previous theoretical development, is that a *clock does not measure the total time interval; it measures only the time progression.* Referring back to the discussion of the motion of the Hydra galaxy in Part Three, if we utilize a device which measures only the change in position due to the recession and ignores the random motion, we have the space equivalent of the clock which we use for the measurement of time. Where the random velocity is low, the inaccuracy thus introduced is negligible, but if this velocity is high and the changes in position due to the random motion are appreciable in comparison with the movement due to the recession, the measurement obtained by means of this "space clock" is seriously in error. So it is with clock time. As long as velocities are low the difference between clock time and total time is inappreciable, but at high velocities there is a serious discrepancy.

One of the major sources of confusion in the application of the Relativity Theory is the conclusion, which follows logically from Einstein's basic assumptions (including the items that were simply taken for granted, "without examination" as Tolman puts it, as well as those that were expressly stated), that the clocks in a moving system run at a different rate from those in a stationary system, if both rates are measured in the same system of reference. When we recognize the true nature of a clock, which is a device that measures the time progression only, it is obvious that all accurate clocks are equivalent irrespective of location or system of reference, just as the rate of recession of a galaxy is the same for all points in the galaxy. But Einstein saw that the *total time* in a moving system differs from that in a stationary system, and not realizing that there are two components included in this total time, he thought that he was dealing with clock time only and therefore deduced erroneously that the clock time varies.

This is the origin of many of the so-called "paradoxes" of Relativity including the famous Twin Paradox, in which the conclusions drawn from a straightforward application of the

Relativity principles are so outrageous that many of the staunch supporters of the theory are reluctant to accept them, and they have occasioned a great deal of controversy within the ranks of the relativists themselves. In the usual statement of this paradox it is assumed that one of the twins remains on earth, whereas the other embarks on a journey into the far reaches of the Galaxy, traveling at a velocity approaching that of light. According to the Relativity Theory, the clocks by which the fast-moving twin lives are slowed down to a very low rate, hence he returns from his journey in what to him was a rather short time, and he comes back still a young man, while his twin brother has been subject to the faster-moving clocks on earth and has grown old in the meantime.

Such fantastic conclusions are, of course, incompatible with the principles of the Reciprocal System. In this system the operation of clocks, the aging process, and all other such time-connected mechanisms in which no appreciable differences in coordinate time are involved, are determined by the relationships of the various factors as they exist in the local environment, and whether or not that environment is in motion, relatively or absolutely, is entirely irrelevant. Any change in position in time other than that resulting from the everpresent progression and registered on all clocks, affects only those relationships in which a significant difference in coordinate time is involved.

A somewhat modified statement of the initial premises arrives at what is called the Clock Paradox. Here it is assumed that clock B is accelerated relative to clock A and that subsequently, after a period of time at a constant relative velocity, the acceleration is reversed and the clocks return to their initial locations. According to the principles of Special Relativity clock B. the moving clock, has been running more slowly than clock A, the stationary clock, and hence the time interval registered by B is less than that registered by A. But Special Relativity also tells us that we cannot distinguish between motion of clock B relative to clock A and motion of clock A relative to clock B. Thus it is equally correct to say that A is the moving clock and B is the stationary clock, in which case the time interval registered by clock A is less than that registered by clock B. Each clock therefore registers both more and less than the other: definitely a paradoxical situation.

Tolman explains, "The apparent paradox is, however, readily solved with the help of the general theory of relativity, if we do not neglect the actual lack of symmetry between the treatment given to the clock A which was at no time subjected to any force, and that given to the clock B which was subjected to the successive forces F_1, F_2, and F_3 when the relative motion of the clocks was changed,"[73] and he goes on to develop his solution with several pages of the usual complex Relativity mathematics. "The solution thus provided," he says, "gives a specially illuminating example of the justification for regarding all kinds of motion as relative..."

The alleged solution of the paradox does more than this; it provides us with a "specially illuminating example" of the way in which the originator of the Relativity Theory and his disciples pass hastily over the weak points in their initial assumptions and concentrate their c efforts on building up an invulnerable mathematical structure, apparently oblivious to the fact that the right answers cannot be obtained from the wrong premises, regardless of the power of the mathematical techniques. Let us go back and take a good look at these initial assumptions Tolman begins with the clocks in coincidence and subjects clock B to a temporary force which produces an acceleration relative to clock A. Then follows an extended period of time during which clock B has a velocity u relative to clock A. The Relativity Theory insists that this velocity u *is purely* relative: that there is no such thing as absolute velocity. On this basis, therefore, we cannot say that one clock is moving and the other stationary; irrespective of how the present situation originated each clock is moving relative to the other and we cannot attribute any motion to clock B that cannot be attributed equally legitimately to clock A.

Furthermore, if the end result is a purely relative motion as the theory contends, then the acceleration that produced the motion must be purely relative, since an absolute acceleration would not produce a purely relative motion. It then follows that the force must also be relative, in order to produce a relative acceleration. Tolman definitely states that the "successive forces F_1, F_2 and F_3" cause a change in the "relative motion of the clocks." If this orthodox relativistic view of the situation is correct, then we cannot attribute the change in motion to clock B any more than to clock A, and this in turn bars us from assuming that the forces are applied specifically to clock B. Tolman's assumption as to the application of the forces contradicts the basic principles of the theory on which he bases his analysis, and hence the entire "solution" is invalid, irrespective of the elegance of the mathematical treatment.

If we hew to the line and apply the Relativity principles consistently throughout the argument concerning the Clock Paradox, the end result is an absurdity. Strictly according to these principles, it is not possible to apply a force specifically to a particular mass. Force is defined, by Einstein as well as by Newton, by means of the equation $F = ma$ and just as acceleration must be relative to produce relative motion, force must also be relative to produce relative acceleration. This relativity of force does not make much sense, if we judge the idea according to our normal standards, but it is a necessary consequence of the Relativity Theory, and if it does not make sense, this simply means that the Relativity Theory itself does not make sense. Those who claim to have resolved the paradox and circumvented the *reductio ad absurdum* have simply forsaken Relativity and reverted to the "absolute" system at one point or another in their development.

Tolman does not specifically admit that he is violating Relativity principles and giving clock B an absolute acceleration, but Moller is more candid and concedes that the acceleration of clock B is "relative to the fixed stars":[74] an expression which is merely a euphemism for absolute acceleration. The fixed stars are taken as representing in an approximate way the general background of the universe, and motion relative to these stars is motion relative to the universe as a whole. Since we have only one universe, so far as we know, there is no meaningful distinction between this kind of motion and "absolute" motion. As Eddington puts it, "motion with respect to... any universally significant flame would be called absolute."[75] Thus both Tolman and Moller find it necessary, in order to resolve the Clock Paradox which results from the application of Relativity Theory, to assume the existence of absolute motion: a concept whose validity is specifically denied by Relativity Theory.

The truth of the matter is that the adherents of the Relativity Theory have allowed themselves to be so carried away by their enthusiasm for a theory which gives them plausible answers to *some* of the perplexing questions concerning the laws of motion that they have accepted the basic assertions of the theory without giving them the kind of critical scrutiny that should properly be applied to innovations in science. The assertion that it is impossible to distinguish between motion of A relative to B and motion of B relative to A is a case in point. Eddington cites the example of a train passing a station at 60 miles per hour. "Since velocity is relative," he contends, "it does not matter whether we say that the train is moving at 60 miles an hour past the station or the station is moving at 60 miles an hour past the train."[76] Then he spends the next three pages trying to "explain away" (using his own expression previously quoted) the fact that if the relative motion is suddenly changed--by an accident, for instance--the passengers in the train are the ones that suffer injuries, not the occupants of the station.

But this situation cannot be explained away, and Eddington's attempt gets nowhere. The motion of the train past the station is something of a totally different character than the motion of the station past the train, however strongly Eddington and his colleagues, past and present, may assert the contrary. We know that the accident causes a change in the relative velocity of the station with respect to the train, but we also know that this accident does not change the absolute velocity of the station, because we have a system of essentially constant absolute velocity, the surface of the earth, that we can use for reference. On the other hand, we know from similar considerations that the train undergoes an alteration of both its absolute velocity and its relative velocity with respect to the station. This demonstrates that a change in *relative velocity only* produces no physical effects, whereas a change in relative velocity *arid absolute velocity* does. It is clear from this that only absolute velocity has any physical significance; the relativists' contentions that "There is no meaning in absolute velocity" and "There is no meaning in absolute acceleration"[77] are one hundred percent wrong.

The proponents of the Relativity Theory have simply taken advantage of the prevailing strong desire for some kind of an explanation of the experimentally verified deviations from Newton's Laws of Motion and have persuaded the scientific community to accept the extraordinary reasoning that since uniform absolute velocity cannot be detected by a *particular kind of an experiment* specified by the relativists themselves, absolute velocity does not exist, no matter how many other ways there may be of detecting it. Even the well-known willingness of scientists to go to almost any lengths to avoid admitting ignorance is hardly enough to explain their uncritical acceptance of this argument based entirely on inability to detect absolute translational motion by methods available within an isolated system, when it is clear that absolute motion (that is, motion relative to the universe in general) *can* be detected by means of observations extending outside that system, and that absolute acceleration, which implies the existence of absolute motion, can be detected not only by such external observations but by evidence obtainable within the isolated system as well.

This technique of dealing only with artificially simplified systems, which is standard practice in explanations and discussions of Relativity, arrives at conclusions which are, for all practical purposes, meaningless. Conclusions with respect to "isolated systems" have no meaning in relation to actual physical systems, all of which are constituent parts of the physical universe as a whole. Just as soon as we place the isolated system in its proper place in the universe, it becomes obvious that we do have an absolute system of reference defined with the aid of the fixed stars. As Moller admits, "Experience shows that the fixed stars as a whole may be regarded as approximately at rest relative to the 'absolute space'..."[78] Similarly Eddington's futile efforts to "explain away" the effects of a sudden deceleration of his hypothetical train are seen in their true light when we consider the train-station system in its actual setting rather than in a fictitious Isolation.

An extreme example of this sort of thing is provided by the attempts that have been made to portray rotational motion as purely relative. Tolman considers the case of a rotating platform and concludes that "...we can with equal success treat the platform or the remainder of the universe as subject to the rotation."[79] When we consider the fantastic velocities that the distant sectors of the universe would have to possess in order to account for even a modest rate of revolution of the platform, this statement of the relativist position is nothing short of outrageous; when we go a step farther and ask how the rotation of the "remainder of the universe" could accommodate itself to numerous relative rotations at different velocities and around different centers of rotation, it is evident that the whole concept is utter nonsense.

The paradoxes of Relativity are merely consequences of the fact that the entire theory is constructed on a false conceptual foundation: one which attempts to compensate for a basic error in its definition of the nature of time by the introduction of a fictitious variability in space and time magnitudes. Such paradoxes cannot be resolved on any logical basis; they are inherent in the structure of the theory itself.

Closely connected with the concept of the clock is that of *simultaneity.* This is another of those expressions whose meaning seems obvious in ordinary usage, yet turns out to be quite elusive when we attempt to be more specific. In large measure this difficulty stems from the very hazy nature of the existing concepts of time itself. As Tolman puts it, "To attempt a definite statement as to the meaning of so fundamental and underlying a notion as that of time is a task from which even philosophy may shrink."[80] We can hardly expect to be able to formulate a clear definition of what we mean by the expression "the same time" while we have only a vague idea as to what we mean by the word "time," and the first objective of the present work was to accomplish a clarification of the basic nature of this phenomenon. Even when its nature and properties are definitely and positively spelled out, as they are in the Reciprocal System, however, we are still laboring under a handicap because we are not accustomed to thinking of time in these terms. It may therefore be helpful to take advantage of our greater familiarity with space and to define just what we mean by "the same place" before we attempt to consider the meaning of the analogous expression "the same time."

As brought out in the discussion of basic physical principles in Part Three, any object which has no independent motion of its own, and which must therefore stay in the same place indefinitely unless it is acted upon by some outside agency, actually moves outward at the constant velocity of one unit of space per unit of time. From the natural viewpoint, therefore, "the same place" is a thing in motion. In common usage, however, the term "the same place" means the same place with respect to some arbitrary reference system. For ordinary purposes the reference system is the earth; astronomers find it more convenient to use the sun, or in dealing with more distant regions, the Galaxy. In all cases the reference system that is selected is one that does not progress in space (although it is usually in motion) and "the same place" as defined by such a reference system is the same relative location in coordinate space.

It is evident that "the same place" in clock space, the space of the progression, means the same point in the progression, and since the path of the progression can be identified in terms of the reference systems utilized for coordinate space, all points in a progressing system are in constant motion relative to our usual frames of reference. A distant galaxy which has no random motion does not remain at the same place relative to one of these conventional reference systems (our galaxy, for example); it occupies a specific place only momentarily and the progression then moves it along to another place. Our galaxy is similarly progressing outward away from the distant galaxies and from the overall standpoint, therefore, two events cannot occur at the same place unless they also occur at the same time.

On first consideration this statement seems to outrage common sense. Surely if I walk across the intersection of First and Main Streets today, I can return to the same place and do the same thing again tomorrow. But a little reflection will tell us that, even without the progression, First and Main Streets will not be at the same location in the universe tomorrow that it is today. Of course, this intersection does remain at the same place with respect to our usual system of reference, the surface of the earth, but if we look at the situation from a broader viewpoint we will realize that in the meantime the earth will have traveled more than 1½ million miles in its orbit around the sun; it will have accompanied the sun and its fellow planets over a distance of some 15 million miles on the long path around the center of the Galaxy; and it will have been carried an unknown distance by the movement of the Galaxy itself. The progression merely adds one more motion to the many others that exist. No, we cannot return to the same location in the universe tomorrow. Whatever we wish to do at that same place (as thus defined) can only be done at the same time.

So far as time is concerned, our reference system is analogous to a distant galaxy, as the progression of time continues unchecked in the material universe. In view of the symmetrical relation between space and time we may therefore invert the previous statement and say that two events cannot occur at the same time unless they occur at the same place. Events that take place at different locations cannot be simultaneous with reference to time in its totality.

It is possible, however, to define "the same time" in the same manner as we normally define "the same place"; that is, with respect to a reference system which is stationary in one of the two components of time. We could, for instance, define the expression "the same time" as meaning the same point in coordinate time, just as the usual meaning of the expression "the same place" is the same point in coordinate space. But this would require a reference system stationary in coordinate time, and since we have no such system in the material universe, the time referred to a system of this kind would be meaningless to us. It is also possible to define "the same time" as the same clock time; that is, the same point in the progression, and this is a more practical alternative, as in so doing we are conforming to the meaning of simultaneity as the term is used in common parlance.

Once again let us turn to the galactic recession as an aid in visualizing the time relations. Fig. 5 represents a galaxy that is receding at approximately the velocity of light in the direction shown. The entire galaxy recedes or progresses in space as a unit, hence the particular point in the progression which it occupies at any instant, the clock space applicable to the galaxy as a whole, can be identified by utilizing the position of any specified location within the galaxy as a reference point. Let us take the center of the galaxy for convenience. When this center is at point A, the clock space for the entire galaxy is XA, the distance between A and some previous location X

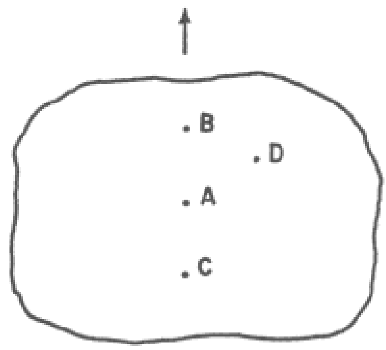

Fig. 5

of the galactic center which will be taken as the origin of the coordinate system. At the same stage of the progression point B is at distance XB from the origin of the coordinates, but this does not mean that the clock space is any different at this location; the clock space is the distance which the galaxy has been moved by the progression during a certain interval of time, and since that distance is XA for one location within the galaxy, it is likewise XA for all other points in the galaxy. There is, however, a coordinate space AB intervening between A and B. hence the total distance from X to B. the position of point B in terms of the coordinates based on X, is XA plus AB, or XB. Similarly, the total distance between location C and the origin of the coordinates is XA minus AC, or XC. For a location such as D which is not collinear with A and X, it is necessary to convert the distance AD in three-dimensional coordinate space to the equivalent one-dimensional value in order to combine it with XA, but otherwise the situation here is identical with that applying to locations B and C. It is obvious, of course, that the relation of AD to its clock space equivalent depends on the spatial location assigned to point X since the galaxy is receding in all directions, whereas the line AD has a specific direction in coordinate space.

Now let us give Fig. 5 a new significance. Let us say that it represents our Milky Way galaxy instead of some distant galaxy, and that it is being depicted in coordinate time rather than coordinate space. The arrow now indicates the direction of progression of time from some assumed origin of time coordinates X. Points A, B. C, and D are locations in coordinate time within the galaxy, and are separated from one another by time intervals AB, AC, etc., which, in view of the equivalence of the unit of time and the unit of space, are commensurate with the corresponding space intervals AB, AC, etc. This equivalence enables us to measure the time intervals indirectly, but accurately, by measuring the space intervals and converting the results to the time equivalents.

We now have an exact analogy with the original significance of the diagram as indicating a galactic recession. The clock time for our galaxy as a whole, and for any individual point within the galaxy, at the stage of the time progression portrayed in the diagram is XA. The time interval between X and B is the clock time XA plus the coordinate time interval AB, making a total of XB. The time interval between X and C is XA minus AC, or XC. The time interval between X and D is XA plus or minus the component of the coordinate time interval AD in the direction XA. The magnitude of this component depends on the location of the origin X of the coordinates; that is, on the direction XA of the time progression.

This latter point is one which is somewhat difficult to grasp if we look at the time situation only, without the aid of the analogy provided by the galactic recession, because it is hard to think in terms of a time concept totally different from the one which has been handed down to us from past generations. But the recession of the galaxies, a manifestation of the space phenomenon analogous to the progression of time, is not nearly so hard to visualize. It is, indeed, quite easy to get a clear mental picture of the observed situation in which the distant galaxies are moving outward away from us in all spatial directions. The further conclusion, which necessarily follows, that our galaxy is likewise moving outward in *all spatial directions* away from all other galaxies, is a somewhat more difficult concept. We do not readily picture motion in all directions simultaneously, but the analogies which the astronomers use in explaining this phenomenon, such as the behavior of points on the surface of a balloon which is being expanded gradually, should help to clarify this aspect of the situation. The mere fact that the astronomical profession accepts this outward movement of the Galaxy in all directions as an established fact is, in itself, an aid to understanding, as a new idea can be more readily assimilated if there is some advance assurance that it is wellfounded.

The essential point here, so far as the matters now at issue are concerned, is that the motion of the galactic recession is *scalar.* All galaxies, including our own, move in the same manner: *outward* from all other galaxies. If we wish to translate this outward scalar motion into its equivalent in three-dimensional coordinate space, we must select a point of reference, and whatever conclusions we reach concerning the coordinate space equivalent of the scalar motion are valid only for that particular reference system. If we designate our Milky Way galaxy as M, we are receding from galaxy A in the direction AM in coordinate space. At the same time we are receding from galaxy B in a different direction BM. If we wish to combine some distance CD in coordinate space with the space progression (the recession of the galaxy) we must first specify our reference system, since the component of CD in the direction AM will not be equal, unless by mere chance, to the component in the direction BM.

Similarly, the motion of the time progression is *scalar.* Time does not flow past us in the "unidirectional, one-valued, one-dimensional" manner which is usually "assumed without examination," as Tolman expresses it; the progression of time is a scalar motion in a three dimensional time: each point in time moves outward from all other points in time, just as each galaxy moves outward from all other galaxies under the influence of the same kind of a progression. As long as we are dealing with matters which involve only the progression (clock time) the direction is immaterial, but when any question involving coordinate time arises, it is again necessary to have a point of reference. In the case of a beam of light, for example, the direction of the progression is from the point of origin of the beam along the path of the beam. Any conclusions involving coordinate time are valid only for this particular reference system, and may be altered very materially if the reference system is changed, as for instance, by considering some other light beam emanating from a different source.

In earlier days when physical science dealt only with relatively low velocities, the contribution of the coordinate time to the total time interval in any physical process was negligible, and it was possible to carry out all calculations involving motion on the basis of clock time only. The advent of high velocity measurements, particularly those concerned with the velocity of light, showed that there was an error somewhere in the system, and it was a study of the background of this discrepancy that led Einstein to his conclusion that, "There is no such thing as simultaneity of distant events."[81] If we are referring to total time, this present study is in full accord with Einstein's conclusion, but for most purposes the *useful* definition of simultaneity is that which regards events as simultaneous if they occur at the same clock time; that is, at the same stage of the time progression, and this kind of simultaneity definitely does exist.

Einstein and his colleagues accepted the "operational" point of view in this instance and rejected the concept of an objectively real simultaneity because of its lack of an operational basis. As Moller explains, "The concept of simultaneity between two events in different places obviously has no exact objective meaning at all, since we cannot give any experimental method by which this simultaneity could be ascertained."[82] The present work shows that this conclusion is in error; that simultaneity, defined as the same clock time, is something that *can* be ascertained by physical means, and this concept can therefore be legitimately employed in any connection in which it happens to be useful: a category that includes most of the applications in which the idea of simultaneity is normally employed. In this sense (the only sense that is of any particular importance to us) Einstein is wrong and there *is* such a thing as simultaneity of distant events.

It is worth mentioning that this case illustrates the validity of one of the principal objections that is advanced against the operational viewpoint. The operational school of thought contends that no physical concept should be employed in the formulation of theory unless there are specific operations by means of which the concept can be defined. The objective of setting up such a qualification is to prevent the use of vague and misleading concepts and ideas in the construction of theory. Such an aim is hardly open to criticism per se, but the weakness of operationalism is that it is necessary to assume that if "we cannot give any experimental method by which this... could be ascertained" as the present time, we will never be able to do so; that is, there is no such method. In the present case, this assumption has been proved wrong, and it could likewise be wrong in any other in stance. This does not necessarily mean that the operational idea has no merit, but it indicates that considerable care should be exercised in applying it.

Another concept which plays a major part in the detailed development of the Relativity Theory, although it is by no means a necessary consequence of the basic postulates of the theory, is that of the *gravitational field.* Einstein makes it clear that, so far as he is concerned, this field is not merely a mental construct or a tool of thought; it is "something physically real." He emphasizes this point by drawing an analogy with a magnetic field where, he says, "...we are constrained to imagine--after the manner of Faraday--that the magnet always calls into being something physically real in the space around it, that something being what we call a 'magnetic field'... The effects of gravitation are also regarded in an analogous manner."[83] In another place he tells us, "The electromagnetic field is, for the modern physicist, as real as the chair on which he sits."[84]

In view of the highly critical comments that have been made and are being made about the theory of the ether, many of which imply that the originators and supporters of that theory were almost incredibly naive in believing in the physical reality of a purely hypothetical concept of whose existence no observational evidence could be detected, it is rather amusing to find the outspoken critics of the ether firmly convinced of the physical reality of the gravitational field: another purely hypothetical concept for which there is no observational evidence. The "field" theory is, in fact, almost an exact duplicate of the "ether" theory. In both cases we find matter and radiation exhibiting certain patterns of behavior that are not explained, or not completely explained, in terms of what is currently known. In order to provide some kind of an explanation of these behavior characteristics there has been invented, in each case, a purely imaginary entity having just those properties which are necessary for the purpose. In neither case is there any *independent* evidence of the existence of the postulated entity; it was necessary to invest both the ether and the field with certain hypothetical properties in order to explain effects that were already known to exist, but we have no indication of any *other* properties or any *other* effects of the postulated properties.

But even though these two concepts are birds of a feather almost down to the last detail, present-day theorists tell us that we should discard the ether, because there is no evidence of its existence, but that we should accept the physical reality of the field, even though this is equally without observational support. The truth is that the theory of the ether is not nearly as lacking in merit as the present-day appraisals suggest; the fact that a physicist of the caliber of P.A.M. Dirac is seriously proposing a return to the ether theory is enough to verify this point. "...the failure of the world's physicists to find such a (satisfactory) theory, after many years of intensive research," says Dirac, "leads me to think that the aetherless basis of physical theory may have reached the end of its capabilities and to see in the nether a new hope for the future."[85] Actually both the ether theory and the theory of the field were reasonable working hypotheses at the stage of development of scientific knowledge in which each was originally proposed, but neither is tenable as matters now stand, particularly in view of the findings of the present study.

The need for these artificial constructs--mental crutches, we might call them--has resulted from unrecognized, but equally artificial, restrictions that have been placed on the viewpoint from which physical problems have been approached. In the case of gravitation it has been taken for granted that there are only two alternatives. Either we must concede the reality of action at a distance: some mysterious power, altogether foreign to physical relationships as we know them elsewhere, whereby one mass can exert an instantaneous influence on another distant mass without any connection between the two, or else we must have some kind of a medium, an ether or a deformable space (which is simply an ether under a different name) through which the gravitational effect is propagated at a finite velocity. In this way all thinking about gravitation has been restricted to the narrow field defined by these two concepts, and since the idea of action at a distance is repugnant to most physicists, the latitude for constructive thought has been reduced to the point where the only thing left for the theorists to do is to speculate about the nature and properties of the gravitational medium. Thus Einstein rejects the ether and gives space the properties of a medium. Then when Dirac is disillusioned with Einstein's theories and concludes that they have arrived at a dead end, he sees no alternative but to return to the ether as "a new hope for the future."

But in spite of the unquestioning acceptance of the existence of this dilemma in present-day science, these are *not* the only alternatives. The development of the Reciprocal System leads to another explanation altogether different from the two which have hitherto been regarded as the only possibilities, and examination of this new hypothesis not only shows that it is a consistent and wholly logical explanation of the observed facts, but also reveals that there are *other* physical phenomena which behave in a similar manner, and hence this is not even a novelty; it is something that has been in plain sight all the time, but has not heretofore been recognized as being applicable to the gravitational situation. We are very familiar with the aftermath of an explosion, in which the individual fragments of debris are moving outward away from each other *as if* they are subject to a force of mutual repulsion. We also find the galaxies behaving in a similar fashion *as if* they are subject to a repulsive force: the force of cosmic repulsion as it is sometimes called. We recognize in these instances that just because the individual units behave *as if* mutually generated forces are acting upon them, we do not necessarily have to conclude that a mutual action actually exists. Here we take the stand, definitely in one case and somewhat tentatively in the other, that there is no mutual action, that each individual unit is pursuing its own independent course and that the interaction is only apparent and not real. Obviously this same explanation could apply to *any* case where individual units behave *as if* they are subject to mutual forces. The prevailing belief that we are forced to choose between action at a distance and propagation through a medium (or a medium-like space) is therefore erroneous; we have a third alternative, and the development outlined in the preceding pages indicates that this third alternative is in agreement with the observed facts at all points.

This new explanation completely eliminates all justification for postulating the existence of a gravitational field as "something physically real." It accounts for all aspects of the gravitational phenomenon in terms of the motion of the individual mass units, without any participation by either a medium or a field. It is legitimate to use the term "field" to describe the region in which the gravitational effect makes its appearance, and to call the magnitude of this effect at any specific location the "strength of the field" at that point. But this is merely an artificial method of expression adopted for convenience: "nothing more than an aid in the calculations that have to be performed,"[29] as McVittie expresses it. The so-called "field" neither acts upon matter nor is itself acted upon by matter.

When the concept of the gravitational field as a physically real entity goes into the discard it automatically carries with it the deformation of space which, according to current theory, creates the field. Actually it is very difficult to distinguish the present-day concept of "space" from that of the "field" or, for that matter, from the concept of the "ether." At first glance these appear to be altogether different entities, but when a closer analysis is made, to determine just how each of these concepts fits into the picture as a whole, the differences tend to disappear. Eddington makes the following comment, referring to the distinction between field and space: "The distinction thus created is a rather artificial one which is unlikely to be accepted permanently."[86] At the same time, it is commonly recognized that the distinction between the ether and the present-day concept of space is almost entirely verbal. As R. H. Dicke puts it, "One suspects that, with empty space having so many properties, all that had been accomplished in destroying the ether was a semantic trick. The ether had been renamed the vacuum."[1] Marshall J. Walker says flatly, "The distinction between "space" and "ether" is largely semantic."[87]

Two general concepts of the nature of space have come down to us from the philosopher-scientists of antiquity. One viewpoint--that held by Aristotle--regards space merely as a *relationship* between material objects, while an opposing view, favored by Democritus and his fellow atomists, regards it as a *container* in which these material objects exist. Neither of these concepts provides any *connection* between the objects; on the contrary, they are merely different ways of looking at the *discontinuity* between them. As scientific knowledge expanded, however, more and more phenomena were discovered which the scientific profession was unable to explain without some kind of a physical connection between these material objects: the transmission of radiation, the existence of gravitational effects, electric and magnetic phenomena, etc. The concept of the ether was therefore invented to meet the requirements of this situation. As originally conceived, this ether was a substance pervading all space in somewhat the same manner that the air fills the otherwise unoccupied space in our local environment. It then constitutes the connecting medium through which the various effects are transmitted.

The principal weakness of the ether theory, aside from the total lack of any independent evidence of the existence of anything of this kind, is that when the ether is postulated to be a "substance" it becomes identified with material substances, whereas the properties which it must have in order to perform the functions for which it was invented are incompatible with those of material substances. It must, for example, be more rigid than steel, in order to account for the transverse vibration of electromagnetic radiation, but at the same time it must be even more fluid than the lightest gas, in order that material objects may move through it without frictional effects. What Einstein and his colleagues have done is to attribute to space all of the properties that were previously conceived as properties of the ether. Thus the utility of the ether as a medium is retained--space itself has now become a medium--but inasmuch as this medium is no longer identified as a "substance" there are no longer any restrictions on the kind of properties that can be postulated. Who can say for instance, that a rigid *space is* incompatible with the absence of friction?

The difficulty of distinguishing between the concepts of "space," "field" and "ether" is a result of the fact that, as currently employed, all three terms refer to the same thing: the hypothetical universal medium. The significant properties that are attributed to these entities, the properties that are actually needed for the performance of their assumed physical functions, are the same in all cases; the only differences between them are in connotations of the language employed that are carried over from the sources from which that language was derived, but have no meaning in the terms of reference of current theory. The word "field," for instance, calls up a considerably different conceptual image than the word "space," yet if we examine the way in which each word is used *in present-day physical theory*, we are compelled to agree with Eddington that any distinction between the two is purely artificial.

The present confusion in this area is largely chargeable to Einstein. Before his day the accepted world picture included an ether located in and coextensive with space. It is commonly contended that Einstein's system eliminated the ether and accounts for gravitation as a product of the geometry of space, but in reality what he did was to eliminate the *name* "ether" and the *concept* "space." The entity to which he applies the name "space" is the same one that was previously called the "ether." His "space" has all of the properties that were formerly assigned to the ether concept: properties that are altogether different from those of the previous concept of space, and likewise totally unlike the properties which we are able to recognize in space where we are in a position to observe it.

Even Einstein himself was forced to admit that the ether still exists in his system: "...we may say that according to the general theory of relativity space is endowed with physical qualities;

in this sense, therefore, there exists an ether."[88] In another connection he elaborates, "But therewith (through the General Theory) the conception of the ether has again acquired an intelligible content, although this content differs widely from that of the ether of the mechanical undulatory theory of light. The ether of the general theory of relativity is a medium which is itself devoid of *all* mechanical and kinematical qualities, but helps to determine mechanical (and electromagnetic) events."[89] Elsewhere we find this significant admission: "We shall say: our space has the physical property of transmitting waves, and so omit the use of a word (ether) we have decided to avoid."[90]

The view of space as the *discontinuity'* between physical objects, which is basic in both of the traditional concepts of the nature of this entity and which is the essence of the meaning attached to the word "space" in everyday usage, has now been discarded, and space has become the *connecting medium* between the objects. "There is then no 'empty' space," Einstein asserts, "that is, there is no space without a field."[91] Thus a totally new concept of space has been introduced.

Then, to compound the confusion, Einstein insists that in the General Relativity Theory gravitation is solely a result of a deformation or curvature of this redefined space, resulting from the presence of mass, and he makes it clear that in his opinion he has reduced gravitation to a property of space-time. Yet he is equally insistent that the gravitational field is, as he puts it, "something physically real in the space." Here again is a direct contradiction similar to the one pointed out in connection with the mass-energy relations. If gravitation is simply a geometrical effect, as Einstein claims, there can be no "physically real" entity which produces gravitational effects; if there is a physically real gravitational field "in the space" as Einstein also claims, then gravitation is not a purely geometrical affect. He cannot have it both ways. If it were not for the "exceedingly complex and difficult" nature of the General Theory, which has insulated it against effective criticism, both this and the equally glaring conflict in the mass-energy relations no doubt would have been recognized long ago.

In retrospect it is clear that gravitational theory was diverted into the wrong channel at the very beginning of its development by the uncritical acceptance of the concept of gravitation as an action of one mass upon another. No subsequent skill or ingenuity could compensate for such a serious initial error, and the "failure" of the currently accepted theory to which Dirac refers in the statement previously quoted was inevitable from the start.

Einstein presents one independent argument in support of his "curved space" hypothesis which deserves special comment. He points out that a gravitational force following the inverse square law in an Euclidean universe is incompatible with a uniform or approximately uniform density of matter. On such a basis, he says, "The stellar universe ought to be a finite island in the infinite ocean of space."[92] A. C. B. Lovell elaborates the same thought in these words: "The application of Newton's theory of gravitation, in which the attraction between bodies varies inversely as the square of their distance apart, to the large-scale structure of the universe would require that the universe had a center in which the spatial density of stars and galaxies was a maximum. As we proceed outwards from this center the spatial density should diminish, until finally at great distances it should be succeeded by an infinite region of emptiness."[93]

It is evident that the observed universe does not conform to this theoretical condition that would result from the assumed premises, and Einstein therefore arrives at the conclusion that space must be curved so that it is finite in extent even though unbounded. But this argument contains a hidden assumption: the assumption that the gravitational force of each individual mass is effective over infinite space. According to the new information presented herein, this is not true. There is a gravitational limit for each mass and a net gravitational force exists only within this limit. Einstein's argument is therefore valid only for the region within the gravitational limit of each mass aggregate, and in each of these regions the observed behavior is just what he claims it would be if space is Euclidean; that is, each galaxy and each star system (single star or multiple star system) is a "finite island in the ocean of space" defined by the gravitational limits of that galaxy or star system. Even before the true nature of the external galaxies was definitely established, Kant and others were referring to these objects as "island universes." Einstein's point therefore not only ceases to be a valid argument *against* Euclidean space, but becomes an argument in *favor* of the Euclidean system.

One of the most frequent comments offered by those who have become acquainted with the gravitational theory of this work through previous publications concerns the relatively minor use of mathematics in the development. "I am particularly puzzled about the lack of mathematics associated with your methods," writes a British correspondent, "surely in order to show the superiority of your theory you must be able to predict all the experimental facts explained by present theories and more. It is difficult to see how you will do this without setting the whole thing on a rigorous mathematical basis." Another correspondent asks, "Can you put your theories into a tensor formulation?"

These comments reflect a general misconception that has developed in science, particularly in physics, within the present century, in which the "rigor" of the mathematical treatment is judged on the basis of its length and complexity, not on the basis of its adequacy for the task at hand. Following Einstein's lead in calling upon complex mathematics in an attempt to compensate for conceptual errors, present-day physical theory has become largely a juggling of abstract mathematical relationships, the meaning of which (if any) "we do not ask," as Eddington says. As so often happens when form is overemphasized, form rather than substance has come to be regarded as the essence. To arrive at a result in the realm of basic theory by plain arithmetic or simple algebra is today unthinkable; unless we can express that result in terms of tensors, or spinors, or matrix algebra, or some other currently fashionable mathematical device, it is automatically unacceptable.

How far would Newton get today with his gravitational equation? Could such a simple expression as

$$F = G\frac{m\ m'}{d^2}$$

ever hope to receive any consideration from a generation of physicists accustomed to tensors of the fourth rank? Obviously not. But this simple and unpretentious equation is the only *practical* expression of the gravitational effect ever formulated: the only one that gives us answers to *real* problems. To the engineer gravitation and Newton's Law are synonymous, and as Einstein himself admits in the statement previously quoted, this simple law "still remains the basis of all astronomical calculations." What this present work has done is to show that this simple expression that gives such remarkably good results in all practical applications is an *exact* statement of the theoretically correct relationships and that, in its proper context, it is *universally applicable*. On this basis there is no need whatever for any new mathematical development; Newton gave us all of the necessary mathematics three hundred years ago. Simple as his expression is, the present analysis indicates that it cannot be improved upon.

The gravitational theory derived from the postulates of the Reciprocal System is Newton's gravitational law. The detailed development of this theory shows that the objections that have been lodged against Newton's Law by modern investigators are based on erroneous conclusions, and that his gravitational equation is actually valid throughout the universe, precisely and with no exceptions. As has been pointed out previously, the only one of the items of evidence currently offered in support of Einstein's proposed modification of Newton's gravitational ideas that can stand up under critical scrutiny is the advance of the perhelion of Mercury, and the new information developed in this work shows that this is due to the high velocity of the planet and has no connection with gravitation. It is a result of the same factors which are responsible for the negative outcome of the Michelson-Morley experiment, not of any deficiency in the gravitational law.

The other objections of a less tangible nature that have been advanced against Newton's theory have been similarly overthrown. Eddington lists three such objections.[65] "The most serious objection against the Newtonian law as an exact law was that it had become ambiguous," he tells us, and then continues with the statement previously quoted in part, "The law refers to the product of the masses of the two bodies; but the mass depends on the velocity--a fact unknown in Newton's day." Even without the evidence from the present work which shows that mass does *not* depend on the velocity, it is obvious that this is not a "fact"; whenever such a statement is challenged it has to be admitted that this concept of an increase in mass is purely an arbitrary selection from among several possible explanations of the experimental facts. Here is a good illustration of the extreme lengths to which modern physicists have gone in their attempt to build up a case against Newton. When the "most serious objection against the Newtonian law" is based on a totally unsupported assumption it is evident that the other objections must be flimsy indeed.

Such a conclusion is fully justified by Eddington's next objection, which is that Newton's theory is incompatible with a finite velocity of propagation of the gravitational effect. "In the theory given in this book," he says, "gravitation is propagated with the speed of light..." In other words, Newton is wrong because his assumption does not agree with Eddington's assumption. This present work demonstrates that gravitation is not propagated with the speed of light, nor is it propagated instantaneously; it is not propagated at all: a fact which is fully compatible with Newton's theory. Likewise this work disposes of Eddington's third objection: "Further, *distance,* also referred to in the law, is something relative to an observer..."

In the simple, completely understandable world of the Reciprocal System all of these present-day objections are swept away and Newton's gravitational equation is valid throughout the universe, from the smallest region to the largest. Where, then, is there any place for complex mathematics? Do we need to call upon matrix algebra or tensors to restate the Newton equation? The whole idea of a more "rigorous" mathematical foundation is preposterous. If the mathematics at hand are fully adequate for their purpose there cannot be anything more complete or more rigorous, even if the mathematical formulation amounts to nothing more than a statement that two plus two equal four. Once it has been established that the Reciprocal System leads to Newton's gravitational law and that it demolishes the objections that have hitherto been raised against the universal validity of that law, there is nothing further for mathematics to do. Newton's equation cannot be made any simpler and nothing can be gained by expressing it in a more complex manner.

Present-day basic physical theory does not need more mathematics--it is overflowing with mathematics already. What it needs is a conceptual clarification that will enable making full use of the physical knowledge and the mathematical tools already available. This is the objective of this present work: not to add to the profusion of abstruse mathematical speculations now in existence, but to identify the conceptual errors in the previous development of theory and to point the way to the changes in thinking that are necessary in order to make full use of the mathematical and theoretical equipment already on land.

It is not contended here that *all* phases of Newton's system are universally valid; on the contrary, the Reciprocal System agrees with currently accepted physical theory in the conclusion that Newton's Laws of Motion must be modified in application to high velocities. Again, however, there is no need for any elaborate mathematical development. The Reciprocal System raises some serious questions as to whether any useful purpose is served by expressing the high velocity relationships in terms of clock time, in accordance with current practice, but if any such purpose exists, this system leads directly to the same mathematical expressions--the Lorentz transformations--that are utilized by currently accepted theory. Once again, therefore, we find the necessary mathematics already in existence, and further mathematical development is wholly superfluous.

At this point it should again be emphasized that the mathematical aspects of Einstein's Special Theory did not originate from that theory; they are purely empirical relations which were current in physical circles before the Relativity Theory was formulated. The Michelson-Morley experiment showed that the velocity of light is independent of the reference system. This made it clear that if the existing concepts of space, time and motion were to be retained, a variation of distance (and perhaps time) with velocity must be introduced, and the amount of the necessary variation can be readily calculated in a straightforward manner from empirical data. Such a calculation led to the conclusion that distance magnitudes are reduced by the factor $(1\text{-}V_2/C_2)^{1/2}$ when bodies in motion are observed from a reference system at rest, whereas the corresponding time magnitudes are increased by the same factor. As an empirical relationship, this result is obviously valid regardless of the theoretical approach that is employed and no theory is acceptable unless it arrives at the same or an equivalent result.

This answer to the problem is *conceptually* wrong; that is, space and time magnitudes are in fact absolute and a change in reference system does not alter them, other than to introduce the differences between the coordinates of the reference systems. Time does not pass more slowly in a moving system nor does space contract. But for this special case, where the relative motion is uniform and translatory, the correct *numerical* results can be obtained by assuming a fictitious contraction of space and dilatation of time, and what Einstein did was to set up the mathematical and theoretical framework of a system that would accomplish this result. In spite of the fact that this system is conceptually wrong, it is mathematically correct for this special case. Obviously it *must* be correct if the error in using clock time only is a function of the velocity, since the correction factor was obtained empirically.

Let us now examine the theoretical basis of this empirically determined correction factor. According to the principles of the Reciprocal System, the distance measured on the basis of Euclidean geometry is the true coordinate distance regardless of velocities and irrespective of the system of reference (as long as the reference system qualifies as a legitimate one on the basis of the criteria previously specified). In any application within our own galaxy, where we do not have to take the galactic recession into account, we are dealing with coordinate distance only, and hence this measured coordinate distance is also the total physical distance.

Similarly, the time measured by any accurate clock is the true clock time irrespective of whether the system of reference in which the clock is located is stationary or in motion, and thus the clock time interval is also an absolute magnitude. But when an object is in motion it is not only moving in clock time, the quantitative expression of the motion of the progression, a motion that all material objects participate in, even when they are at rest in our usual system of reference, but is also moving in coordinate time, analogous to coordinate space. If we are dealing with the velocity of light, which is one unit of space per unit of time, any points which are separated by n units of coordinate space are also separated by n units of coordinate time. This coordinate time difference is separate and distinct from

Figure 6

the clock time and must be added to the clock time to obtain the true physical time, just as we had to add the random motion of the distant galaxy to the motion of the galactic recession before we could determine where the galaxy would actually be found. It is evident that the velocity of light is always unity in such a system, but it is likewise clear that when we take the coordinate time into consideration as well as the clock time, there is no conflict between the constant velocity of light and the absolute magnitudes of the space and time intervals involved.

Inasmuch as any material particle is continually passing from one unit of space to another (since it is moving against the direction of the space-time progression) and the direction of the progression of each new unit is indeterminate, the motion of such a particle is distributed equally in all spatial directions. Radiation in free space, on the other hand, maintains the same spatial direction indefinitely, as the photon has no independent motion of its own. It follows that whether a particle is in motion or at rest relative to our usual reference system, and regardless of what direction in coordinate space any such motion may take, the particle is moving with the progression, and hence with the radiation, half of the distance that it travels and opposite to the direction of the radiation during the other half. We may therefore treat any movement of light or other radiation relative to material objects as if it involved a round trip, irrespective of the situation that may prevail in the usual system of reference.

Let us assume that a light signal originates at point A on a rigid rod AB which is in motion toward the right of the diagram, Fig. 6, with velocity v. The light signal travels to the point B. which in the meantime has moved forward to B', and here it is reflected back. By the time it completes the round trip, point A has moved to A', and the round trip is AB'A' rather than ABA. If we analyze this situation on the basis of the assumption (accepted by both Newton and Einstein) that physical time consists of clock time only, the distance traveled by the signal is ct. since we have found from experiment that the velocity of light is constant irrespective of the reference system. The time t, according to Newtonian principles, is the distance AB, which we will call s, divided by the net velocity c-v on the outward trip and the same distance divided by the net velocity c+v on the return trip This gives us

$$t = \frac{s}{c-v} + \frac{s}{c+v} = \frac{2 \cdot c \cdot s}{c^2 - v^2}$$

Multiplying by c, we then have the distance traveled:

$$\frac{2 \cdot c \cdot s}{c^2 - v^2} \times c = \frac{2 \cdot s}{1 - \frac{v^2}{c^2}}$$

At rest, the round trip distance ABA is 2s. Now we find that if we insist on expressing our results in terms of clock time only, we must introduce a mathematical correction equivalent to reducing distances applying to objects in motion by the factor $1\text{-}v^2/c^2$, in order to be consistent with the distances measured at rest. Since space and time are reciprocally related in velocity, the correction does not necessarily have to be applied to the distance; it can be applied either to distance or to time or to both. In the light of the points developed in this volume it would be most logical to apply the correction to time, since it is through a misunderstanding of the nature of time that the whole difficulty arises, but as the Relativity Theory actually developed, the correction was divided equally between space and time, the distance being reduced by the factor $(1\text{-}v_2/c_2)^{1/2}$ and the time extended by the reciprocal of this factor.

As indicated in the preceding discussion, the advance of the perhelion of the planet Mercury, which is commonly interpreted as indicating a deficiency in Newton's gravitational law, is actually a result of the same misconception of the nature of time that the Special Theory tries to compensate for. The orbital velocity of Mercury is approximately 29.8 miles/sec, which, in terms of the velocity of light as unity, is .00016. The correction for the coordinate time, v^2/c^2, is then 2.56×10^{-8}; that is, the clock time must be increased by this factor. Since the gravitational motion is inward, the scalar space-time direction of the orbital motion is outward, and the computed time increase is radial. To obtain the circumferential space equivalent of this linear time increase, we multiply by π obtaining $8.04 \text{ X } 10^{-8}$, or .1042 seconds of arc per revolution. This amounts to 43.35 seconds per century, which agrees with the observed advance of the perhelion, within the accuracy of the measurements. Tolman reports 43.5 seconds per century as the observed value and 42.9 seconds per century as the result obtained by calculations based on the Relativity Theory.

In connection with this discussion of the incidental aspects of the gravitational situation, it may be in order to make some comments about the methods of approach to the problem which were utilized in the construction of the three theories that have been discussed: Newton's Law, Einstein's General Theory, and the gravitational theory derived from the Reciprocal System.

Newton's gravitational theory was developed during a relatively early scientific era in which basic physical concepts were simple and direct. When and if a theory became inadequate the corrective measures were applied to the basic concepts; these were drastically modified or else discarded and replaced by other simple and direct concepts. Einstein's General Theory, on the other hand, is a product of the more sophisticated and ingenious modern school, which relies upon mathematical techniques to fit existing concepts to the observed facts rather than giving up basic ideas which encounter trouble. If a theory which agrees with the observed facts in a restricted area fails in application to a broader field there is, of course, a very strong probability that the theory is in error in some important respect. But abandonment of a cherished theory or concept is extremely distasteful, not only to the author of the theory, but also to those who have accepted it and have based their own thinking upon it, and in recent times the tendency has been to call upon an increasingly numerous assortment of devices whereby the theories can be made "looser" and accommodated more readily to a wider range of observational data, thus avoiding the painful necessity of parting with familiar and comfortable habits of thought.

One of the easiest ways of avoiding conflict with the facts is to make the theory less specific. At the present time, for example, there is a great deal of activity that is directed toward the construction of semi-theoretical mathematical expressions designed to represent physical properties of matter. The usual practice is to start with some purely theoretical relation, such as the general gas law $PV = RT$. In order to secure better agreement with the experimental results this relation is then modified by additional terms and adjustable constants. In developing the first "equation of state" for gases from the general gas law, Van der Waals used two such constants. For a better fit with the experimental data, subsequent equation constructors have increased the number of these adjustable or "disposable" constants. The Beattie-Bridgeman equation has four; the Benedict-Webb-Rubin equation has eight.

If the objective of this activity is the attainment of close agreement with the experimental values for the purpose of facilitating interpolation and extrapolation of the experimental results, the prevailing policy has been successful, since the correlation is, in general, increasingly better as the number of constants is increased. But if the objective is to ascertain the *correct* relationships and numerical values, this program of increasing the flexibility of the equation by adding more and more adjustable constants is definitely proceeding in the wrong direction. Every added constant makes it easier for the equation to fit the experimental data, to be sure, but in so doing it correspondingly decreases the probability that the equation and the results obtained from it are correct. This is an inescapable mathematical consequence of the increase in the number of possible variations of the experimental data which will agree with the equation.

In order to make progress toward the correct answers it is essential to reduce rather than increase the adjustability of the equation. As we move in this direction we must obviously keep the results of the calculations within the limits of experimental uncertainty, and we can move only as fast as we are able to devise new modifications that will stay within those limits, but as long as this requirement is met, every additional restriction that can be placed on the quantities entering into the calculations increases the mathematical probability that the values obtained from these calculations correctly represent the true physical magnitudes.

The difficulty with this line of approach is that it is the hard road to follow. The prevailing practice of increasing the flexibility of the mathematical expressions through the addition of more adjustable constants or similar means follows a well-defined path: one which is almost certain to achieve results of some kind if sufficient time and effort are applied to the task. Most attempts to make progress toward the difficult goal of a more restrictive equation, on the contrary, will inevitably end in nothing but frustration and disappointment, and ordinarily no really significant advance can be made without discarding some cherished idea of long standing. The preference for the easy route is therefore quite understandable, but here, as in so many other lines of human endeavor, true forward progress can only be made in the hard way.

The situation in such areas as gravitational theory is not quite as obvious as that which results from the addition of successive adjustable constants to the equations of state, but any measure that increases the flexibility of a theoretical relationship so that it can more readily accommodate itself to the experimental data produces the same results as these added constants: it increases the number of possible situations which can be made to agree with the postulated relation and hence decreases the mathematical probability that the relationship is correct. A theory such as Special Relativity which denies the constancy of the magnitudes of space and time intervals has a smaller probability of being correct than one which accepts fixed space and time magnitudes, providing that neither is inconsistent with the observed facts. A theory such as General Relativity which goes still farther in the same direction and eliminates the "metrical meaning" of the coordinates that are employed in describing these magnitudes has a still lower probability of being correct, and if Einstein had succeeded in his attempt to devise a general field theory by further loosening of the theoretical structure along similar lines, the a *priori* probability of the validity of such a theory would have been essentially negligible.

In this connection, Bondi makes the comment, "...it may justifiably be asked at this stage, when the mathematical complexity of the theory emerges, why Einstein should require ten potentials of gravitation where one was good enough for Newton."[94] The answer is, of course, that instead of locating and correcting the error in the basic space-time concepts of Newton's gravitational theory Einstein set up a looser and more flexible theory that can be stretched far enough to cover the observational facts with the error left intact. His gravitational potentials serve exactly the same purpose as the eight adjustable constants of the Benedict-Webb-Rubin equation of state; in both cases mathematical flexibility is substituted for a correct conceptual foundation.

Every *ad hoc* assumption that is made in the construction of the theory has the same kind of an effect on the probability of the validity of the theory as the addition of one of these adjustable constants or potentials. Since there is no independent evidence of a deformability or curvature of space, any theory which postulates such a property has a lower probability of being correct than one which does not have to resort to an unsupported postulate of this kind, other things being equal. The same is true of any other *ad hoc* postulate. Here again, as in the formulation of equations of state and similar mathematical expressions, true forward progress toward the ultimate goal can come only by way of an increasingly restrictive approach: one which decreases, rather than increases, the employment of *ad hoc* assumptions. This ultimate goal, as defined in Part One, is a verifiable first order explanation: a theoretical structure which is based solely on simple assumptions as to fundamental properties of the universe, the validity of which can be independently confirmed, and which is consistent with all positively established facts in its field, without exception. Such a theory, by definition, cannot rely upon any *ad hoc* assumption anywhere in the line of development. Progress toward that theory must therefore involve a reduction in the amount of reliance placed on such assumptions, either by eliminating the need for certain assumptions, or by deriving their substance from the basic postulates of the theoretical system, so that they no longer have the *ad hoc* status.

The validity of the foregoing assertions is practically self-evident. Such ideas are, however, given scant consideration in current scientific thinking, not because of any disagreement in principle with the contention that this is the true route toward a complete, logical and understandable theory if such a theory exists, but rather on the ground that such a goal is an impossible one. There is a very general tendency to extrapolate *it has not been done* to *it cannot be done* and to conclude that whatever science has failed to accomplish after making a serious attempt must be unattainable. As Philipp Frank expresses the current attitude, "the belief that science will eventually reveal the 'truth' about the universe" is a nineteenth century idea that "broke down" during the last decades of that century.[95] Those who adopt this viewpoint realize that their conclusions will be met with amazement and incredulity outside of their own circle. "To the outsider," says Henry Margenau, "the conclusions reached by a modern physicist seem almost like a declaration of the bankruptcy of science."[96] But the "modern physicist" cannot envision the possibility that this outside viewpoint may be a correct appraisal of the situation and that he and his colleagues may be on the wrong track. Margenau merely reflects the general sentiment of the scientific community when he *assumes* as a basis for an extended consideration of the problem of formulating physical theory that a comprehensive, clearly understandable general physical theory is impossible.

From this premise he then reasons that we have two alternatives. One possibility is to utilize some intelligible model as far as it will go, and then set up additional, probably incompatible, models of the same kind to cover the areas outside the scope of the original model. This was the idea expressed by Jeans: "The most we can aspire to is a model or picture which shall explain and account for some of the observed properties of matter; where this fails, we must supplement it with some other model or picture, which will in its turn fail with other properties of matter, and so on."[97] The second alternative, according to Margenau, the one which he favors personally, is to achieve more generality by making the theory more abstract. In following this line of development "models lose their... intuitable features; in short, abstractness is the price science pays for embraciveness of conception."[98] This is the philosophy of the two major theoretical developments of recent times: Relativity and the various quantum theories.

When we subject Margenau's conclusions to a critical examination, however, it is apparent that the so-called trend toward abstraction is not so much a matter of making the theory more *abstract,* but of making it more *flexible, so* that the theorist can meet further demands on his constructions without having to face the distasteful necessity of altering any of his basic concepts. The Special Theory of Relativity, for example, did not produce the correct results when applied to non-uniform motion, hence Einstein introduced some further flexibility--abandoning the "metrical meaning" of his coordinate systems, and abandoning the fixed and determinate Euclidean geometry in favor of a geometry of variable space curvature--in order to stretch the basic elements of the Special Theory far enough to cover the more general situation. As he explains, "But in sketching the way in which it (the construction of the General Theory of Relativity) was accomplished we must be even vaguer than we have been so far. New difficulties arising in the development of science force our theory to become more and more abstract."[99] The word "abstract" is thus being used as a synonym for "vague."

But all this is a means of evading the issue, not of meeting it. If Newton's Laws of Motion do not give the right answers in application to bodies moving at high velocities, the clear implication is that there is some error in the basic assumptions underlying these laws, as Einstein recognized. If the Special Theory of Relativity fails to give the right answers in application to non-uniform motion, the equally clear implication is that there is an error in the basic assumptions of this Special Theory, but Einstein was not willing to accept, in application to his own theory, the conclusion which seemed so clear to him so far as Newton's system was concerned, and the introduction of more flexibility or abstraction was simply a way of avoiding the necessity of facing this uncomfortable situation.

It is quite understandable that the author of a theory that has received general acceptance and widespread public acclaim should be reluctant to concede that there are fundamental defects in this theory and should resort to every possible expedient to save this invention that has brought him fame, but there is no good reason why the scientific profession as a whole should meekly acquiesce in a course of action dictated by proprietary pride rather than by scientific considerations, and Einstein should not have been permitted to run away from the problem. In order to arrive at the correct answer, it is obviously necessary to move in the opposite direction from Einstein's course: to ascertain just where the basic assumptions are wrong and then to make the appropriate correction. As the findings of this work indicate, Einstein was right in his conclusion that there is an error in the basic assumptions of Newton's Laws of Motion, but he was wrong in his conclusion as to the location of the error and the measures that were required in order to correct it, and his insistence on maintaining his original constructions intact at all costs has simply blocked all progress toward the correct answer. Actually both Newton's Laws of Motion and the Special Theory of Relativity foundered on the same rock: an erroneous concept of the nature of time. No amount of additional "abstraction" can compensate for such a basic error, except in the very simplest situations.

Modern theorists pride themselves on having eliminated the "rigidity" of previously existing scientific concepts. Heisenberg states the case in these words: "Coming back now to the contributions of modern physics, one may say that the most important change brought about by its results consists in the dissolution of this rigid frame of concepts of the nineteenth century."[100] But this "rigid frame" is one of the prerequisites for true progress; any change should be in the direction of more rigidity rather than less. As long as the experimental evidence shows that the gravitational action is instantaneous and that there is no medium, nothing of any real value can be accomplished by evading the "rigidity" of these observed facts and constructing a theory "floating in air" as modern practice has been described. No genuine forward progress can be made in this area unless a theory based on instantaneous action without a medium can be devised, and until such a theory makes its appearance (as it now has) the only sound policy is to follow Newton's example and accept the empirical facts with the realization that their underlying significance is unknown, however great a blow this may be to the ego of the theorist. Attempts to circumvent these observed facts by greater abstraction or mathematical manipulation are futile; they simply direct the time and effort of the scientific profession into channels that lead nowhere.

The development of the consequences of the postulates of the Reciprocal System has now demonstrated that Newton was right: that an explanation *can* be found for gravitation which accounts for all of the observed characteristics of this phenomenon in terms of the familiar concepts of everyday experience, without any medium and without action at a distance. The mere existence of this third alternative automatically invalidates all constructions based on the argument that only the two previously recognized alternatives are available. It is now obvious that the present-day policy of maintaining basic physical theories intact at all costs--by abstraction or other evasive devices--has accomplished nothing in this instance but to postpone the day of reckoning and to waste countless hours of scientific effort. Physics would have been far better situated now if the "rigid frame" of pre-Einstein theory had been maintained and the time and effort of the scientific profession had been channeled into activities directed toward identifying and correcting the error in the basic premises of gravitational theory, instead of being devoted to fruitless wanderings in a maze of complex mathematics and abstract theoretical concepts.

In Newton's era it was generally agreed that physical theory was to be derived from experiment and observation in the first instance, and that the development of such theory was essentially a matter *of* applying mathematical and logical processes to the basic information derived from these physical sources. As Einstein describes the situation, "... the scientists of those times (the 18th and 19th centuries) were for the most part convinced that the basic concepts and laws of physics were not in a logical sense free inventions of the human mind, but rather that they were derivable by abstraction, i.e., by a logical process, from experiments."[60]

Einstein asserts, however, that we cannot get a true picture in this way: by observation or by theoretical constructs based on observation. "Since, however, sense perception only gives information of this external world or of 'physical reality' indirectly," he says, "we can only grasp the latter by speculative means,"[101] and he specifically condemns Newton's line of approach in these words, "Newton... still believed that the basic concepts and laws of his system could be derived from experience... the tremendous practical success of his doctrines may well have prevented him and the physicists of the eighteenth and nineteenth centuries from recognizing the fictitious character of the foundations of his system."[102] Elaborating this thought in another connection, he continues, "The theoretical scientist is compelled in an increasing degree to be guided by purely mathematical, formal considerations in his search for a theory, because the physical experience of the experimenter cannot lift him into the regions of highest abstraction."[103]

In these statements Einstein is advancing the curious contention that it is possible to derive from purely theoretical processes specific information about the physical world that cannot be obtained, directly or indirectly, from observations of the physical world itself. One might hesitate to believe that he actually meant what these statements seem to say, were it not for the fact that he repeats them over and over, and acquiesces in interpretations of his views such as that of F. S. C. Northrop, who states plainly, "It has been noted that the basic concepts of deductively formulated scientific theory as conceived by him (Einstein) are neither abstracted from nor deduced from empirically given data... they are concepts of a kind fundamentally different from the nominalistic particulars which denote data given empirically... And because the theoretic term cannot be derived from the empirical term, theoretic physics contributes something of its own to the scientific conception of nature and reality."[104] Einstein's approval of this statement may be inferred from his high praise of the article in which it appeared. "I see in this critique," he says, "a masterpiece of unbiased thinking and concise discussion, which nowhere permits itself to be diverted from the essential."[105]

Here is strange doctrine indeed. Even the Kantian concept of a *priori* knowledge, which asserts that we have an inherent perception of certain truths that makes physical observation unnecessary in these particular areas, does not go anywhere near this far. Kant's viewpoint does not claim that there are facts of nature, which cannot be determined from observation; it merely contends that observation is superfluous in these particular instances. Now we meet the strange contention that. The information, which we derive directly from experience, is "fictitious" and that theoretical processes can give us authentic information about the physical world, which cannot be obtained by observation or by logical processes based on such observation. Modern physical science has lived in its dream world of "free inventions" and mathematical theories "floating in air" for so long that, like any individual who withdraws from reality and builds his own world of fantasy, the scientist has now arrived at the stage where the phantoms of his imagination seem real and the physical realities appear fictitious.

The truth is that this contention that there are physical facts which are inherently beyond our ability to observe or measure, or to ascertain by mathematical or logical processes based on such observation or measurement is preposterous. Perhaps there are some facts which are beyond the capabilities of existing methods, but even this is a highly questionable assumption as there is little reason to believe that we are anywhere near the point of having exhausted the potentialities of the methods now available. Furthermore, the possibilities in the way of developing new methods are, so far as we are aware, essentially unlimited. We cannot say, therefore, in any particular case that it is impossible to devise a method that will serve our purpose. Hence, if the theoretical processes furnish "something of their own"--some information which cannot be "abstracted or deduced from experimentally given data"--this is not information about the physical world. If it has any meaning at all, it is simply information about the theory, or the model, which has been set up to represent the physical reality. It belongs to the dream world, not the real world.

The question then naturally arises, how did a scientist of Einstein's competence ever come to formulate such an upside down viewpoint as this: a viewpoint from which the data of experience are "fictitious" and only the "free inventions of the human mind" can represent "physical reality"? Fortunately for the peace of mind of future historians of science, who would otherwise be confronted with a baffling enigma, he supplies the answer himself. "It was the General Theory of Relativity which showed in a convincing manner the incorrectness of this view," he says, referring to his description of the 19th century viewpoint previously quoted. He points out that Newton's theory agreed with the facts over a very wide area, and that the General Theory achieves a still wider range of agreement, over most of which it also agrees with Newton's results. Thus it is possible to obtain "a large measure of agreement with experience" from two widely different bases, from which fact he draws the conclusion: "This indicates that any attempt logically to derive the basic concepts and laws of mechanics from the ultimate data of experience is doomed to failure."[60]

To Einstein, the lover of pure theory, already strongly predisposed to regard his theories as something more than mere tools of thought ("To him who is a discoverer in this field the products of his imagination appear so necessary and natural that he regards them, and would like to have them regarded by others, not as creations of thought but as given realities"),[106] this was enough. "...The axiomatic basis of theoretical physics cannot be an inference from experience, but must be free invention..."[60] he tells us. The process of constructing a theory from such "free inventions" is described by Rudolf Carnap in these words: "The calculus is first constructed floating in the air, so to speak; the construction begins at the top and then adds lower and lower levels. Finally by the semantical rules, the lowest level is anchored at the solid ground of the observable facts." Philipp Frank, who quotes the foregoing passage in a discussion of Einstein's methods, goes on to say, "This conception of logical empiricism seems to be fairly in accordance with the way Einstein anchored his theory of gravitation in the solid grounds of observable facts by deriving phenomena like the redshift of spectral lines, etc."[107]

The most appropriate comment that can be made on this statement is to repeat the previously quoted up-to-date opinion as to the true status of the gravitational red shift: "the red shift follows from more elementary considerations and is not really a test of general relativity."[56] In other words, the "solid grounds of observable facts" have turned out to be quicksand.

The fatal weakness in Einstein's concept of deriving the basic laws of physics by "free inventions of the human mind" is that this policy makes no provision for correcting any errors in the premises, which are accepted as the foundation for the inventions. In essence this puts the scientific investigator in the same position as a mechanical computer. He can accomplish only those results, which are obtainable by manipulation of the data that are put into the system in the original program; if those data are erroneous then the answers that are obtained are necessarily wrong. The validity of the Special Theory of Relativity was programmed into

Einstein's mental analogue of the mechanical computer. His development of General Relativity and his attempt at development of a general field theory were therefore limited to what could be done by building on the Special Theory. Had that theory been conceptually correct, rather than merely a device, which attained mathematical validity by counterbalancing, one conceptual error with another, this procedure might well have been successful. But the *usual* reason for the protracted existence of a difficult physical problem is, as in this case, an error in the premises on which the theoretical reasoning is based, and Einstein's methods were unable to cope with such a situation. He could only take refuge in what Margenau describes as making the theory more "abstract": a term, which Einstein himself admits, is synonymous with making it more vague.

The possibility that errors in the basic premises of physical theory can be found and corrected by "free inventions of the human mind" is quite remote. Any program such as Einstein's which relies on more and more abstraction definitely excludes any such possibility, since the need for any correction becomes progressively less apparent as the development of theory makes the conceptual structure progressively more vague. Some other purely speculative program might be better adapted to the purpose, but *any* procedure of this kind encounters almost insuperable obstacles. Innate resistance to altering long-established habits of thought, both on the part of the investigator himself and on the part of those who evaluate his work, is a powerful factor in this connection, but a still more formidable obstacle is the sheer inability of the human mind to devise conceptual innovations of the necessary scope, and magnitude without some outside help, such as is obtained by inductive processes from the data of observation and measurement.

The explanation of gravitation outlined in this work is a case in point. For hundreds of years the scientific world has accepted without question the contention that there are only two possibilities here: either we must admit the existence of action at a distance or we must admit that the effect is propagated through something with the properties of a medium (ether, field or deformable space). There is no reason to believe that the "free inventions of the human mind" would have produced any other possible explanation for many more hundreds of years; the scientific mind was already convinced that it had thoroughly explored the field. But the appeal to experience, which Einstein spurns as a "fictitious" basis for theory, has *forced* recognition of a third alternative, and when we are finally compelled by the weight of factual evidence to acknowledge that this alternative exists, it immediately becomes apparent that this new concept not only explains the existence of gravitation in readily understandable terms, but also explains all of the peculiar characteristics of the gravitational phenomenon with which other theories have had such a struggle.

This is by no means an isolated case. On the contrary, the great majority of our basic physical laws were "abstracted or deduced from experience" and were not "free inventions." Whether or not the story of the falling apple is apocryphal, there is no question but that Newton's Laws were distilled from experience. The same is true of the first step, which Einstein took along the relativity route. His Special Theory was not a "free invention"; it was deliberately designed to give a theoretical basis to a fact of experience: a mathematical relation--the Lorentz transformation--which expressed the modification of numerical values necessary to reconcile another fact of experience--the constant velocity of light--with the accepted laws of motion. According to the findings of this present work, the Special Theory was not *a correct* derivation from experiences (other than in its mathematical content) but it is definitely a derivation, not a free invention. The experimental facts were not relegated to the "fictitious" category by the theorists until *after* the shortcomings of the Special Theory manifested themselves by preventing a direct extension of the relationships of this theory to the more general situation of non-uniform motion.

It thus becomes evident that the difficulties which have led to Margenau's conclusion that a fully satisfactory physical theory is impossible and that we must necessarily be content with something less than the optimum are not inherent in the structure of nature itself, but are a result of the fact that Einstein took the wrong road after his initial success and carried the scientific world with him. His argument in favor of the conclusion stated by Margenau cannot stand up under a cold-blooded scrutiny. The mere fact that two different theories, or many different theories, for that matter, achieve "a large measure of agreement with experience" does not preclude the existence of another theory, which agrees with *all* experience. Indeed, it raises a strong presumption that such a theory does exist. As Reichenbach puts it, "... contradictory theories can be helpful only because there exists, though unknown at that time, a better theory which comprehends all observational data and is free from contradictions."[108]

The guideposts that have been set up in the preceding pages point out the true route the traditional scientific goal of a complete and understandable physical theory: a route which is almost diametrically opposite to the path toward increased flexibility (or abstraction) that has been followed by Einstein in the realm of the very large and by Bohr, Heisenberg and their associates in the realm of the very small. This opposite route is the one that has been taken in the development of the Reciprocal System. In this development Einstein's dictum that we can only grasp "physical reality by speculative means" has been explicitly repudiated and the entire project has been devoted to accomplishing the very thing that Einstein claims is "doomed to failure"; that is, to "derive the basic concepts" of physical science "from the ultimate data of experience."

The program that was followed in this work began with long years of study of the experimental values of the physical properties of thousands of different substances, directed toward the development of more accurate and more generally applicable mathematical expressions to represent the variability of these properties. After a number of such expressions had been formulated, the next step, one which also extended over many years, was an intensive study of these expressions, during the course of which they were thrown into every conceivable mathematical form, and each of the functions thus derived was subjected to an exhaustive examination in an attempt to discover possible physical relationships corresponding to the mathematical relations. Several of these lines of approach finally converged to the reciprocal postulate, bringing the inductive phase of the project to a conclusion. *After* the reciprocal postulate was formulated as the final product of this long and involved investigation of physical relationships, it became clear that this same conclusion could have been reached by a direct extrapolation of known facts, as indicated in the introduction to Part Three. However, the conceptual innovation that is required in order to make this extrapolation possible represents such a radical break with preexisting thought that it is difficult to take the necessary mental step, and the reciprocal idea did not actually crystallize until it became practically a matter of mathematical necessity.

The second, or deductive phase of the project initially involved the formulation of the collateral and supplementary assumptions required in conjunction with the reciprocal postulate to form the fully integrated set of postulates that underlies the Reciprocal System. The development of the consequences of the postulates of this system then followed. This is a gigantic task which is still under way and can be expected to continue for a long time to come, gradually extending into more and more detail. As can be seen from the foregoing description, the Fundamental Postulates of the Reciprocal System were obtained inductively from the empirical data, and all of the subsequent conclusions have been derived deductively from these postulates. This entire system therefore rests upon the facts of observation; it *has been* "derived from the ultimate data of experience."

The final result of attacking the problem along this line has been the achievement of the very thing that current scientific thought assumes is unattainable: a complete and comprehensive theoretical structure that is readily understandable in the terms of reference of everyday experience. The present discussion covers only one of the many aspects of the Reciprocal System, but in each of the other subsidiary areas the same result has been obtained; that is, a development of the consequences of the Fundamental Postulates of this system has established a complete and logical theory for the phenomena included in the particular area: one which requires no supplemental theories or *ad hoc* assumptions, yet is consistent with all established knowledge throughout the field to which it applies.

In retrospect it is clear that overconfidence in the capabilities of the theorists and in the validity of accepted modes of scientific thought has been a major factor--perhaps the most important factor--in diverting physical science from the straightforward path and into unproductive side excursions. Over and over again we find that a proposition which in reality is true only *if* the basic premises are valid and *if* no unrecognized alternative exists is accepted as a matter of logical necessity, and not infrequently is accorded a standing superior to that of the facts of observation.

The current viewpoint with respect to the propagation of the gravitational effect is typical. Modern physicists have been able to visualize only two alternatives: propagation at a finite velocity through a medium or instantaneous action at a distance. Being unwilling to accept action at a distance and thoroughly convinced that their inability to conceive of any other alternative is definite proof that no such alternative exists, they have taken it for granted that the effect must be propagated through a medium at a finite velocity, even though there is not the slightest evidence to support this conclusion, whereas there is some significant evidence to the contrary, including the inescapable fact that energy which is determined by position in space cannot be propagated through space.

Newton did not agree with the present-day viewpoint. He was equally as opposed to accepting action at a distance as the modern scientist, but he contended that the existence of gravitational effects conforming to his gravitational equation should be accepted as an empirical fact pending the discovery of some plausible explanation of the phenomenon at some future time. The developments of this work have completely vindicated Ncwton's position. So far as this point is concerned, any judgment that may be passed on the merits of the present work is entirely immaterial. Whether or not the gravitational mechanism derived from the postulates of the Reciprocal System is ultimately accepted as correct by the scientific community, it cannot be denied that this does provide a third and totally different alternative in this case where present-day thought contends that no more than two alternatives are logically possible. The mere *existence* of this additional possibility is sufficient in itself to completely demolish the present contention that there are only two alternatives. We now know that there are at least three alternatives, and the fate of the confident assertion that only two alternatives exist should make it clear that *any* limitation of this kind is unsound. The contention that the possible alternatives in a case of this kind are confined to those already visualized assumes an omniscience on the part of the scientific profession, which the record certainly does not justify.

The situation with respect to the assumed contraction of objects in motion is similar. The statements that are made in this connection by modern authors are positive and categorical. "But the constancy of c in different inertial systems," says Margenau, "requires that moving objects contract, that moving clocks be retarded, that there can be no universal simultaneity, and so forth."[109] Einstein is equally positive: "...if the velocity of light is the same in all CS (coordinate systems), then moving rods must change their length, moving clocks must change their rhythm... it is difficult to get rid of deep-rooted prejudices, but there is no other way."[110]

Whatever someone else may think about the work of modern physical theorists, they have mode than ample confidence in their own results. *There is no other way is* about as definite and unequivocal as any statement can be. But it is now evident that it is totally wrong. There is another way; perhaps there may even be many other ways.

Here again it is immaterial whether or not the new explanation presented in this work is accepted as correct. Whether correct or incorrect, the new theory derived from the Reciprocal System provides a logical and self-consistent explanation in which a constant velocity of light in all systems of reference does *not* require contraction of moving objects or retardation of clocks, and it thus automatically destroys all of the arguments that have been so confidently advanced by Einstein and his disciples on the basis of their assumption that "there is no other way."

It is not appropriate to enter into an extended consideration of this aspect of modern science in a volume addressed to such a limited subject as gravitation, but one can hardly refrain from making some comment about the way in which the most astounding and fantastic conclusions are accepted by the scientific community purely on the basis of what amounts to an assumption that the collective opinion and judgment of the scientific profession are infallible. One of the standard tools of logic is the *reductio ad absurdum* in, which the falsity of certain assumed premises is proved by showing that the necessary and unavoidable consequences of these premises lead to an absurdity. But modern physical science now repudiates this well established doctrine and advances the weird contention that the basic premises which have been accepted by the scientific profession *cannot* be wrong, and hence the conclusions drawn from these premises must be correct, even if they are absurdities or near absurdities. It then follows as a matter of course that the universe itself is an absurdity. Here the physicist at least demonstrates that he has the courage of his convictions, for he does not shrink from this astounding end product of his line of reasoning. "The 'real' world is not only unknown and unknowable," says Herbert Dingle, "but inconceivable--that is to say, contradictory or absurd."[111] Willem de Sitter argues that this conclusion, preposterous as it may seem, is in reality quite plausible: "After all the 'universe' is an hypothesis, like the atom, and must be allowed the freedom to have properties and to do things which would be contradictory and impossible for a finite material structure."[112] Even Bridgman, usually very much on the alert for fallacies of this kind, was swept along with the tide, and we find him making the flat statement: "The world is not intrinsically reasonable or understandable..."[113]

Now let us bear in mind that no one is arguing that an absurd and contradictory universe is a *priori* more probable than a reasonable and rational one; the absurdity currently ascribed to the universe is simply a conclusion reached by developing the consequences of the initial premises from which the physicist starts his reasoning. On this basis, then, we would naturally expect that these initial premises would be of such a positive and incontestable character that there could be no reasonable doubt of their validity. But the truth is that the essential elements of these basic premises are almost invariably pure assumptions without factual support of any kind. As has been brought out in the preceding pages, the initial premises on which gravitational theory has been erected have reference to the properties of space and time, and these are the items, which Tolman says we simply "assume without examination." The mere thought of trying to define the nature of time appalls him. Even philosophy, he says, would shrink from the task. Yet he has such overwhelming confidence in the validity of these unanalyzable basic assumptions, in spite of their dubious ancestry, that he is willing to accept the conclusion that the world is irrational and absurd rather than to concede that the initial assumptions are in any way open to question.

What has just been said with reference to Tolman and gravitational theory applies with equal force to the scientific profession as a whole and to physical theory in general. For example, the situation with respect to atomic theory which was discussed in detail in *The Case Against the Nuclear Atom*[114] is a duplicate of the gravitational situation on a larger scale. Here again the basic premises are purely assumptions--even less than pure assumptions, we might well say, since some of them can only be justified by making the highly questionable additional assumption that existing knowledge about such matters does not apply in these particular cases--yet when these initial premises lead to absurdities, the physicist cheerfully concludes that the universe is inherently absurd and even denies the "objective reality" of the ultimate units of that universe rather than permit any shadow of doubt to be cast upon the sacrosanct assumptions on which the whole structure of currently accepted theory is based. Here is the true reason for the recurring "crises" with which modern physics finds itself faced: a situation which an outside observer, Jose Ferrater Mora, describes in these words, "Since approximately 1900 physics has been in what it is now customary to call 'a state of crisis.' No sooner has a theory been erected than its very foundations have started collapsing; new theories have been hastily introduced to patch up the shaky foundations only to have the same fate overtake them shortly."[115]

Of course, a question such as that of the basic nature of time is not something that we can resolve by direct observation, and we have no option but to make an assumption of some kind. The fact remains, however, that when a development of the consequences of this and other basic assumptions ultimately leads to an absurdity, what we have proved is that one or more of the initial assumptions was in error, not that the universe is absurd and illogical. In arriving at the latter conclusion, the modern physicist is himself being absurd and illogical. It is quite evident that the "self-criticism" upon which physical science has relied to keep its progress headed in the right direction has failed in its appointed task, and that some more detached and less sympathetic analyses and appraisals of present-day physical theory are badly needed. As James R. Newman expresses it, the modern physicist has been allowed to "get away with murder," and the consequences that have ensued make it clear that it is now high time that this unlimited license be revoked. No amount of sophistry or doubletalk can evade the cold, hard fact that the conclusions of modern physics as to the irrational and unpredictable behavior of the universe or portions thereof are nothing more than speculations; they are based on pure assumptions, not on solid knowledge.

Actually the theoretical physicists themselves are somewhat uneasy about the tenability of the position which they now occupy in this connection. The concept of a universe, which is basically irrational and absurd, is definitely objectionable from a philosophical standpoint, and considerable thought has therefore been applied to devising some modifications of this idea, which the scientist can live with more comfortably. Thus Herbert Dingle gives us a "new estimate" of the situation that differs materially from the uncompromising viewpoint which he expressed in the statement previously quoted:

> The practice of physics has not changed, and the new estimate of its discoveries is forced on it; it is not a matter of choice. When we thought we were studying an external world our data were still simply our observations; the world was an inference from them. Until this century it was possible to make such an inference intelligibly... But now we find that... we can no longer express them as the structure of an external world unless we accept a world which is arbitrary, irrational and largely unknowable.[116] In this statement Dingle has shifted his position and he now attributes the irrationality and nintelligibility not to the universe itself but to the limitations inherent in our observations: limitations which, he contends, make it impossible to deal directly with the universe itself. Here is a strange new idea totally foreign to the traditional philosophy of science. From the very beginning of scientific inquiry the great majority of scientists have agreed that the subject of their investigations is a physical universe external to and independent of the observer. But now Dingle and those who share this same viewpoint are repudiating this long-standing concept of the fundamental nature of scientific knowledge and are taking the stand that science is merely "a method of correlating sense-data."

"On this view of science," McVittie explains, "the Laws of Nature are simply the fundamental postulates lying at the base of a theory and are to be regarded as free creations of the human mind... Unobservable such as light, atoms, electromagnetic and gravitational fields, etc., are not constituents of an independently existing rational External World; are but concepts useful in the manufacture of the systems of correlation."[57] Heisenberg concurs: "...the new mathematical formulae no longer describe nature itself but our *knowledge of nature."*[117] Jeans expresses essentially the same thing: "The true object of scientific study can never be the realities of nature, but only our own observations on nature."[118]

Now let us ask, what justification does modern science advance for this drastic revision of its basic philosophy? By any logical standards we are certainly entitled to be given some compelling reason for any such far-reaching change: some outstanding new discovery, perhaps, or some significant clarification of the general scientific picture. But do we get anything of this kind? Positively not. The whole case for this extraordinary alteration of the underlying philosophy of science rests on the assumption that the failure of the scientific profession to attain the goals originally envisioned cannot be due to any shortcomings on their part; it must be due to the fact that these goals are non-existent.

"In short," says McVittie, "if the doctrine of a rational External World is accepted, past experience forces us to conclude that science is everlastingly in error, a Kepler, a Newton or an Einstein periodically 'proving' that his predecessors severe mistaken."[57] Most laymen would probably be willing to accept this as an eminently reasonable appraisal of the situation, aside from a certain amount of poetic license in the use of the word "everlastingly." To them the idea that some future Smith, Brown and Robinson may continue the pattern of successive modifications of basic physical theory carried out by Kepler, Newton and Einstein is by no means inconceivable, nor does this, in their estimation, preclude the possibility that this process may ultimately culminate in a complete and fully satisfactory theoretical system. But the modern theorist will not concur in any viewpoint, which suggests that there is anything lacking in his own treatment of the problems. So far as he is concerned, what modern science has not been able to do cannot be done; where the objectives that have been established have not been reached the fault must lie in the problem, not in his methods of attack. To McVittie any inference that "science is everlastingly in error" is unthinkable, hence he regards the point brought out in the foregoing quotation as strong evidence of the falsity of "the doctrine of a rational External World," even though to the ordinary observer there is no merit at all in this argument.

Dingle applies a similar type of reasoning in this statement: "...both relativity and quantum theory, the highlights of modern physics, are concerned not with an external world but with the operations of physicists and... they become nonsensical when they are presented as descriptions of external Nature." If what Dingle asserts is true, then the most natural and logical conclusion is that these two "highlights of modern physics" are, in fact, nonsensical. But the present-day physicist refuses to recognize the possibility that the accepted pattern of thought of his profession may be wrong; he closes his eyes to this distressing prospect and pretends that it does not exist, thereby twisting Dingle's point into another argument against the existence of a rational external world.

Once a more realistic appraisal of the situation is made and it is realized that it is no longer possible to avoid conceding that modern science *could* be wrong in its assumption of omniscience; that it could have overlooked some alternative explanations of the results of crucial experiments such as Rutherford's scattering experiments and the Michelson-Morley experiment; that the presumed necessity of choosing between action at a distance and propagation through a medium (or the equivalent of a medium) is a result of insufficient consideration of the problem and not a reflection of the true physical situation, and so on, all such arguments against the existence of a rational external world independent of the observer simply collapse.

The new gravitational theory based on the postulates of the Reciprocal System sacrifices neither traditional logic nor the external world. Here again, as in the more specific situations previously discussed, this new theory adheres to the simple and natural viewpoint rather than introducing complicated and questionable *ad hoc* constructions. Just as the geometry of this system follows the familiar Euclidean pattern, physical magnitudes are fixed and unchanging, space is space, not a renamed ether, the gravitational effect is instantaneous just as our calculations have always assumed, Newton's gravitational equation is universally valid, and so on, we also find that the gravitational effect which is revealed by our observations actually takes place in a rational external world of physical reality.

Another feature of current scientific thought, which has been emphasized by the development of the Reciprocal System, is a strange dichotomy in the prevailing viewpoint concerning the nature of scientific proof. On the one hand, the possibility of the verification of a theory is specifically and categorically denied. Northrop tells us, for instance, "Thus no theory in mathematical physics can be established as true for all time. Nor can the probability of the truth of any given theory be scientifically formulated. For there is neither an empirical frequency nor a theoretical *a priori* definition of all the possibles with respect to which any particular theory can function as a certain ratio in which the number of all the possibles is the denominator term."[120] George R. Harrison goes a step farther and contends that we not only cannot *prove* that a theory is true, but that there is no such thing as an absolute truth. As he puts it, "...in recent years scientists have discovered, largely through such verified theories as Einstein's Relativity, that our feeling that there is such a thing as absolute reality is incorrect, and that truth is always relative."[121]

Similar statements are quite common in present-day scientific literature, but Harrison's words are particularly interesting because he lets the cat out of the bag, so to speak, by telling us specifically where this remarkable conclusion comes from. Modern scientists have "discovered" that there is no absolute truth by means of a chain of reasoning based on the assumption that the Theory of Relativity is absolutely true. The extraordinary nature of this reasoning is still further emphasized by the extremely liberal standards that have been applied in arriving at the "truth" of the Relativity Theory. Here is a theory whose factual supports are so flimsy that, as Bondi says in the statement quoted in Part One, a "substantial minority" of present-day theoretical physicists regard them as wholly inadequate, yet this theory is accepted as a solid foundation on which to base conclusions of the most far-reaching character.

It cannot be denied that establishing the truth of a physical principle or theory is a *difficult* task. This fact has already been emphasized in connection with the discussion of the Relativity Theory in Part Four. This does not mean, however, that it is an *impossible* task, as Einstein and his disciples contend. As pointed out in the previous discussion, a theory can be proved if a correlation can be established between the theory and the facts of observation which is sufficiently complete and comprehensive to reduce the possibility of a hidden conflict somewhere in the system to a negligible level. This means that there must be an exact correspondence in a large number of cases throughout the area affected, without any inconsistency at any point, and without the use of contrived methods of evading contradictions or inconsistencies.

There is, of course, no definite rule by which we can say specifically at what point the probability of a hidden error becomes negligible; this will always be a matter of judgment. It is evident, however, that where a very large number of correlations are made and these correlations cover the entire field of application of the theory, so that the possibility of an unrecognized limitation on the scope of the theory is ruled out, there must be such a point somewhere along the line. Northrop's contention that wee cannot arrive at the probability of the truth of a theory is thus manifestly erroneous in application to a theory which meets the requirements specified in the preceding paragraph. Here the "empirical frequency" and "definition of all the possibles" of which he speaks lose their meaning because the actual numerical values of the probabilities are no longer significant. After the term x in the function 1/x becomes so large that the difference between 1/x and zero is negligible, the exact value of x ceases to mean anything at all. No matter how much larger the term x may become, the effective value of 1/x still remains the same: it is still zero.

The present-day contention that positive proof is impossible in principle is therefore untenable; the most that can be asserted on any reasonable basis is that a rigid proof is not possible as a practical matter, and even here the facts do not support such a contention. It is true that most of the highly publicized physical theories of the current era, those which are so widely hailed as having revolutionized our entire scientific outlook, cannot be factually substantiated, since they are not only deficient in the number of correlations with observation and measurement, but are also inherently incapable of proof because they are based in part on principles of impotence. But oddly enough, the prevailing conclusions as to scientific proof in general are not applied here; in current practice these cherished products of modern ingenuity are accorded a status which puts them beyond the necessity of proof: a status which even qualifies them as basic principles that can be used to "prove" the validity of other conclusions, in the manner of Harrison's contentions. The amazing extent to which this strange exaltation of currently popular theory has been carried is well demonstrated by the fact that no less a scientist than Sir Arthur Eddingtonbegins one of his explanations with the statement, "One proof rests on Einstein's theory."[122]

Obviously there is much confusion in current thinking on this subject. With all due respect to Eddington, Harrison, and the many others, who have said essentially the same thing, a *theory* cannot be used to *prove* anything. We can prove the validity of a theory, in which case it becomes more than a theory, but as long as it is merely a theory and no more, it is, by definition, unproved and cannot be used to prove anything else. On the other hand, the extreme idea that *nothing* can be proved, an idea which, strangely enough, has been derived from considerations based on these popular theories whose validity is assumed without proof, is equally lacking in merit. Most of the broad general principles of physical science are still open to question in some degree, but there are a great many subsidiary laws and principles which meet every requirement for proof on the basic premise that proof has been attained when it has been demonstrated that the probability of error is negligible.

The case for the gravitational theory presented herein, and for the entire Reciprocal System of which the gravitational theory is a part, is based on this same concept of the nature of proof; that is, we have achieved a proof when we have reduced the chance of error to the vanishing point. In elaborating, it will be convenient to draw an analogy between scientific theory, which is a concise representation of scientific knowledge, and a map, which is a concise representation of geographic knowledge. The traditional method of map making involves first a series of explorations, then a critical evaluation of the reports submitted by the explorers, and finally the construction of the map on the basis of those reports which the geographers consider correct. Similarly in the scientific field explorations are carried out by experiment and observation, reports of the findings and the conclusions based on these findings are submitted, these reports are evaluated by the scientific community and those which are judged to be authentic are added to the scientific map: the accepted body of factual and theoretical knowledge.

But this traditional method of map making is not the only way in which a geographic map can be prepared. We may, for instance, devise some photographic system whereby we can secure a representation of an entire area in one operation by a single process. In either case, whether we are offered a map of the traditional kind or a photographic map we will want to make some tests to satisfy ourselves that the map is accurate before we use it for our purposes, but because of the difference in the manner in which the maps were produced the nature of these tests will be altogether different in the two cases. In checking a map of the traditional type we have no option but to verify each feature of the map individually, because aside from a relatively small amount of interrelation each feature is independent. Verification of the position shown for a mountain in one part of the map does not in any way guarantee the accuracy of the position shown for a river in another part of the map. The only way in which the position of the river can be verified is to compare what we see on the map with such other information as may be available concerning the river itself. Since these collateral data are often scanty or even entirely lacking, particularly along the frontiers of knowledge, the verification of a map of this kind in either the geographic field or the scientific field is primarily a matter of judgment and the final conclusion cannot be more than tentative at best.

In the case of a photographic map, on the other hand, each test that is made is a test of the validity of the process and any verification of an individual feature is merely incidental. If there is even one place where an item that can definitely be seen on the map is in conflict with something that is positively known to be a fact, this is enough to show that the process is not accurate and it provides sufficient justification for discarding the map in its entirety. If no such conflict is found, however, the fact that every test is a test of the process means that each additional test that is made without finding a discrepancy reduces the mathematical probability that any conflict exists anywhere on the map. By making a suitably large number and variety of such tests the remaining uncertainty can be reduced to the point where it is negligible, thereby definitely establishing the accuracy of the map as a whole. In making these tests it is neither necessary nor advantageous to give any consideration to items which are in any degree doubtful. It serves no purpose because there is nothing to be gained by establishing the existence of a conflict if the significance of that conflict is unknown. It is not necessary because a map of this kind includes so many hundreds or thousands of individual features that there are ample opportunities for comparisons with facts that are not open to question, even if some areas are inaccessible. The whole operation of verifying a map of this kind is therefore a purely objective process in which features that can definitely be seen on the map are compared with facts that have been definitely established by other means. The final conclusion is an unequivocal yes or no.

This is the kind of a map of the scientific field which is presented in *The Structure of the Physical Universe* and the more detailed discussion of the gravitational aspects of the Reciprocal System in this volume. Like the photographic map, the theoretical structure developed in this work has been produced in one operation by a single process and it is therefore subject to the same kind of positive verification. The entire work consists of the development of the consequences of two fundamental postulates without the introduction of any other factors of any kind. If the postulates are valid then certain primary consequences, including the existence of radiation, gravitating matter, electric and magnetic effects, and the other major physical phenomena, necessarily and unavoidably follow. Interaction of these primary consequences with each other and with the postulates then results in a large number and variety of secondary consequences, and further development along the same lines ultimately produces a system, which is so extensive that it constitutes a complete theoretical universe. Having been developed entirely by the application of mathematical and logical processes to the fundamental postulates, this whole system is one integral unit. If the postulates are valid then each and every one of the necessary consequences is likewise valid.

Conversely, if even a single one of the thousands of these necessary consequences conflicts with a fact that has been definitely established, the postulates are thereby invalidated and the entire structure falls. But if no such conflict is found in making a very large number of comparisons with known facts the probability of the existence of any hidden conflict anywhere in the system is reduced to a negligible level. Thus the verification of this theoretical system, like the verification of the photographic map, is a purely objective process in which there is no place for judgment or opinion.

There is, however, one important precaution, which must be observed: we must be certain of the validity of the alleged facts, which we propose to use for test purposes. As has been emphasized previously, the human mind is so constituted that it does not like to admit ignorance and in those cases where we do not know there is a rather strong tendency to dress our best guess in fine clothes and parade it as knowledge. For example, one of the first items to emerge from the new theoretical development is a new concept of the structure of the atom, and the general opinion undoubtedly will be that this conflicts with a known fact: the nuclear atom. But in reality we do not know that the atom has a nuclear structure. On the contrary, the facts brought out in *The Case Against the Nuclear Atom*[114] show that such a structure is impossible. Even during the time that it was universally accepted, the acceptance was not based on agreement between the theory and the facts of observation; it could be justified only by the assumption that the known facts do not apply in the atomic situation, either because there are some unknown forces which offset the known forces that would otherwise disrupt the hypothetical atomic structure or because the laws and principles that are valid in the known areas of the universe do not apply on the atomic scale.

Similarly the new development finds normal hydrogen (H^1) more stable than helium under high temperature conditions, which rules out the conversion of hydrogen to helium as an available process for the generation of stellar energy. Here again the first reaction is likely to be that the new concept is in conflict with an established fact, but the hydrogen conversion process is not a known fact; it is actually nothing more than the best guess thus far, in spite of the virtual unanimity with which it is currently accepted. Certainly no one is able to *prove* that this is the process whereby energy is generated in the stars, nor can it be shown that it is a naturally occurring process *anywhere*. It has been demonstrated that the unstable isotopes of hydrogen can be stimulated in such a manner as to cause them to do rapidly what they will do spontaneously at a slow rate, and the stable hydrogen isotope can be altered forcibly (that is, by the expenditure of energy) but there is no evidence that this stable isotope can be caused to become unstable.

Development of the consequences of the fundamental postulates of this work results in many other conclusions which differ from currently accepted ideas but careful analysis has indicated that all of these cases are similar to those mentioned in the preceding paragraphs; that is, these popular ideas which are challenged by the new system are not factual; they are either inferences, hypotheses, or unsupported extensions of observational findings. In no case does this analysis disclose any conflict with genuine facts. Many of the theoretical conclusions cannot be tested at all, since they apply to areas in which no factual knowledge exists, but wherever and whenever the theory can be checked against solid facts the two are in agreement.

It is perhaps inevitable that such statements in favor of a new and revolutionary theory should be met with profound skepticism, but the objective of this discussion is to bring out the point that the appraisal of the new theoretical structure by the scientific community can be, and therefore should be, a purely objective check of theory against fact, without regard for the characteristically human but definitely unscientific sentimental bias in favor of familiar ideas. Nor should it be in any way surprising when this objective check does verify the validity of the new theory. After all, the most conservative assumption that we can make about the phenomena in the unknown regions of the universe, the assumption that has by far the greatest *a priori* probability of being correct, is that they follow the same relationships that hold good in the known regions. This work has, for the first time, explored the consequences of extrapolating all of the basic relations in the known regions, including the relationship between space and time, and in view of the high inherent probability that such an extrapolation will yield correct results, it should be no occasion for surprise or incredulity when the theoretical deductions based on these premises are found to be in full agreement with the facts.