CHAPTER XXXVI

ON THE SEMANTICS OF THE EINSTEIN THEORY

> It is precisely here, in an improved understanding of our mental relations to nature, that the permanent contribution of relativity is to be found. We should now make it our business to understand so thoroughly the character of our permanent mental relations to nature that another change in our attitude such as that due to Einstein, shall be forever impossible. (55) P. W. BRIDGMAN

It is not my aim to expound the Einstein Theory as such. There are many excellent and competent books written on this subject. I have already explained and stressed several structural points which in the last analysis are the foundation of Einstein's work. Many 'thinkers' through the ages have felt vaguely the dangers of the structure of language and the viciousness of objectification, that is, of the delusional ascribing of objective values to verbal forms. This vague feeling, of course, is useful in individuals, but it is a private benefit, which cannot be made public without some sort of formulation. The stroke of genius of Einstein was that he produced a *non-elementalistic*, linguistic system of new structure. Einstein, being a physicist, decided rightly, as we understand now, to be entirely actional, behaviouristic, functional, and operational, and to stop gambling on words. The older *el* linguistic problems of 'matter', 'space', and 'time' were in such a mess, due to the objectification of verbal structures, that it was useless to talk any more in the old way. He decided to describe what a physicist *does* when he measures 'space' and 'time', and to abandon, perhaps unconsciously, the 'is' of identity.

It seems unnecessary to stress the simple fact that when we measure a piece of wood, for example, we mark it off with another piece of material which we have accepted arbitrarily as our 'unit of length'. The coincidence of our 'unit' with the intervals between the marks is again judged by an extremely complex electromagnetic-neural process, which was quite disregarded until Einstein. Our judgement is conditioned by the light rays travelling with finite velocity which excite our nervous system through the retina, this excitation in turn also travelling with finite velocity. We see that the apparently simple measurement of a 'length' is really an extremely complex process, in which the *finite* velocity of light and of the nerve currents plays a very important role. Naturally, if we were to assume an 'infinite' velocity of the propagation of light, our verbal speculations about 'space' and 'time' might be perhaps entertaining, but they would nevertheless be fundamentally and structurally wrong.

Similar remarks apply to the measurement of 'time'. What do we mean when we say that a train has arrived at the station at 9 o'clock ? We mean no more and no less than that the arrival of the train coincided with the arrival of the pointer of a clock at a point marked 9 on the clock face. In other words,

we saw ‘simultaneously’ the arrival of the train and the pointer of the clock reaching the mark 9.

Our judgement about the results of measurements of ‘time’ depends on the *seen* coincidence of events—in this case, of the arrival of the train with the arrival of the pointer of the clock at the mark 9. Similar considerations, which applied to the measurements of ‘lengths’, apply also to the measurements of ‘time’.

We see with Einstein that if we want to make any headway we shall have to investigate the two key terms; namely, ‘velocity’ and ‘simultaneity’.

The newtonians take a particular delight in accusing Einstein of being a ‘psychologist’ and not a physicist. We have already stressed the physical subjectivity of physical instruments. What is said there applies, not only to the retina of the eye, but also to a photographic camera, or to a microscope or telescope, or any other instrument. Before an energetic packet, be it a light-impulse or a bullet, is able to accomplish any result it must first reach its mark, and so the finite velocity of propagation must be taken into consideration, which is a hard, established, empirical structural fact. So the criticisms of the newtonians are simply shallow and unscientific (1933). They disregard most important empirical physical facts, and so simply defend a semantic disturbance without aiding science (1933).

With the einsteinians, we treat the eye on the same footing as we would treat the camera or any other physical instrument. Even the newtonians must admit that when they photograph some happening on the sun, for example, the happening actually occurred (approximately) eight minutes *before* the photographic plate was affected. The eight minutes is the ‘time’ taken by the light to reach the earth from the sun.

Let us analyse the term ‘velocity’ first. We find ourselves here, as in any other human problem, on two distinct levels of abstraction, and we must discriminate between them.

Let us take up the verbal level first. We see that before we can talk about our terms ‘space’ or ‘time’, ‘length’ or ‘seconds’, we have to know a great deal about the term ‘velocity’. How do we define the term ‘velocity’ ? We define it as ‘space divided by time’, $v=s/t$. We see that on the *verbal* level the situation is perfectly hopeless and no result can be expected from verbal gambling. It may be added that older notions were based on objectification, or confusion between the two levels of abstraction, and the affective belief in the magic of words, identification playing most of the structural havoc.

How about the instrumental level, the silent level of the lower order abstraction ? On this level, we find that physicists in their actions, behaviour, operations. , have elaborated a fairly definite technique for finding the data they require. So we see that there is no choice, we must *start* on this level.

But starting on this level is not all, and not enough. We must somehow *talk* about these doings and operations. Hence we must select a language which in its *structure* will reflect the structure of these actions and operations. Therefore we must abandon the ‘is’ of identity and *describe* in the asymmetrical

language of order the happenings recorded by an instrument or by our lower nerve centres.

Without going into details we may summarize the results as achieved by the physicists. Experiments by the physicists, as indicated by the coincidences of pointers on different instruments, have seemingly established the fact that the 'velocity' of light, as defined by *behaviouristic, operational* instrumental means, is a *constant, c*=3.10^{10} cm./sec., independent of the relative velocity of the observers. By the 'observers' we mean again the readings on the instruments which the observer carries with him. Now this result contradicts flatly the established *verbal expectations* which we reached on verbal levels through the elementalistic structure of language and the semantic disturbance, of ascribing 'objective' existence, to the *terms* 'space' and 'time'.

The situation is acute. Shall we follow our semantic disturbances and reject hard empirical structural facts, or shall we accept the experimental facts and eliminate semantic disturbances ?

As usual, the answer is implied by the method of putting the question. We accept the experimental facts and revise our semantic disturbances. In this case a psychiatrist might be a useful co-worker with the physicist.

The einsteinian revolution is structurally and semantically so fundamental, that every intelligent person should be acquainted with it. It will therefore be as well to consider some of its details.

In classical mechanics we had the classical mechanical principle of relativity; namely, that all mechanical equations have one form for two co-ordinate systems moving uniformly with respect to each other. The above has a very simple empirical meaning. If we travel in a train, let us say at a velocity of 50 miles an hour, all our activities in the train have one familiar relative velocity as if the train were at rest. If we throw a ball with a velocity of 20 miles an hour to another passenger on the train in the direction of the movement of the train, the ball will not reach the other passenger with the velocity of 20 miles an hour *plus* the additional 50 miles an hour velocity of the train but will reach him with the velocity as if the train were standing still. Not so, however, if the ball were thrown to an observer, standing on the tracks. The ball might hurt him, because it would have, relative to him, the velocity of 20 miles an hour of the ball, plus the velocity of 50 miles an hour of the train, or in all, a velocity of 70 miles an hour.

Quite probably, even our remote ancestors who used artificial means of transportation on land or water did not overlook the structural fact that mechanical events happen in just one way, whether the system is at rest or in relative motion. With the advent of *verbal* formulations of physics and mechanics, such happenings were formulated verbally; and so, slowly, the language of old structure with its consequent objectifications was built.

Now on *verbal grounds*, which seemed to be justified by experimental, macro-mechanical facts, we concluded that one law should prove valid in the case of electrodynamic and optical events.

To reformulate the above in simple symbols, let us imagine two parallel co-ordinate systems, *O'* and *O"*, of which the second moves with a velocity *u* relative to the first in the common *x* direction. If we denote the co-ordinates of the first system by single primes, and the co-ordinates of the second system by double primes, then, as usual, the co-ordinates of a point, *P*, in the second system would be connected with its co-ordinates in the first system, by the equation $x''=x'-ut$, which means that the x'' co-ordinate is less than the x' co-ordinate by the amount that our second co-ordinate system has moved; namely, by $a=ut$. We gave the diagram in two dimensions because it is simpler, and, as we have assumed that the displacement is parallel to the *x* axis, the other co-ordinates remain unaltered, $y''=y'$, $z''=z'$. 'Time' by the older assumptions, being 'objective' and 'absolute' would be 'the same'; namely, $t''=t'$ ('absolute time'). The classical law of relative motion states that if the equation of motion in the first system is $f'(x',y',z',t)=0$, this function must also be zero when x' is replaced by its new value; namely, $(x'-ut)=x''$ so that $f'(x'', y'', z'', t) =0$,

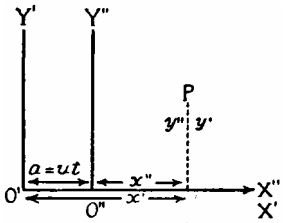

FIG. 1

Let us see if the above conditions hold true when we deal with the *propagation of light in spherical waves.*

$OB^2 = OA^2 + AB^2$

$OB^2 = x^2 + y^2$

$OP^2 = OB^2 + BP^2$

$OP^2 = x^2 + y^2 + z^2$

$c^2t^2 = x^2 + y^2 + z^2$

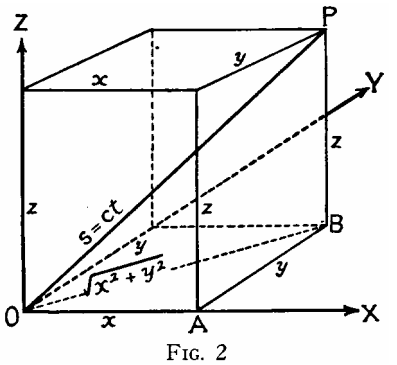

FIG. 2

If we select a three dimensional coordinate system *O*, the distance *s* of the point *P* from *O* is equal, by the pythagorean rule, to $s^2=x^2+y^2+z^2$. If we assume that a light ray is travelling from *O* to *P*. the distance *s* could then be represented by the product of the velocity of light *c* by the 'time' or *ct*. The square of this distance would then be $c^2t^2=s^2$. We have $x^2+y^2+z^2=c^2t^2$, or $x^2+y^2+z^2-c^2t^2=0$

We can easily convince ourselves that if the last equation for light-waves holds good in the first co-ordinate system it cannot hold in the second.

Writing the last equation in our primed letters, we have $x'^2+y'^2+z'^2-c^2t^2=0$. If we pass to our second system of co-ordinates moving uniformly in the *X* direction with the velocity *u* relative to the first system, our *y'*, *z'*, *t*, do not alter by assumption, but only $x''=x'-ut$. We would have by substituting $x'-ut$ for x'', and retaining the primed values for y'', z'', t:

$$(x'-ut)^2 +y'^2 +z'^2-c^2t^2 = x'^2- 2x'ut+u^2t^2+y'^2+z'^2-c^2t^2 \qquad (1)$$
$$= x'^2+y'^2+z'^2-c^2t^2+(u^2t^2 - 2x'ut).$$

But, by assumption, $x'^2+y'^2+z'^2-c^2t^2=0$, and therefore equation (1) cannot be zero unless $(u^2t^2-2x'ut)=0$. This last condition would mean that our second system of co-ordinates is also at rest. We see that for *light-waves* the older mechanical principle of relativity does *not* hold, as the equations *are altered* when we pass from one system of co-ordinates to another which moves with uniform velocity relative to the first.

To indicate this more obviously, we will express it in formulae. Consider two co-ordinate systems *O'* and *O"*, in which the second moves with a uniform velocity in the *X* direction relative to the first. If for the *light-waves* the equation $x'^2+y'^2+z'^2-c^2t^2=0$ holds in the first system, a similar equation for the second moving co-ordinate system, $x''^2+y''^2+z''^2-c^2t^2=0$, cannot be true. In other words, $x'^2+y'^2+z'^2-c^2t^2\neq x''^2+y''^2+z''^2-c^2t^2$; whence we have an *inequality*, fundamentally contradicting the classical principle of relativity.

This extraordinary and unexpected inequality, because it contradicted structurally the classical mechanical principles of relativity, which apparently had been well established experimentally, created a baffling semantic situation which was profoundly unsatisfactory.

What could we do about it ? Should we abandon the older principle of mechanical relativity; or should we have two different laws, one for the older gross macroscopic mechanical relativity, and another for optical and electrodynamic events; or should we investigate the fundamental structural assumptions which underlie our formulae, and see if the discrepancy is not due to some prejudice or some structural dogma which we have overlooked for centuries ?

If a solution of the last kind should be found it would naturally be most satisfactory. The admission of two relativities, one for the mechanical events, the other for the optical events, would be against the whole trend of science, which requires the unification of theories.

Such a structural revision; namely, the rooting out of the old unjustified dogma which made all the trouble, was the work of Einstein's genius. In this epoch-making discovery he was *assisted* in the beginning by the famous Michelson-Morley experiment, since performed repeatedly with similar results, *seemingly* proving that the velocity of light is a constant no matter what the relative motion of the observer. If we take the equation for the spherical propagation of light-waves $x^2+y^2+z^2-c^2t^2=0$ or $x^2+y^2+z^2=c^2t^2$;

then $$c=\frac{\sqrt{x^2+y^2+z^2}}{t}$$ in one system of co-ordinates,

and $$c=\frac{\sqrt{x'^2+y'^2+z'^2}}{t}$$ in another system of co-ordinates,

are equal, which stated in another form would mean that

$$x^2+y^2+z^2-c^2t^2=x'^2+y'^2+z'^2-c^2t^2.$$

The experiment says this relation is true; the arguments already advanced show it cannot be true. So we have to hunt for some error or compensation.

With Einstein's explanation, the finding of the error is simplicity itself. In the older mechanical relativity our 'space' and 'time' were *objectified*, we

endowed them with objective values of definiteness and rigidity we dealt with 'absolute space' and with 'absolute time', which was 'unchanging' and 'the same for all'. In the older assumptions our *velocities varied.* If *A* had a velocity of 5 centimetres per second, for instance, and *B* was overtaking *A* with a velocity of 7 centimetres per second, the relative velocity between *A* and *B* would be 7-5=2 cm. per second. The *units of 'space' and 'time' were definite, immutable and did not and could not vary,* which followed directly from the assumptions of an 'objective' 'absolute space' and 'absolute time'.

In the case of light, we came in contact with a velocity which did *not vary* for any observer no matter what his relative motion. The velocity *c* was found to be constant, so the natural assumption to make is that our *'space' and 'time' vary* for different observers.

In the above equations as they stand, 'absolute time', $t=t$, the 'same' for all observers is assumed, which made such equality impossible. Assuming different 'times' for different observers, *t* for the first, and *t'* for the second, such a compensation transforms our inequality into an equality, as demanded both by the experiment and by the theory. Instead of writing

$$x^2+y^2+z^2-c^2t^2 = x'^2+y'^2+z'^2-c^2t^2, \ (t = t)$$

which *cannot be true,* we write,

$$x^2+y^2+z^2-c^2t^2 = x'^2+y'^2+z'^2-c^2t'^2 = 0, \ (t \neq t')$$

which can be true. We should notice that in the first equation we have on both sides *t,* which makes the equation impossible, whereas in the second equation we have on the left-hand side *t* and on the right-hand side a different *t;* namely, *t'.*

The above considerations mean that there is a definite structural discrepancy between the old language and the empirical world, requiring a fundamental structural linguistic revision. This revision has been accomplished, and is known as the Einstein theory. It is not implied that Einstein's work is final, but that it shows clearly the structural errors of the old elementalism to which we can never return.

In other words, in the older mechanics we had definite and permanent 'time' (absolute) and varying relative velocities. Dealing with *light-waves* we find experimentally that the velocity, *c,* of light does *not vary* with the relative motions of the observers and we must assume a *variable time* to preserve our equations.

An obvious objection can be raised to this: why alter our habitual notions of 'time' ? Can we not keep the old *s.r* and find some other method of compensation, less bothersome and less revolutionary ? The older physicists and Einstein give a long and convincing list of perfectly sufficient reasons for such a change; yet their arguments always leave us somehow in doubt, with the feeling of a lurking possibility that the old can be preserved.

What has already been said in this work about structure and semantic disturbances and the fact that the *terms* 'matter', 'space', and 'time' *are not objects,* which they cannot be, removes perhaps for good and all, the last doubt as to the revolutionary and epoch-making significance and value of the structural linguistic discoveries of Einstein. On these grounds *alone* the return to

the old is impossible. The old is due to objectification of the structural peculiarities of the old *el* language, and to semantic disturbances, which at the present low level of our development is inevitably the result of *copying lower animals in our 'thinking',* a *pathological* process for 'man'.

It will be well to explain at this point why I said that the Michelson-Morley experiment only *assisted* Einstein, and only *seemingly* proved the constant velocity of light. Historically, there is no doubt that the beginning of the theory of Einstein was suggested by, and had its physical basis in this experiment. In reality, as the whole of this present work about structure shows, the two issues are quite independent. The fact of the *finite* velocity of light has never been challenged, on the contrary it is becoming more and more solidly established, both empirically and theoretically, simply because an 'infinite velocity' has no meaning.

With the structural results of this present work, and the establishment of the fact of the finite velocity of light, the whole Einstein *theory* has a perfectly solid structural, linguistic foundation (1933). Nevertheless it is extremely gratifying that the latest, very important, and painstaking work of Doctor Roy J. Kennedy seems once more to add fundamental experimental support to the correctness of the Einstein theory.[*] From the point of view of structure, Einstein merely eliminated some primitive, perhaps even animalistic, remains of objectification which still lingered in the structure of our language of 'matter', 'space ', and 'time'. These, being animalistic, were unfit for humans; vitiating not only our daily lives but science as well. (Eddington in *The Mathematical Theory of Relativity,* p. 196, uses the term 'pre-human' in a similar connection.)

It must be recalled that the definition of velocity is connected in a *circular* way with 'space' and 'time'. That is, in the definition of the relation of velocity, (v=s/t), 'space' and 'time ', the definition of any one of our three terms depends upon our definition of the other two; whence there are many possible ways of verbal adjustment.

As we saw, the mechanical verbal principle of relativity with which we are all familiar was not structurally able to account satisfactorily for a similar relativity of optical and electrodynamic events. The older formulae of transformations were, as already given, $x'=x-ut$, $y'=y$, $z'=z$, $t=t$. These formulae are called the Galileo transformations in honour of the founder of mechanics; and, as we have seen, structurally they are not general enough.

If we consider the equation $x^2+y^2+z^2-c^2t^2=0$ and $x'^2+y'^2+z'^2-c^2t'^2=0$, we find that the galilean transformations do not satisfy them. Lorentz and Einstein have found another set of transformations which satisfies uniquely the above equations. These formulae of new structure are called the Lorentz-Einstein transformation, and are given by the following equations: $x'=\beta(x-vt)$, $y'=y$, $z'=z$, $t'=\beta(t-vx/c^2)$; where v is the relative velocity of one system with

[*] See 'The Velocity of Light', in *Nature,* Aug. 20, 1932, by R. J. Kennedy, and his latest paper (No. 261) in the Bibliography.

respect to the other, c, as usual, represents the velocity of light, and the factor $\beta\square=1/\sqrt{1-v^2/c^2}$.

The most striking characteristic of these formulae is that if we assume that c, the velocity of light, is *'infinite'*, all the expressions containing c^2 would become zero c^2 entering only in the denominators of fractions. In such a limiting case $\beta\square=1/\sqrt{(1-0)}=1/1=1$ and $x'=(x-ut)$, $y'=y$, $z'=z$, $t'=t$ which are the older galilean transformations.

Thus there appears the astonishing fact that all the pre-einsteinian physics and mechanics which involved the structural assumption of the galilean transformation, had a *tacit structural assumption* of the infinite velocity of light. This assumption, *known since 1676* to be false as to facts, remained unnoticed before Einstein.

As $c=3\times10^{10}$ cm./sec., $c^2=9\times10^{20}$ is a very large number, whence the fractions vx/c^2 and v^2/c^2 are very small, and β differs very little from unity.

If we apply the Lorentz-Einstein transformation instead of the older galilean transformation to mechanical problems, the changes are so small that they can hardly be detected by experiments, the terrestrial velocities v^2 or vx being so small in comparison with the square of the velocity of light.

The galilean transformations are *experimentally* shown to be structurally invalid for optical and electrodynamic events. The Lorentz-Einstein transformations satisfy structurally the optical and electrodynamic events, and also apply to the older mechanical problems. We see that the Lorentz-Einstein transformations are *more general*, as they include the galilean transformations as a particular case when we assume $c = \infty$.

In a few instances, where we deal with large velocities, the values of the fractions containing the square of the velocity of light become appreciable and allow experimental testing. As yet all such experiments have verified the Einstein theory.

We should repeat again that the achievement of Einstein was the building of a linguistic system similar in structure to the world, which eliminated a pathological pre-human factor of objectification of terms. Such structural elimination was bound to bring some sanity to our theories; and this fact is independent of experiments in physical laboratories. However, it is gratifying to find that experiments support (1933) the Einstein theory. It was particularly gratifying in the beginning, when physicists and Einstein himself believed that his theory would stand or fall by experiment. Today we see that this theory represents such an enormous general, structural, epistemological, psycho-logical, and methodological *non-elementalistic* advance, that no matter what the experiments show or may show in the future we cannot return to a language of the old, *el*, obviously wrong, structure of the pre-einsteinian days. As usual, the negative results are the important ones. No matter what experiments may show we shall never again accept the silent structural assumption of 'infinite' velocity for light, when we know positively that the velocity is finite. We shall never again treat *terms* of 'matter', 'space', and 'time' as objects—lower order abstractions, when we know that they represent *terms*—higher order abstractions. When

once this is realized, we cannot ascribe ‘finiteness’ or ‘infiniteness’, ‘definiteness’, ‘rigidity’. , to *terms*, verbal forms, forms of representation. From this point of view we may consider the Einstein theory as an irreversible gain. If it had achieved only the elimination of various structural prejudices and dogmas, it has done well; and at least this much Einstein has already achieved.

The structural, verbal, cortical quest for invariance in our formulations also becomes apparent. The older mechanics were invariant under the galilean transformation, equations preserved their form in different systems of co-ordinates. In the special theory of relativity the new laws are invariant under the Lorentz-Einstein transformation. In this special, or restricted, theory of relativity only uniform relative motion was taken into account. If we generalize the principle of relativity to *any* kind of relative motion we pass from the restricted to the *general* theory, which demands that the laws of physics should be formulated in a generally invariant form for any arbitrary transformations.

For this structural, cortical reason it is necessary to express all the laws of physics in tensor equations, which satisfy such conditions of general invariance. If this cannot be done, there must be something wrong with our language, as such, and with our verbal laws. We require structural revision of those laws so as to be able to express them in tensor equations. The newtonian law of gravitation and the older form of the law of conservation of energy are perhaps the most remarkable examples. They do not survive such minimal, and yet entirely justified, structural requirements as those of the general theory of Einstein, and therefore they cannot be structurally satisfactory.

We have already seen that the equation $x^2+y^2+z^2=c^2t^2$ or $x^2+y^2+z^2-c^2t^2=0$ represents the equation of the spherical *propagation of light* with the finite velocity *c*. The discovery that the velocity of light is a universal constant for all observers; and the above equation, led historically to the re-discovery by Einstein of the Lorentz transformation which, as we have seen, has assumed such overwhelming structural importance. The meaning of these facts is worth considering.

In Chapter XVII we analysed briefly the elementalistic language of ‘matter’, ‘space’, and ‘time’, and came to the conclusion that to eliminate objectification we must abandon the semantic disturbance and the use of the term ‘is’ of identity. Instead, we must use an actional functional language to describe ordered functioning, behaviour, or operations. By necessity we were led to a ‘contact’ method. We also discovered that in accepting the above structural methods we were compelled to discriminate between different orders of abstraction, since what we see, feel, and experience is *not* what we say about it. We found that on the ‘objective’ level of our actual activities, (manipulating instruments. ,) which represent the silent *un-speakable* level, we could never find a situation in which the old language of ‘matter’, ‘space’, and ‘time’ could be used without coming violently into conflict with the properly analysed facts. We came to the conclusion that this language was not structurally satisfactory, for *verbally*, ‘space’, ‘time’, and ‘matter’ were supposed to be quite clear-cut and *separate* entities, while in actual experience we *never could find such separated* objective entities. It became obvious that the *structure* of the

old language of ‘matter’, ‘space’, and ‘time’ was *different* from the structure of the outside world as we now know it. We found ourselves in a situation where we had to choose either to keep the old language which, as it differed from them in structure, could never give a coherent account of facts at hand, or else to build up a new language with *structure* similar to that of the outside world, in order to have the possibility of coherent conversation about it.

The invention of such a new language is of course an extremely difficult undertaking. In fact, it requires some genius to invent new, more structurally similar, forms of representation for the old facts. Lorentz, Einstein, and Minkowski prepared and finally produced such a structurally new language. The difficulty was that verbally we had already separated what empirically could not be separated. The problem was to amalgamate somehow the old structurally *elementalistic* language of ‘space’ *and* ‘time’ into a *non-elementalistic* language. The key to such an amalgamation is found in the light-wave equation which gives us the structural information about the world, $x^2+y^2+z^2=c^2t^2$.

This equation represents an equality. The left-hand side is expressed in ‘spatial’ terms only—the *distance* between two points *O* and *P*. The right-hand side expresses the ‘spatial’ length, but in a ‘temporal’ term. We see that here we have means of translation, and a possibility of amalgamation of two *elementalistic* languages, which were not supposed to be intertranslatable.

The Lorentz-Einstein transformation formulae are $x'=\beta(x-vt)$, $y'=y$, $z'=z$, $t'=\beta(t-vx/c^2)$ where v is the relative velocity of the two systems of co-ordinates; c, the constant velocity of light, and $\beta=1/\sqrt{1-v^2/c^2}$ ..

The formulae for x' and t' which typify, on the left-hand side, x' a ‘spatial’ *length* and t' a ‘time’, are of particular interest. We see that on the right-hand side of the expressions the value of the ‘spatial’ x' is given by $\beta(x-vt)$ which involves ‘*time*’. The value of ‘time’, t' is given by $\beta(t-vx/c^2)$, which involves the ‘spatial’ *length* x. So we see that our amalgamation is complete, and separation impossible. The above formulae express structurally the *simple experimental* fact that ‘space’ and ‘time’ cannot be separated. At this point we are not ready to discuss ‘matter’. This will be considered further on in this work (see Chapters XL and XLI).

The above formulae have also a very important physical and experimental meaning, as they introduce the ‘contact’ methods into our language. Our actual measurements of ‘space’ and ‘time’ are strictly connected with readings on some instruments, and involve therefore coincidences between pointers and ‘simultaneity’. In all instances the finite velocity of propagation of signals must be taken into consideration. When our instrument, or the eye, is affected by signals there is always a delay due to the finite velocity of the propagation of the signals. These delays are part and parcel of our experiment, and so our formulae must contain terms explicitly involving this finite velocity of propagation. This innovation involves not only a most profound structural epistemological and semantic revolution but supplies the very factor that enables us to formulate more structurally satisfactory languages (theories), which Lorentz, Einstein, and Minkowski have produced.

We have been contrasting finite and 'infinite' velocities. Let us say frankly that 'infinite' velocity is a polite way of speaking about blunders of observation. 'Infinite' velocity is meaningless. Velocity is defined as $v=s/t$ and if t is taken as zero or in other words, if one of the fundamental factors in our *definition* is lacking, our *definition ceases to define the term in question*—in this case, velocity. So when the term 'time' is lacking, we have *no velocity*, by definition; so, to speak or speculate about 'infinite' velocity is simply making noises, and not saying anything. The *negative* of this noise; namely, saying that velocity is *not* 'infinite', or in a positive sense, that velocity is 'finite', is on a different verbal footing, although it remains a polite invitation to stop talking non-sense.

It should be noticed carefully that the *general* theory of Einstein is a high structural generalization of the special theory; and that both of them are generalizations of the classical mechanical principle of relativity. It is founded, not on the introduction of any extraordinary structural assumptions, but on the elimination of some unjustified and false-as-to-facts structural assumptions, such as that of the 'infinite' velocity of light.

Both the theory of Einstein, and the theory presented in this work are long overdue. The Einstein theory could have been formulated as soon as we discovered the *finite* velocity of light, in 1676. It should be noticed that this last discovery was also overdue, as it did *not* require experiments to establish the finite velocity of light. It was sufficient to establish the meaningless character of 'infinite' velocity, which on symbolic grounds, could have been accomplished much earlier, and to conclude, that the velocity of light *must* be finite. This example shows the hampering, blocking, semantic effect which different meaningless verbal structures have on us. To express this high and satisfactory structural generalization, Einstein had to select the most general and structurally appropriate language in existence. He chose at some stage of his work the language of $\overline{E}$ and four-dimensional geometries in general and that of the differential geometry and the tensor calculus in particular. In the latest field theory, Einstein and Mayer introduce a new *more general* and very revolutionary mathematical language where vectors and tensors in an n-dimensional spread may have m components.

At present it appears that two other very general mathematical disciplines will be used increasingly in the future. One of them is the *theory of groups;* the other is *analysis situs.* In the latter we study only these characteristics of figures that are unaffected (invariant) by continuous deformation produced without tearing. Two structural points are relevant for us in this connection: namely, that the analysis situs is fundamentally a *differential* and also an *ordinal* discipline, based on asymmetrical relations. In the next chapter, as an illustration of the actional, behaviouristic, functional, operational, differential, contact method a short account will be given of the way Einstein structurally treated 'simultaneity'. The elimination of the old structural dogma about 'simultaneity' resulting from the semantic disturbance of objectification of 'time', is one of the outstanding achievements of Einstein and is historically the beginning of his theory.