

Can Metaphysics be a Science?

Why should there be metaphysics?

In the preliminary part of our paper it is our aim to define what we consider to be "metaphysics". But it is common knowledge that so many definitions of metaphysics have been given, all of which use technical and specialized language and are closely dependent upon by no means necessary or obvious beliefs. It is therefore preferable to describe the human needs out of which the systems, traditionally called "metaphysics", originate; let us put the question as to whether these needs can or should disappear and how, if they cannot and should not disappear, they can be satisfied efficiently and without major disadvantages.

When this has been done, it will perhaps become evident that "metaphysics" is not "metaphysical" (in the derogatory meaning of that word).

The systems associated with the names of Plato, Aristotle, Plotinos, Thomas Aquinas, Bruno, Leibniz; Descartes, Hegel, Schelling, Schopenhauer, Bergson, Pierce and Whitehead, examples of what we call "metaphysical systems" are due to a threefold human need, the basic features of which we wish to describe briefly.

a) This desire has an intellectual aspect. What is the intellect? It is the element in us that wants and allows us to understand all types of reality. This understanding is brought about by the analysis of wholes into their parts, by the discovery of general laws and by the systematic deduction of these laws from a few simple postulates. Thus, the multiple disconnected and individualised concrete world becomes a connected closed and general structure. This tendency towards deduction and justification, towards the introduction of connection and structure where there was only particularity and fact never stops. Even the postulates of the various sciences are always too particular and too contingent. The intellect wants to see why the laws of nature are as they are, why they should be as we discover them. The intellect wants to bring all these laws found in the various sciences together in one unified system.

We are compelled to search for a science that will have the whole of reality as its object. The aim of this science will be the deduction of this whole of reality as necessary.

When we examine the historical examples cited, it is evident that we have thus defined metaphysics.

The need that metaphysics is meant to alleviate is very difficult to satisfy: a) the synthesis is always premature (we lack and will always lack most of the necessary data, because there is no achievement possible for any of our sciences).

b) the deduction of the world as necessary should start from premises. Which ones? Certainly we do not aspire to the ambitions of some of our predecessors and try to infer from logical propositions the structure of the factual world. The failures are striking. But then what type of premise, not logical in nature, would be intelligible enough and at the same time wide enough to yield a deduction that is more than farcical?

Placed before these many difficulties, we might perhaps feel that we should abandon the undertaking altogether. But it is possible to prove that we cannot even if we wish to do so.

According to the best substantiated theory of thought that we possess, thought is a technique used by the human species to control its material, social and psychical environment. Maximal control would be complete mastery over this environment and thus unified control of it out of one center. If man wants to obtain this maximal control (and his environment is the universe) then man will feel compelled to search for a complete picture of this environment as the ultimate goal of his search. This complete picture (it naturally is only an asymptote) will have the unity and intelligibility of metaphysics, and the certainty, empirical richness and rigour of science. Even the most biological theory of mind compels us thus to believe that mind will never abandon the search for a metaphysical system.

But there is more to be inferred from such a view. Such a theory of mind also implies that our mind will need not only a metaphysics, but also a scientific metaphysics, i.e. a metaphysics that is of the nature of a science, that is based upon the data of the various sciences and that eventually serves to regulate the development of these sciences. The real need for a synthesis that makes metaphysics unavoidable, compels us to include in this synthesis the maximum number of collectively obtained and controlled facts. This maximum number is preserved and laid down in the various scientific disciplines.

The biological theory of mind demands the combination of the two attitudes that are mostly distinct — at least amongst our contemporaries — the metaphysical attitude and the scientific attitude. We realise that this combination will be very difficult to achieve and yet we consider that the very simple and widely accepted data about the nature of the human thought processes referred to make this above combination inevitable.

b) But the sole purpose of man is not just to know. Man has an emotional life. This emotional side of man also leads him towards metaphysics. The fact is widely recognised by those who attack the value of metaphysics. In their recent books, Morris Lazerowitz and Ernst Topitsch are examples of this trend. Lazerowitz, for instance, tells us: we can be reasonably sure that a philosopher who unalterably and with complete assurance maintains that change is unreal, is, under the guise of making scientific statements, covertly reassuring himself against certain feared changes and giving expression to the wish that certain conditions and things remain as they are, (we quote "The Structure of Metaphysics", p. 69). This seems very probable. But is it possible to avoid the influence of our emotional commitments? The only difference between the healthy and the sick is that the healthy have a large variety of needs. These needs are often contradictory and mostly conscious. The sick have one overpowering desire, eliminating many others and for some reason hidden or distorted. The philosopher stating the universe to be outside of time, satisfies his desire towards security and thwarts his desire towards adventure, while the Heraclitean deprives himself of all reassurance against his fear of death. Man, however he may be, healthy or sick, needs a unified picture of the universe, to show himself for what he can hope or what he must fear. This will make the universe emotionally significant. Psychology shows us that man must thus relate his environment to himself or disappear. If we are not ashamed of our emotional needs, and aware of the multiple and contradictory nature of them, we shall not hide from our selves important features of reality but we will show both the shadows and the light; both the security and the danger. We need a metaphysical system to give to our environment the emotional significance, that will allow us to accept our place in this environment or revolt against it, or both, accept and revolt. The very same emotional needs compels us again to desire a scientific metaphysics; if we want to give emotive meaning and human pattern to our environment, we need to enter into contact with it, and not to hide it from us by means of the subconscious projective mechanisms of a priori thought. It is only through the collective undertaking that is science that we, together with others can have the feeling that we touch reality. This metaphysics for which we seek, needs to be a collective and not a solitary metaphysics, and the result of our closest and most diversified contact with that which exists, outside ourselves. Let us finally not abandon the topic of the emotional needs leading towards metaphysical thought without mentioning the aesthetical desire for a global unity; a universe of unorganised fragments has no beauty. Metaphysics is needed to show us the universe as aesthetically significant (beauti-

ful or ugly or both). But every artist requires the most complete contact with the material he uses to create. Only science gives this contact to the metaphysical artist.

The very "subjective" roots underlying the many metaphysical systems show the inevitable character of metaphysical thinking. There is no such thing as non wishful thinking; all thinking is wishful. But we can and should be aware of the variety, intensity and multiplicity of our wishes we should refer to them all, try to indulge them all and know that only through contact with the "real reality", revealed in our science, can any desire be satisfied. In that case our search for emotive meaning of the universe as a whole, can be protected from any tendency towards distortion, by a frank recognition of the multiple emotional meanings. These can be positive for one desire, negative for another. The positivistic withdrawal from "world-building" is an expression of dangerous and unnecessary ascetism, in just the same way as the much too unilateral metaphysical patterns of the past have been expressions of partly repressed, partly grossly magnified needs, and not of the whole of our nature.

c) Finally man is also an actor. This means that he makes plans, plans that are of his own stature and that can concern the total future organisation of mankind. Can these projects be executed? Is the universe such that the aims man wants to realise can be realised? To know this, man wants to use physical, biological, social and psychological knowledge because his actions have consequences that are not confined to small parts of reality. The more man reaches control over his environment, the more his actions start modifying the major features of this environment and thus demand a theory of the total structure of this environment. The age of space travel and nuclear physics is the real metaphysical age.

Let us state a dichotomy: either one admits that judgements of value in some sense derive from judgements of fact, or one does not admit this but then one at least admits that from judgments of value certain judgements of fact are derivable (if I say "liberty is the highest value", I must at least be able to define what liberty is and to prove that some steps in the direction of liberty can be taken in our universe as it is). If I admit that judgements of value are derivable from judgements of fact, then, in order to develop a coherent and complete system of judgements of value, I need a complete and coherent system of judgements of fact. If I only believe that judgements of fact are derivable from judgements of value, then whatever my value system may be, I need a complete and coherent set of judgements of fact to inform me what steps should be taken (and in what order) to realise my values.

The fact that action simultaneously occurs at all levels of reality and affects them and is affected by all of them (the more so the more powerful this action is) makes the search for a metaphysical system unavoidable. Man desires a real knowledge of the universe to guide his actions, to justify his judgements of value. Actions are sanctioned by objective failure or success, and values are not subjectively selected but stated as rationally justifiable, by all competent human minds. *To give this universal and objective knowledge the metaphysical system has to be a scientific system,*

Let us reach a conclusion: *we need the universe as an intelligible whole, as an emotionally significant totality and as an organised field of action.* These three needs, distinct from each other, all demand the development of a metaphysical system. They all demand also the development of a metaphysical system that has the collective, progressive, empirical and rigorous character of the scientific system.

To quote Brentano "vera philosophiae methodus nulla nisi physicae est". We believe that metaphysics does not belong to the past but, on the contrary, belongs to the future.

In the past, few sciences were mature and only minor unifications were achieved. In the contemporary period, many sciences have already developed and a few extremely comprehensive theories have been reached.

In the past, man did not know himself, and, enslaved both socially and psychologically, did not accept his nature. Psychoanalysis and philosophical anthropology, combined with the development of sociology and economy allow man to know his own needs and to recognise himself as a creature of multiple desires.

In the past, man was relatively powerless. But at the end of the third industrial revolution (the coal-steel revolution, the electromagnetic revolution and the atomic revolution) man influences enormous forces.

For all these reasons it seems obvious to us that metaphysical thinking (in its scientific version) will be much more important in the future than it was in the past.

2. Is Metaphysics possible, as a Science?

At the beginning of our article we stated that there was a need for a study of metaphysics. It is now necessary to examine the means by which this need can be satisfied.

Let us start with a definition and discuss it later. Metaphysics is the inquiry that has as its object:

1) The totality of all that exists i.e. the universe.

- 2) More specifically, the properties common to all that exists (ontology).
- 3) Even more specifically, the internal structure or architecture of this totality.
- 4) And, as a consequence the properties and relations belonging to elements of this totality (or classes of such elements) in virtue of their place and rank in a whole having such a global pattern.

In metaphysics the aim of studying all these objects is the search for explanation or reason for the totality and its pattern.

It is our intention to state this definition in such terms that the main objections against the possibility of metaphysics will immediately come to the mind. Our conception of what metaphysics is, should become clearer through the refutation of these standard objections.

Before arriving at that point we have to indicate that this definition is not too remote from those most often given.

Pringle Pattison, in "Baldwin's Dictionary", tells us, that "metaphysics might rather be defined as simply the systematic interpretation of experience and of all its implicates, an attempt to see everything as aspects of parts of one concrete whole" (vol. II, p. 73) while Eisler's "Philosophisches Wörterbuch" tells us "ist die kritische Metaphysik der stets zu erneuernde Versuch, auf Grundlage der allgemeinen Ergebnisse der Einzelwissenschaften eine Universal Synthese des Inhalts der Erfahrung überhaupt in einer einheitlichen, erkenntnistheoretische fundierten Weltanschauung zu schaffen" (Vol. II, p. 126).

Eisler also states "Metaphysik" becomes "Theorie des Zusammenhangs der Gesamterfahrung".

These definitions coincide with our own to a large extent, provided "the totality of all that is" is also "the totality of all that can be experienced" and provided "experience" is understood as "the totality of all that can be experienced". and is not understood as "the totality of all that has been experienced" or "the quality of being experienced".

If our metaphysical inquiry is to be founded upon the data of empirical science, then we can very well understand, in the attempt to formulate an inductive or empirical metaphysics this stress upon "experience". We preferred not to include the concept of "experience" in our own definition, because to be unified, all experience needs to be completed, and because the need towards the most complete unification implies also the need towards unification of that which can be experienced with that which can only be inferred.

In Lalande's vocabulary, we meet various definitions of metaphysics that derive already from specific answers to the problems of metaphysics.

Some will define (as Kant does) metaphysics as a science on the basis

of pure reason while others, as Bergson, will define it as a science on the basis of pure intuition. Such definitions are derived from the fact that these various authors believe that the totality of being as such can only be attained by pure deduction, or by pure intuition, or that the explanation of this totality can only so be derived. If this is true, then those who reject metaphysics because it is based upon pure reason without experience (note the contradiction with the earlier descriptions), or upon pure intuition without analysis, should first inquire if the link between totality of being and pure reason or intuition is not too weak to make them reject our undertaking because they reject a science from pure reason or intuition.

Those who define metaphysics as the study of God (the self sufficient being) should once more realise that they define a science by means of some specific type of solution traditionally given to the problems of this science. Those who reject metaphysics (as Nietzsche did) because they refuse to accept such a science of the transcendent, only refute a specific incarnation of it (Platonic dualism).

It is interesting to note that in the Marxist tradition, metaphysics is rejected as implying *a*) a realism of universals *b*) a static picture of reality, it not being recognised that the dynamic nominalism of Marx himself is as much an answer to the basic metaphysical questions as the answers of his opponents. In the existentialist tradition also, metaphysics is rejected as the useless attempt to study that what is without asking about the nature of being itself. This rejection is incomprehensible; it is impossible to examine the global structure of being without inquiring into being itself. The assertion that being is a quality, with which existentialism identifies metaphysics, is only once more once possible answer to the basic problem, an answer by no means implied by the asking of the question itself.

The confusion caused by the way in which some writers identify metaphysics with the metaphysics of their opponents comes out very clearly when we compare a quotation from Carnap with one from Pierce. In "Science and Metaphysics", Carnap gives us an implicit definition of metaphysics in the following sentence (we quote the french translation) "les choses sont telles qu'il ne peut y avoir des propositions pourvues de sens en métaphysique. C'est une conséquence du but même qu'elle poursuit : découvrir et décrire une connaissance inaccessible à la science expérimentale" (Herrmann, *Actualités Scientifiques et Industrielles*, 1935).

If we examine Pierce's statements about metaphysics we find something completely different "Its (= metaphysics) business is to study the most general features of reality and real objects" (6. 2) and "metaphysics

really rests on observations" (6. 2) (Pierce : Collected Works — Harvard University Press). It is obvious that for Pierce the most general features of reality can be discovered through empirical observations. Though his pragmatism and Carnap's empirical criterion of meaning have so much in common, he would certainly not call metaphysical statements meaningless while Carnap seems to believe that he has shown or that someone has shown that all metaphysical statements are not verifiable. It seems that the comparison with Pierce shows, that one should not *define* metaphysical statements as unverifiable synthetic assertions but rather, describe them through their content and purpose (even if later one wants to use this description to prove their unverifiability).

After this digression, let us clarify our definition by analysing two standard objections :

1. *The objection of type error* : It is stated that we cannot talk with any significance about the totality of all that is, because the totality of all that is surely must include the class of all classes, and since Russell we are well aware that the totality of all classes is a contradictory concept. We can reply in diverse ways to this objection,

a) On the supposition that what exists, according to a theory, is the set of individuals referred to in the undefined concepts of this theory, and if we call "totality of a set" an individual having all members of the set as elements, then the totality of all that is, is an individual defined with reference to a set having as member only individuals of one type and even of the lowest type.

b) But it is definitely not our aim to impose such a dogmatic point of view : we intend making an inventory of the things "that are" for different synthetic sciences, things about which propositions and laws are discovered in these various sciences (we limit ourselves to the empirical sciences) and we call "universe" the historically growing set of those "things that there are" considered as a whole. We can find theories having symbols the type of which is greater than the maximal type of entities mentioned in the empirical sciences.

c) We might suggest in a final reply that the set of all sets is not in all theories of sets a contradictory concept, to take also the formal sciences into account (Fitch, to make metaphysics possible, wants to define a set theory not using the elimination of the set of all sets ; in the Appendix C (p. 217-225) of his "Symbolic Logic" (Ronald Press Company, 1952, New York). *To summarise* : the totality of all "that is" according to our opinion, is something gained by induction and abstraction from a given finite set of concepts present in our empirical sciences. Being thus ob-

tained, it will never have the properties that produce the paradoxes. This is a powerful argument for an *inductive metaphysics*.

2. *The objection of Non-Specificity.* But while inductive metaphysics seems to solve the first problem, metaphysics can be too strongly inductive.

At the end of the 19th century, there was a fairly strong movement of "inductive metaphysics". Let us only mention Wilhelm Wundt "Essays (Leipzig, Engelmann 1906), Eduard von Hartmann "Philosophie des Unbewussten" (he has written an article on "Metaphysik als Induktive Wissenschaft"), Gerhard Heymans' "Einführung in die Metaphysik" (he defines emphatically metaphysics as an inductive science having as its object the totality of the real world). There were others who had practically the same ideas such as Hans Driesch ("Ordnungslehre" and "Wirklichkeitslehre"), Otto Külpe (who in his "Einführung in die Metaphysik" also states the ideal of an inductive metaphysics) and Alois Wenzl "Weltanschauung und Physik". However, this school of critical realists, who had among their members such remarkable scientists as Heymans and Driesch did not leave a very strong mark upon the history of philosophy. Indeed they tried to generalise inductively starting with the known laws of nature (as Herbert Spencer whose method is so close to theirs, and who also proposed an inductive metaphysics), but they did not try to deduce these laws of nature from more or less general principles. The failure of Schelling's and Hegel's deductions made them fear the worst. Yet, if we really desire in our inductive metaphysics an explanation of the universe (even a partial one) then *we have to add, to the inductive moment the deductive moment as every other science does.* This is what occurs in the definitions of metaphysics given by Whitehead, and Pierce. A more recent representative of the same school of thought is that other critical realist, Nikolai Hartmann. In his "Zur Grundlegung der Ontologie" he also defends the ideal of a metaphysical system that is not a "scientia prima" but a "scientia ultima". For him, metaphysics is a general theory of categories. He wants to know the laws according to which the most general categories of every science are inserted into the total system of categories known at the present moment. Many critics of Hartmann have already pointed out how his purely descriptive procedure lacks the unity and explanatory power that is expected from a metaphysical system (for instance Wolfgang Stegmüller in his "Hauptströmungen der Gegenwartsphilosophie" Kröner Verlag, pag. 281 and following).

If this need to explain is recognised, the main problem then is: how should the deduction occur?

Let us consult, as stated, Whitehead and Pierce and see what suggestions they offer. Whitehead in the introductory chapter of his "Process and

Reality” emphasises strongly the simultaneously deductive and inductive aspect of metaphysics. “speculative boldness must be balanced by complete humility before logic and before fact” (p. 25) and “speculative philosophy (= metaphysics) is the endeavour to frame a coherent, logical, necessary system of general ideas in terms of which every element of experience can be interpreted” (p. 4).

This quotation of Whitehead’s book shows that a metaphysical system has to be adequate and applicable (has to interpret facts and all facts) but moreover has to be necessary, logical and coherent.

Pierce who stressed to such an extent, the empirical foundation of metaphysics (see page 14) is also of the opinion that “metaphysics consists in the result of the absolute acceptance of logical principles, not merely as regulatively valid, but as truths of being”.

It seems then that we have the following very difficult choice—either to consider the premises of this metaphysical deduction as simply very general statements about nature, and thus to admit that metaphysics is no separate science since it has no specific premises — or to consider that metaphysics deduces the truths of science from the truths of logic. Certain scientists are still willing to accept the latter idea — Victor von Weiszacker is a case in point — but most logicians would strongly reject their views.

We consider an intermediary solution to be the right answer. Let us take the following set of premises :

- a) the universe is a system (id est : any change in part of the laws of the system implies a change in all other parts of the laws of system).
- b) the universe is the most comprehensive system (no additions to it are possible)
- c) the universe is a whole or totality
- d) the universe is a self sufficient system
- e) the universe is a system with a sufficient degree of stability and yet also a system with a sufficient degree of creativity (as it is also a system with a sufficient degree of multiplicity and of unity)
- f) the universe contains parts that explain other parts and are again explained by other parts in such a way that finally every part explains and is explained by every other part.

These premises are by no means logical truths. They are not necessary and, even if made more precise, their negations are not contradictory. Yet they are consequences of the *idea itself of an autonomous, unique, self sufficient, comprehensive and selfexplanatory system. But what is the concept of universe if not the idea of such a system?*

If we are able to deduce some of the main features of the universe from the fact that it satisfies such conditions, we say in a sense *our universe*

is as it is, because no different system would be a universe (the analysis of the idea of universe by means of our basic requirements is the crucial point of the deduction).

If now one provocative logician could show that the logic he favours is only applicable to systems having the properties we attributed to the *universe*, this would be a major *contribution*. But we are not willing to make the destiny of metaphysics dependent upon this last possibility (even though we do *not* exclude it).

We claim that metaphysics wants to bring out the form taken by the unity of the world and the form taken by this unity is best brought out by the specific methods that have to be followed in deductions from the premises just selected. In a sense: *it is in a meta theory about these deductions that the structure of the universe as a whole will appear* (Here the theory of categories of Hartmann could definitely be placed, so could the generalised evolution theory of Spencer, or the generalised theory of isomorphisms between parts of reality in Heymans). One might object that, to say that the universe as such is a system, implies at least that the universe is a set (upon which a relation can be defined). Are we allowed to call the universe a set and, in what set theory should we consider it? What guarantee have we in favour of the idea that the universe is a system? One might moreover object that the linguistic analysis of universe, given here, depends upon the basic natural language used and changes with it. We recognize all these difficulties but we answer

- a) that there is a non controversial kernel common to all set theories
- b) that in this kernel the concept of system can be defined
- c) that we can have as many metaphysical deductions as we have concepts of the universe, and
- d) that as far as we see no reason has been given for the idea that the non controversial set axioms do not apply to the universe.

To summarize: *without having to give up the distinction between analytic and synthetic, we still are able to find premises a) that can be called typically metaphysical because they state the most general properties of any universe and b) yet seem sufficient to derive some of its detailed features.*

3. Now we are also able to refute *the objection of circularity*. The metaphysician wants to show that even the most different features of our universe imply each other reciprocally. Moreover, he wants this implication to be an explanation. Let us concentrate first upon the mutual implication the metaphysician wishes to indicate.

These implications will have the form "p implies q, r, s... and q, r, s imply, directly or indirectly, p" So the aim of metaphysics will be to realise

the equivalence of all factual propositions. This aim is naturally asymptotic but it is non contradictory. It is moreover important if we have an intensional logic. The aim of metaphysics, is the reduction of contingency to necessity, and thus can not even be stated within extensional logic. Is it however compatible with the other aim : to give an explanation of the universe? Everything depends upon the meaning of the word "explanation". We can have a minimal definition : to explain is to connect with other facts, and to deduce from more general facts. Then it is certain that the universal connecting activity that is metaphysics will be "explanation". We can also have maximal definitions of explanation that are connected with the theories of knowledge of Arnold Gehlen and Jean Piaget : for Gehlen, to explain is to show how man could produce the fact to be explained, for Piaget, to explain is to show a causal model of the fact to be explained, a model, that is partially isomorphic to the causal model of the human mind. For both : explaining is assimilating to action or thought. But it is easy to show, if we derive the concrete features of the universe from the concept itself of an existent, autonomous and self sufficient whole (id est : from the concept of universe that is simultaneously active and stable, having both Plato's and Aristotle's defining characteristics of existence, namely force and substance) then we assimilate it to the forms themselves of the human mind. The cognitive ideal of the human mind is the deductive system, intellectual prototype of the ontological system (as Piaget points out). This cognitive ideal has been realised in such a universe in which the conditions of possibility of action are satisfied, a universe that is rational and intelligible, in this sense that, as Plato's Demiourgos in the *Timaios*, we would have made it such as it is if we had been its creators.

Both in the minimal and maximal significance of the world "explanation" metaphysics as understood here is able to explain the universe.

4. *The objection of unverifiability.* Finally we come to the most important objection ; it is claimed that metaphysics cannot be a science because propositions about the universe as a whole, its structure and its explanation, are not meaningful propositions, reaching no empirical content.

When do propositions have empirical content?

Various cases can be cited :

- a) a proposition may be completely verifiable in the sense that its content could be observed :
- b) a proposition may be confirmable in the sense that through the observability of some of its consequences its probability may be enhanced
- c) a proposition may be falsifiable in the sense that propositions may be observed that imply the negation of the first proposition

d) a proposition may be weakly falsifiable in the sense that some of the propositions following from it with probability non zero can be falsified (or at least their negations can be confirmed). A proposition may be weakly confirmable in the sense that some propositions following with a certain probability from it may themselves be confirmable.

Do metaphysical propositions, in the sense in which we are taking the word "metaphysics" have empirical content?

They *can* have empirical content, as we shall try to show through an analysis of the definition itself.

a) statements about reality in itself can have empirical content, because we can change observers. Those statements that are invariant under the change of observers have a non-zero probability to be true of the world as it is in itself. Many years ago, Herman Weyl, pointed out, how the relativistic demand for laws invariant under changes of coordinate systems, was a special case of the demand for laws true about reality as it is in itself.

b) Statements about the most general properties or about the most general property (that does not need to be a quality and that can have any logical status whatever) are empirically confirmable because we can confirm that certain properties belong to larger and larger classes of objects.

c) Statements about the whole of the universe and its general structure are confirmable in as far as statements about parts of a whole can confirm statements about this whole, and in as far as the structure of parts of a whole can confirm the total structure of the whole. In a sense, we have to combine theory of confirmation with mereology (or theory of the whole-part relation) and both with a theory of modality to express the features of necessitation as explanation. This work has yet to be done and so we cannot give strict proofs. An analogy can help us however: metaphysical thinking resembles the type of thinking that relates the various manifestations of a culture to the culture as a whole or the various actions of a man to his character; if in some cases this type of thought is confirmable there is no objection in principle against it.

The main point is that we shall have to confirm metaphysical propositions through the results of global scientific theories. We shall never obtain an immediate refutation or proof of a metaphysical statement from one isolated observation about facts if that is what we require. It has been the practice of writers such as Lazerowitz to behave as if this type of observational evidence of low degree of abstraction were the only type available. This easily allows one to arrive at the conclusion that no

observational evidence can either confirm or disconfirm metaphysical statements.

To take an example, the sentence "everything flows" is certainly *not* verifiable or refutable through direct observation. If however, we see that theoretically whenever we observe invariance, this invariance is the result of compensatory flows, and that this flowlike structure is the more visible the more we go towards the infinitely small or the infinitely great then we may consider this as confirmatory evidence for the sentence "everything flows", even though no direct observation can prove or refute this sentence : Thermodynamics of reversible flows will be the confirmatory instance that no single observation can be. This example is only one of many.

We think that in recent litterature J. N. Watkins and S. Korner do not differ widely from our views in their attitude to metaphysics.

For J. N. Watkins (in "Confirmable and Influential Metaphysics" *Mind*, p. 344-365, 1958, LXVII) metaphysical propositions are confirmable but not refutable ; they are rationally arguable but not scientific statements. This position is in concord with that of Karl Popper's (Popper in his "Logic of Scientific Discovery" p. 438 considers metaphysical statements to be rationally arguable and criticizable, but not refutable ; Watkins adds the idea that this rational arguability depends upon the possibility of a weak confirmation of metaphysical statements). However, we would claim that the strict ideal of complete refutability through one observation cannot be, as Duhem showed long ago, the defining characteristic of a scientific system. There is no *experimentum crucis* operating with deductive certainty. This being the case the last reason given for a strict demarcation between scientific and metaphysical statements disappears. Metaphysical statements are weakly confirmable and weakly refutable (and if they are at all confirmable, their negations must be weakly refutable through confirmation of various consequences of these assertions that are not consequences of these negations). As we stated, the only difficulty is that the theory of confirmation of metaphysical statements has to be

- a) the theory of confirmation of relations in totalities
- b) with respect to data pertaining to relations in small parts of these totalities.

We have no formalised theory of confirmation at the present moment using concepts

- (a) from mereology
- (b) from relational calculus
- (c) from theory of probability.

Yet this is what we need.

S. Körner, in his "Conceptual Thinking" (Dover, 1951, ch. 30-33), wants to consider metaphysical statements as statements regulating the construction of scientific systems (id est : as optimum requirements for scientific systems). Thus he hopes simultaneously to maintain a relationship between science and metaphysics without being compelled to say that metaphysical statements are scientific, id est incompatible with some logical functions of observational statements. According to our point of view, Watkins misrepresents the relation between confirmation and refutation, and Körner misrepresents the relation between science and technology. If there are any regulation-rules for the construction of scientific hypotheses, they are only rationally defensible in function of a conception of what the universe is ; and if we have a conception of what the universe is then indeed, if this conception is at all useful, there must be derivable from this conception technological rules to guide the construction of scientific systems studying parts of this whole.

Every technology needs as its basis a science and every science, if genuine can yield a technology. If metaphysics is what we think it is, it must be in agreement with the idea of Körner, but if it is only what Körner thinks it is, it cannot do what he thinks it should.

His *reluctance* to give to metaphysics scientific status derives from his belief that to be confirmable and refutable, a scientific hypothesis must be strictly and logically incompatible with some logical function of observational statements. However, it is sufficient to have probabilistic incompatibility (as the practice of science shows). Once this too stringent requirement is eliminated, there are no objections whatsoever to considering the type of sentences we call "metaphysical" as scientific statements.

To conclude : for us, *metaphysical arguments are scientific arguments of the highest degree of generality, realizing the probabilistic deduction of scientific results of medium generality from very specific types of postulates* (requirements of invariance, of stability, of dynamic fecundity, of unity, of selfexplanatory and comprehensive character for the universe).

3. Criteria of Value for Metaphysical Systems

From the discussion just concluded we derive some criteria of value for a metaphysical system. We should add to every single criterion "all other circumstances being identical" and we should be aware of the fact that the problem of combining these many criteria into a single standard for metaphysical systems, is by no means already solved when the various norms have been stated.

- a) A metaphysical system A is better than a metaphysical system B if the series of scientific theories derived from it has more variety covers a bigger selection of the set of scientific theories held at the moment
- b) A is better than B, if the hypotheses added to those actually accepted in the sciences, are more analogous to the ones already accepted, having higher initial probability and being obtained by methods analogous to those used elsewhere in science.
- c) A is better than B if A realises a higher degree of unification (id est : multiplies the relations of mutual dependence and interdeducibility, probabilistic or rigorous, among many different parts of the observed reality).
- d) A is better than B if A gives more new research suggestions and
- e) A is better than B if the deduction of A derives more features of the real universe from properties shown by any existent, or by any universe (where an adequate analysis of existence and of universe is presupposed)
- f) A is better than B if the incompleted parts and the unsatisfactory deductions or inductions are more clearly shown and thus the continuation of the work better prepared
- g) A is better than B, if, from A are deducible more practically important features that affect human action and human emotions towards the universe considered as a whole.

It is obvious that these features do not imply each other ; a system can be very high on one dimension and very low on another. It is obvious also that for one given state of scientific knowledge there can be many metaphysical systems taking account of it. Finally, it is an immediate consequence of the need for a scientific metaphysics that there is not and cannot be a "philosophia perennis" ; science being in constant evolution, metaphysics must share its fate (even though the science of the future will have enough in common with the science of the present, to guarantee that the metaphysics of the future will at least have something in common with the metaphysics of the past).

It is our belief that the revolt of logical empiricism against metaphysics was absolutely necessary to make metaphysics possible. Indeed : the idea of a unique and perennial metaphysical system kept for decades metaphysically minded persons away from the synthesis of the sciences that is the first (though not the last) step of their undertaking. The ideal of the unity of Science can only be realised in a scientific metaphysics as we sketched it and the ideal of a scientific metaphysics can only be realised through the attempt towards unification of science.

4. Some Types of Metaphysical Inquiry

But the aim of this paper was not methodological. The remarks that have preceded had to explain what we want to do and why we want to do it. The real purpose we pursue however is to sketch some directions in which we might look for the construction of a metaphysics that will not be untrue to its traditional aims and yet will be a science, a metaphysics that will build upon the sciences and will eventually be useful to the sciences.

We want to pursue as many metaphysical inquiries as we can think of because in the present uncertain state of the art, we want to show to the necessarily very doubtful reader, as many roads to unity as we can imagine. We must apologise, in advance, for unavoidable incompetence. No individual should be compelled to construct his metaphysics alone. Only groups should tackle the problem. But these groups are not yet available, in our time of specialisation. So we have to do alone what we know cannot be done by one person.

We are going to analyse the following topics :

A. Considering mechanics, and observing that we have axiom systems for classical point mechanics, rigid body mechanics, mechanics of continua, relativity mechanics and quantum mechanics, we conclude that the ideal conditions in which to undertake a metaphysical inquiry are those in which axiom systems are available. We then try to give a sketch of a metaphysical deduction for these axiom systems, observing how in the various systems certain metaphysical requirements are more or less realised.

B. But there are very many parts of physical science (electromagnetics, thermodynamics, nuclear physics) for which we do not have very adequate axiom systems, and yet their study plays a very important part in our science. We try to take the most important and characteristic laws of these not yet completely systematised sciences, and show that in a metaphysically satisfactory universe these various laws should be present.

C. In A and B the deductive feature of metaphysics is more particularly evident, while the unificatory aspect is less prominent. Therefore in a third part we take a small axiom system for biology developed by Woodger and another small axiom system for relativity mechanics written down in relational calculus by Carnap. Having both these systems expressed in the same simple language, we then try to look for unificatory possibilities.

D. This unificatory attempt should not only exert itself upon skeleton systems, but should also try to bring together the main properties of matter (as chemistry shows them) and the main properties of living systems.

Taking non axiomatised chemistry and biology, this fourth section tries to use Bertalanffy's, Lotka's and Rashevsky's attempts towards a theoretical biology to generalize them in the direction of a metaphysical deduction.

E. In cosmology and cosmogony the positive sciences themselves develop disciplines that tackle metaphysical questions. In this case we try to see if a qualitative generalisation of the positive cosmology of our time could enrich the series of metaphysical deductions.

F. Eddington's fundamental physics is an attempt, as is Milne's cosmology, to derive the main features of the universe from epistemological postulates. This appears to us as a special case of a deduction starting with theory of knowledge and of action (in summary, for us : with general cybernetics) and yielding the main features of the universe. This unification of general anthropology and physics would be an excellent proof of the unity of the universe.

G. Finally, we can try to insert metaphysics in a more general science, general systems theory. This general systems-theory will characterize the existent universe and its sub systems by means of their system-form and will yield in a sense a deduction of the universe from the concept of system.

It will certainly be beyond our powers to finish anyone of these attempt, but we hope to be able to show their possibility and their interest and to bring out certain clear proofs of the possibility of the inquiry we have in mind.

5. Metaphysics and Mechanics

The reader will easily understand why we start our metaphysical inquiry with a study of mechanics. (1) Since Descartes, Huyghens, D'Alembert, Maupertius and so many others founded this science, at least half of its representatives have been of the opinion that its foundation could be deduced from rational principles (See Voss. Enzyklopädie der Mathematischen Wissenschaften, IV, 1). Kant's "Metaphysische Anfangsgrunde der Naturwis-

(1) To see how strong is the belief of scientists in the possibility and necessity of a deduction of their first principles in the history of mechanics one has only to read the old but interesting work of Eugen Dühring "Kritische Geschichte der allgemeinen Principien der Mechanik" (Berlin, Grieben, 1873, pp . 513) and the recent compendium "Histoire de la Mécanique" (by René Dugas, Bibliothèque Scientifique, Paris, Dunod, pp. 649). The article "Über die Grundlagen der Mechanik" (Mathematische Annalen 1909, Vol. 66, pp. 350; 397) gives the reader a better idea of Hamel's anti Machian approach than the article cited in the text (Deutsche Mathematiker Vereinigung 1910).

senschaften" is philosophically the most eminent example of an attempt towards deduction of the mechanical laws. There is no doubt that there has been a reaction: Mach's "Die Mechanik und ihre Entwicklung" shows that the attempts to deduce mechanical principles have been carried out with a neglect for detail, and sometimes not completely without errors of logic. But this reaction has been immediately met by a move in the opposite direction: Hamel, the well known author of an outstanding "Theoretische Mechanik" showed in his article "Über Raum, Zeit, Kraft als a priorische Formen der Mechanik" the a priori core of classical mechanics. It would be extremely rewarding to analyze the historical development of the a priori argument in the history of mechanics. This study would show that its premises were not — as falsely believed — logical truths but rather metaphysical statements.

We cannot undertake this history here; and we only want to point out the possibilities of deduction for the most recent axioms system presented.

1. METAPHYSICAL ANALYSIS OF A SYSTEM OF CLASSICAL R-DIMENSIONAL PARTICLE MECHANICS. (2)

Mc Kinsey, Sugar and Suppes, define a system of classical particle mechanics as follows.

It is an ordered quintuple (P, T, m, S, F) obeying the following postulates:

- P¹ P is a non empty finite set
- P² T is an interval of real numbers
- P³ S is an r-vector valued function with domain P x T so that for all p in P and t in T, $d^2/dt^2 S(p,t)$ exists
- P⁴ m is a positive real valued function with domain P
- P⁵ F is an r-vector valued function with domain P x T x N (where N is the set of positive integers, and for all p in P, t in T the series $\sum F(p, t, i)$ is absolutely convergent.
- P⁶ For all p in P and t in T,
 $m(p) d^2/dt^2 (S(p, t)) = \sum F(p, t, i)$

Mac Kinsey, Sugar, and Suppes give us these axioms as such and justify them presumably through their consequences. A metaphysical analysis has to justify those axioms as consequences of more general demands. Let us try to see why in a given universe the postulates mentioned should be true.

(2) "The axiomatic Method, with special reference to Geometry and Physics Proceedings of an International Symposium held at the University of California" (North Holland Publishing Company, 1959, pp. 250-266: The Foundation of Rigid Body Mechanics").

P¹ Any system should be built up out of a certain type of elementary systems.

P is here the set of elementary systems

P is given moreover as finite; this we do not deduce.

P² Any self explanatory system should be ordered according to a pervasive and fundamental explanatory order. So any self explanatory system should be at least ordered according to one antireflexive, transitive, antisymmetric R (in the Russellian meaning of these words). But the interval of real numbers is not only an order, it is a dense order.

In any self-explanatory system in which the explanatory relation is indefinitely decomposable as relative product of other explanatory relations, this order should be dense.

P³ Any system should possess parallel to the fundamental explanatory relation, a series of independent dimensions on which the elementary constituents of the system can be localised and characterised. This series of dimensions gives the object of the system independent, comparable and ordinal (or even cardinal) measurable, characteristics. The demand of measurability derives, as does the demand of comparability from the demand towards unity of the total system. The demand of partial independence of the various orders derives from the need to have partial identity not implying complete identity (thus makes a synthesis of unity and multiplicity possible). We do not infer the exact value of r , beyond the stipulation $r > 1$.

If there is a pervasive irreversible order then the changes produced in various transformations, the relations between two states A1, B1, must be comparable with the relations between two states A2, B2, representing the change produced in another transformation. This means that at least some derivatives of the vector valued functions have to exist if we want the unity of the system along the time-axis. (the time axis is the axis of the explanatory order). The demand for the second derivative is thereby not yet reached. Two bases for more specific deduction offer themselves.

- A) either we assume that relations must be assimilated to elements, and then we have the existence of derivatives of any degree,
- B) or that the dimension-structure is subjective, so that only the change in localization in any dimension is objective. Then the change in this change is the only symptom we can have for the objective occurrence of an event. The unity of the system then implies the possibility of comparing changes of changes, these being the only objective events the system exhibits

P⁴ m is a constant for given p . It ascribes to the elements of the system a substance-like quality. It is not a relation; it is a unary predicate. In order to make comparison possible, it is a scalar metrical concept m that should represent the invariance properties of the system units.

P⁵ If our system should have some type of unity, there must be element-systems that determine other element systems. The simplest way in which this can be done is through two-place relations between elements (here called forces).

Postulates of unity and of simplicity will determine this result.

Forces have moreover some supplementary properties.

- a) The Post 5 demands that, when forces are added to those that already influence a given mass-point, at the limit these forces will yield a uniquely determined resultant force. If this were not the case, the analysis of the influence exerted upon a mass point into a sequence of pair-influences would not be possible. The simplicity postulate and the determination postulate both imply this property.
- b) Moreover these forces (or two place relations) should be *vectors*. This is also significant:
 1. Any two vectors taken together define a definite resultant vector. This should be the case, because the interactions in existence taken as a whole should be definite (if not the system would be undefined).
 2. Addition of vectors should be commutative and associative (this expresses the independence of the forces with respect to the way in which they are grouped.) The postulate of analysis is here again basic See (a) above.
 3. Vectors are independent of their orientation in space (indeed they are local and not global phenomena).
 4. Vectors are continuous in addition (this implies that small additions will produce small effects: a stability postulate)
 5. Vectors in same direction are added algebraically (another expression of the linear and independent character of vectors).

Simplicity, Stability, Definiteness, and Analysability, These requirements suffice to explain the "force = vector" idea in Post 5. Finally we come to the law of motion.

In most general terms, we can state the law of motion as follows:

The Influence exerted upon a given point at a given moment is a function of the intrinsic characteristics of the point (1) and of the relational characteristics of it (2).

It is a symmetric function of these 2 arguments (if either m or $d^2/dt^2 S(p_t)$ falls to 0, $\sum F(p_{ti})$ also falls to zero).

It is indeed necessary that both intrinsic and relational properties should determine in a symmetrical fashion the influence exerted: if not, the intrinsic or extrinsic structure of an element would lack causal efficiency. Once more however we meet the second derivative. Why not S itself or $d/dt S$, or $dn/dtn S$? A few observations can be made. S itself could not occur in the law of motion: if it did stability would be impossible: the position of a body would already make it a disturbing factor. If $d/dt S$ were present in the formula instead of S then any change would be a disturbing factor. All equilibrium would tend towards static equilibrium. The system that has as its law of motion

$$m(p) \frac{d^2}{dt^2} S (pt) = \sum F (pt_i) \text{ is}$$

the simplest system that could have dynamic equilibrium (id est: that could both be stable and productive).

Let us now come to our conclusion!

If our world has to present

- a. elementary systems
- b. an irreversible order
- c. a set of independent reversible orders
- d. intrinsic and relational predicates
- e. interaction: definite and analysable.
- f. dependent upon both intrinsic and relational properties.
- g. and the possibility of dynamic equilibrium.

Then our world will be more or less the world of classical particle mechanics. (3)

(3) One of the most immediate tasks of metaphysics as we conceive it, is the attempt to bring together and to integrate the various chapters of the book "On Axiomatic Method" quoted in note 2. To give only an example, the space time structure as we introduced it here in our comments upon the Mac Kinsey axioms is largely undetermined. In Karol Borsuk's "Grundlagen der Geometrie vom Standpunkt der Allgemeinen Topologie aus" (ibid 174-187), euclidean space is defined by means of various topological properties. The axioms for these topological spaces can be examined in the light of a metaphysical deduction. We will only give a few examples. A separable space is a space in which there is a denumerable everywhere dense subset. Let us consider that distance is a function of causal connection (greater distance implying less causal relationship). Any universe in which there is a constructible control sub-set (a subset that can be built up, out of elementary parts, and that gives sufficient power over the rest of the system) should be separable if we allow for the correlation between distance and causation. The postulate of local convexity can also be interpreted as a possibility for synthetic control of any two points out of a third. We could give, similar interpretations for the other axioms ascertaining metaphysically topological properties.

2. Supplementary Remarks.

We do not wish to claim that any universe must have elementary systems, independent reversible orders, two-place interaction relations and so forth. Indeed we shall see that in more complex versions of mechanics these simplicity requirements will be rejected, in order to obtain a more completely integrated system. But we do wish to stress that the ad hoc postulates of Mc Kinsey, Sugar and Suppes are partly derivable from some of the features describing a rational universe. Though we are far away, in the example given, from a satisfactory metaphysical deduction (the notions of system, explanation, simplicity are not rigorously defined), we wish to confirm our point of view by means of the following remarks:

- A. What can be said for classical particle mechanics, can be said for classical rigid body mechanics and classical continuum mechanics.
- B. The basic concepts present in those various versions of classical mechanics can be formalised, using relational calculus and the common kernel of laws can be axiomatised, following Hamel's pattern. When this is done, the basic necessity of the whole becomes even clearer.
- C. Relativity Mechanics and Quantum Theoretical Mechanics, in their axiomatised relations constitute more complete realizations of requirements already in part satisfied (but only in part) in classical mechanics.

A.) Metaphysical Analysis of Rigid-Body and Continuum Mechanics.

We only give a few sketchy remarks to show its possibility. Rigid-body mechanics is derivable from particle mechanics if we abandon one basic postulate of the latter, the existence of elementary indivisible systems. In Rigid-Body mechanics, there exists an analogy between the elements and the system as a whole, (the elements are bodies!). This analogy gives greater unity to the whole. But on the other hand we lose the simplicity of our basic level. It will not be the last time that we see the demand for unity stronger than the demand for simplicity.

A new force, the tendency to rotate (id est: for a set of points the tendency to keep their mutual relations and the relations of their set to the totality of points constant while modifying their singular relations to this totality) intervenes, and we shall have to characterize a force by one more parameter the place of its impact on a body.

It is possible to see the necessity of forces such as angular momentum: we should have a universe in which not only elements but also systems interact, and this interaction of systems if it is analysed by means of the force concept will give rise to 3 types of forces.

- a) the external ones

- b) forces leaving internal and external relations of systems constant, but changing the external relations of their elements (angular momentum), and
- c) finally, breaking forces, tensions (not present here, but present in continuum mechanics).

We can describe continuum mechanics as the theory that applies to not necessarily constant sets of points the requirements particle mechanics applies to points. In order to do that, one has to impose regularity conditions on bodies and on frontiers, on contact forces and on space forces. But the aim is clearly deducible as a basic generalization of classical particle mechanics.

B). In order to reach relativity and quantum mechanics, we still have to intensify the demand for unification in two more directions.

1. The order-types that were extrinsic and multiple in classical mechanics should be imposed by the elements ordered and should be seen as features of one and the same field.

This implies relativity.

2. While the elementary systems, completely separate, of classical mechanics should be spread out, in interfering waves, over the whole system (yet without losing their individuality).

This implies quantum theory.

Here, we cannot hope to do more than make few suggestions, but it seems clear that, if our deduction of classical particle mechanics has not been completely at fault, then even those features of more recent parts of mechanics that diverge from the classical picture, are simply more complete realisations of the tendencies at work in the theory we analysed.

C). A General Version of Classical Mechanics. (4)

We can also demonstrate in the very concepts of mechanics a systematic order. Let us consider a system S . Upon this system we define an order O , the field of which is S . But this unique order does not allow us to express most of the important properties of S .

(4) Bertrand Russell's "The Principles of Mathematics" London, Allen and Unwin (Reprint 1951) gives in its chapter LVI "a definition of a dynamical world" the elements of a relation theoretic definition of the concepts of mechanics. He does not however suggest using this picture as a generation procedure for the concepts of mechanics. The idea of finding such a generation process is due to a study group we had the occasion to meet briefly. This was composed of M. Miedzanagora, L. Anglet, and others. A combination of their attempt to define a dialectical generation order of mechanical concepts, with Russell's relation theoretic definitions, would result in very interesting conclusions if this combination were guided by the idea of the universe as a system.

So we define an infinite set Ω of such orders on S . Again we cannot exhaust the properties of S by means of single localizations in all these orders. So let us map n orders on one order. A material point or particle being at any moment in a specific place is a mapping of such a type (of 3 orders on one, in the 3 dimensional case). But one such mapping is not sufficient: let us consider all such mappings as elements of set M . If we order M according to one of the orders already encountered, then we get motion (motion is an ordered sequence of different mappings of places on moments). A change in motion is a mapping of one such (O_iM) on an other (O_jM).

We hope the reader understands the point of this sketch: the basic concepts of mechanics can be reached through a process that simply consists in a *re-iterated refusal of contingency*. We do not accept one particular order; we take the infinite set of all such orders. Then we do not accept this given set, but consider all possible projections of orders upon each other. This we continue to do indefinitely. The idea should thus be evident: the properties of one of the concepts reached by means of this process should be deducible from

- a) its definition in the hierarchy
- b) from the fact that S is the universe (as we defined it on page 16)

Part of this second project has been realised by G. Hamel; Hamel did not know the Russell-definitions which we have just used in an undertaking Russell himself would not condone, but it is easy to transcribe Hamel's thinking as an episode in the deduction just mentioned.

It thus seems that we could define a law of construction yielding at various stages of its application the basic concepts of mechanics (with the properties expressed in the various laws of mechanics as consequences of the place these concepts have in this logicogenetic order).

Instead of building up the system as it were from below, *we could also attempt to reach it from above*, as a privileged special case of an unavoidable general form.

There might even be a possibility of relating the two enterprises.

The reader will realize that only fragments have been given here. Only when classical continuum mechanics, relativity and quanta have been studied in the same way in which we studied point mechanics, only when both the genetic constructional method and the abstractive specification method will have been applied jointly to these sciences will we really begin to have a metaphysics of mechanics. In this exploratory paper, we must already leave this field to describe another attempt to construct a metaphysics.

6. Sketch for a metaphysical analysis of electromagnetic, thermodynamic and nuclear Phenomena.

The reader will have observed that, at the end of our consideration of classical particle mechanics, we pointed out that only one level of our universe should necessarily present the features this classical particle mechanics shows. In no case have we presumed that the universe should in all respects, on all its levels have the same structure. Our undertaking would be legitimately rejected if we were unable to show that also other levels of reality, met with in other physical disciplines, were a priori deducible, partly at least, from the very idea of a world or universe.

If there is to be a real ontological difference of levels in a universe then there should be not only scale free laws, valid on all levels, but also laws which are linked to specific levels and which define the nature of these levels to a certain extent.

Thermodynamic and nuclear phenomena are such level linked phenomena. Nuclear phenomena define the relatively basic levels. They constitute the conditions of possibility for the existence of elementary particles. Even if those particles are not really elements in the absolute sense of the word, they are elements relative to a sequence of other levels and the specific forces that appear in connection with them should be deducible from this fact. It is as if we were giving to the material points of our former paragraphs a structure that should be in accordance with the function they have in the whole.

Thermodynamic phenomena define those levels that contain a practically infinite (id est: very large) number of elementary systems, so that the specific nature of one of those elementary systems cannot influence the global field. So that no organisation imposed on another level can be reflected upon this aggregate. In a sense thermodynamics projects upon levels of higher complexity the fact that they are built up out of levels of lower complexity.

Finally, we consider electromagnetic phenomena. They are not linked to a given level, of extreme smallness or of extreme magnitude. They are present on all levels. If we compare electromagnetic forces to gravitational forces however, we observe very important differences:

- i) there are systems that are electrically or magnetically neutral; there are no systems that have a gravitational neutrality.
- ii) there are two types of electricity: positive and negative, and two types of magnetic poles: north and south. But there are no two types of gravitational energy.

- iii) there are both attractive and repulsive electrical and magnetic forces. There is no repulsive gravitational force.
- iv) even if the law of conservation of charge is valid, the charge of given masses may change while mass is an invariant characteristic.

It seems to be necessary, to us, that there should be in any universe electromagnetic, thermodynamic and nuclear phenomena.

If a universe is to be a system of systems (and it can only be a system through being a system of systems: if not the necessary unity and multiplicity would not be present), then there should be at least three levels: the level of the whole, the level of the elements and the level on which the elements interact with each other.

In order to have interaction from level to level, we have to have phenomena on level II that are due to the phenomena of level I without being determined in their nature by the phenomena of level I as individual phenomena and without being determined by the structure of level II as specific structure of level II. This makes such features as those studied in thermodynamics inevitable.

In order to have a relatively basic level we should have in this relatively basic level forces constituting the individuality and cohesion opposite to those of gravitation: they should guarantee separation and not union. They should have the short range properties of nuclear forces.

But we should not only have elementary phenomena, level-linking phenomena and world unifying phenomena (nuclear, thermodynamic and gravitational features). We should also have such forces that allow the construction of intermediary systems.

These forces should not be resent everywhere; they should be absent in certain sets, because not all sets should be systems. It should be necessary that these sets, where the forces in question are present, possess through these forces a definite order. Gravitation does not order the particles that attract each other when they are of equal magnitude; electricity and magnetism do it (because the poles are always of different sign). Finally the stability of these systems should be guaranteed through the repulsive forces (while in purely gravitational systems, the stability can only be due to the relative bulk of the system parts, any point being attracted by any other, in electromagnetic fields the quantity is not the only stabilising factor). Electromagnetism might thus be described as the structural force. The variability of charges as much as their possible neutralisation are conditions of the possibility for re-organisation.

Thus it seems to be the case that the idea of the universe as having at least three levels and as linking these levels to each other, accompanied by the possibility of organisation on any level, and based upon the rela-

tively elementary character of one level makes us realise the multiplicity of phenomena mentioned in the title of this paragraph.

We are going to show that this general type of deduction is capable of yielding the basic pattern of these various forces.

The reader may however already realise that his fears of our deducing much too much were unfounded : we do not depend upon the primacy and all sufficiency of classical mechanics, a system that we know empirically to be not more — and also not less — than a first approximation.

If he is aware of the contemporary situation of nuclear physics, the reader will perhaps note that we did not mention the weak interactive forces that manifest themselves when particles born through the disintegration of other elementary particles, meet.

The laws of this fourth type of interaction to be found in nature, are not yet well enough known to be studied in any detail in such a paper as this. We may however venture the following hypothesis without being able to substantiate it in detail: if the universe is to be one and if (as seems necessary in function of Einsteins equation linking energy and mass) energy and mass are so linked that the transformability of types of energy in each other (a symptom of the basic unity of the universe on the relational level) entails the transformability of types of mass into each other, then the possibility of transformation of elementary particles into each other should exist (as is also the case). The properties of the minor interaction forces should be deducible from the fact that they are conditions of the possibility of the intertransformability of the building blocks for our world.

There are many questions that still remain to be resolved and it is perhaps preferable that we should demonstrate how more classical results are partly deducible by our methods.

A. What is electro-magnetism, as a feature of a universe? (1)

It is well known that the Maxwell equations give us an axiomatic summary of the properties of electromagnetism. The full quantitative content of those equations is not deducible from our qualitative considerations. What is deducible is a more or less complete qualitative abstract of these equations.

We summarise those parts of the Maxwell equations which we consider are relevant:

(1) Details concerning the properties of electromagnetism [can be found in any handbook of physics. We used Holton and Roller "Foundations of Modern Physical Science" (Addison-Wesley, 1958, pp. 782), and Margenau, Watson, Montgomery "Physics, Principles and Applications" (Mac Graw Hill, second edition, 1953, p. 813).

- I. Let E and M be names respectively of the electrical and the magnetic field. Let a field be a set of forces defined over any point of a connected space region (be there matter present in that region or not). Let Div and $Curl$ be the familiar operators on vectors. These two operators have the following qualitative significance: *Div* is a measure of the rate of change of the total field for a differential displacement *along* its axes. *Curl* is a measure of the differences in rate of change according to the different axes, for a differential displacement along its axes. The first operator measure the global rate of change, the second one the differences among rates of change (and thus is connected with rotation).
2. If there should be non-additive phenomena in the universe enabling the existence of structures as wholes, there should be fields in the universe. There should also be fields of at least two types: (a) : fields like E , with $Div E = k$, and fields like M with $Div M = 0$ (the E and the M are taken over a given surface). The fact that the divergence is zero for the magnetic field shows that the lines of force of this field are cyclic and that thus no global work occurs over a given surface, while the fact that $Div E$ has a positive value shows that some work can be realised. If only one type of field existed we would have either too much stability or too much instability.
3. Both electric and magnetic fields when stable, comply to the Newtonian laws of force: the intensity of electric and magnetic force is inversely proportional to the square of the distances and directly proportional to the product of charges (a generalised expression of this fact constitutes two other Maxwell equations). The Newtonian gravitational law has, as we have already pointed out in an earlier publication, clear metaphysical advantages (the mass of an extended body can be considered as concentrated in a point, and there is no intervention of far away bodies in the motions of our environment (2).) These advantages remain preserved for the newly introduced forces and this constitutes an important reason for the presence of Laws of Newtonian type.
4. The two newly introduced fields depend upon each other in a clearly symmetrical fashion:

$$\text{curl } E = f_1 (d/dt M) \text{ (I) and } \text{curl } M = f_2 (d/dt E) \text{ (2).}$$

We have no intention of making a detailed analysis of the differences between f_1 and f_2 (as we said we do not aspire to infer the totality of the Maxwell equations, but only to derive parts of their content).

(2) "Metaphysisch Essay (Leo Apostel, Dialoog, nr. 1, 1960).

The equations (1) and (2) imply that for an electrical or magnetic field change there is a rotational field-change of the associated magnetic or electric field.

This associated field is directed perpendicularly to the field to which it is associated. Thus the relationship between magnetism and electricity connects forces in one dimension to forces in other dimensions. If we need a multidimensional universe (we have already pointed out its necessity, on page 26) we need also forces that connect happenings in one dimension to happenings in the other dimensions. Moreover, if we consider the fact that the cyclic magnetic field is the minimal field in dimensions 2 and 3 that will preserve as invariant one and only one relation to the electric current moving in dimension 1, then we could say that the three dimensional character of space could be connected with the idea of a multidimensional space having the simplest possible dependency structure among the dimensions.

The fact that the two fields are functions of the variations of each other is in a sense a stabilisation mechanism: when one field changes, the other field is created but the simple existence of one of the two is not to have this effect.

The fact that the electrical field is dynamic (in the sense mentioned in 2) and the magnetic field static (again as in 2) makes of the two Maxwell equations particular cases of the following more general principle: the stabilisation of structures is function of their dynamisation, and the transformation of structures is function of their stabilisation.

If we see the electric and magnetic forces in this way as structuring agencies then the fact that they have to relate different dimensions seems a necessary consequence of their nature, as much as the fact that they are created through each other's changes.

2. What is thermodynamics, seen as a feature of the universe?

Herbert B. Callen, in his "Thermodynamics (3) given us the definition of thermodynamic phenomena on p. 7 of his book, as inter-level phenomena "thermodynamics is the study of the macroscopic consequences of myriads of atomic coordinates which, by virtue of the statistical averaging, do not appear explicitly in a macroscopic description of the system". The question arises immediately: under what conditions will those sublimar phenomena yield a unique and well defined macroscopic result? In other terms: when the sublimar aggregate is divided into n parts, that are made to interact subsequently when will this interaction yield an equilibrium state?

(3) H.B. Callen : "Thermodynamics" Wiley, 1960, pp. 376.

According to Callen this is the basic problem of thermodynamics. It is also one of the basic problems of metaphysics: when will the structures of one level, insofar as they are determined through other levels, take up a definite form, remaining relatively invariant?

The postulates of thermodynamics are explicitly introduced by Callen to show us that a solution of such a problem is possible. Thus, we can describe the foundations of thermodynamics as we are now proposing to present them as conditions for the possibility of stable systems built up out of numerous unstable components.

The postulates are the following (we quote p. 192 from Callen's book) Postulate I. There exist particular states, called equilibrium states which macroscopically are characterised entirely, by the specification of the internal energy U and a set of extensive parameters (the quantities of various different molecules and the volume occupied).

This would mean in more general terms that those states of level I that are stable and yet determined by the multiplicity of level II-states are entirely characterised by their tendency to make their parts modify each other (the energy measures this), by the frequency of parts of different nature, and by the probability of relationship between the various parts — (the volume).

Postulate II. There exists a function (called the entropy) of the extensive parameters defined for all equilibrium states and having the following property: the values assumed by the extensive parameters in the absence of a constraint are those which maximise the entropy over the manifold of constrained equilibrium states.

This is another way of saying that there is a function of energy, volume and molecule distribution that tends to be maximal, and that when it is maximal, defines an equilibrium state. The second postulate states that each large aggregate of systems will, if left free, maximalise a given function.

If this were not the case the inter-level influence could not occur.

Postulate III tells us that the entropy of a composite system is additive over the constituent subsystems, continuous, differentiable and a monotonously increasing function of the energy.

This postulate implies that one can build up stable macroscopic systems out of their parts. If the function maximised in the equilibrium states did not have the additivity property, then through any adjunction the definition of the equilibrium could be drastically modified, and this would imply too weak a link between the phenomena on level I and II.

The continuity property is in fact a consequence of the same demand to have a clear condition for stability. The fact that the function maximised

depends upon internal energy is a consequence of the definition itself of energy (the tendency to modify parts of the system through other parts of the system). It is obvious that the function defining an equilibrium state should depend upon this quantity. The sign of this dependence is purely formally a function of the sign given to the terms of this dependence and thus has no importance whatever.

Postulate IV tells us that the entropy vanishes when the partial derivative of the energy with respect to this same entropy vanishes.

This Nernst postulate is derivable from the fact that when changes in the distribution of the energies have no longer effect upon the total energy, then the energy must be evenly distributed.

The postulates that are mentioned allow a determination to a large extent, of the form of the entropy function (as is shown in the work mentioned). Yet it is clear that they do nothing more than declare that the basic problem of thermodynamics is soluble, namely the problem: how to derive from a large number of unstable components on a level I, a stable aggregate on a level II. The unified and yet emergent character of the universe is expressed by means of the four postulates of Callen (this is especially clear for III).

The fourth postulate shows that only the relationships between the various parts of the aggregate determine the parameter, that the system has a tendency to make maximal: indeed the relationships are the features that determine the internal energy and when these relationships no longer vary through a variation of entropy then the entropy becomes zero. This means that the entropy is the essential measurement of these relationships. If this is the case than the constitution of the equilibrium on level II out of elements on level I is due only to the relationships existig between the lower level parameters. This guarantees the autonomy of the tendency towards the macroscopic equilibrium.

3. What are the nuclear phenomena, seen as features of the universe as a whole? (4)

(4) We do not make an analysis of the two classical chapters of physical research: optics and acoustics, chapters that are among the oldest of the science and chapters also that have been in various periods connected to philosophical research. We leave them out because they are less fundamental than the ones we study (acoustics is a chapter of the study of wave motion in continuous media and optics is a chapter of electromagnetics.) That we have neglected them should not be interpreted as a judgement of impossibility: both optics and acoustics have many interesting and striking features in common (reflexion, refraction, polarization, diffraction and so on) the deduction of which might be pursued. For the moment, let us merely ask: why should any universe contain phenomena that can show these four prop-

The nuclear phenomena can be described as consequences of two basic demands:

- a they must guarantee the independence and stability of the building block with respect to the higher levels and
- b they must manifest the unity of the universe through their mutual transformations, (we use this teleological language not because we would claim that our universe was a finalised system, nor because we would claim that we picture the universe in a certain fashion to obtain a specific effect, but as a figure of style: we shall see that much of what we know about these phenomena can indeed be seen to follow from such presuppositions.)

Werner Heisenberg, in his "Nuclear Physics" (5) mentions the following properties as essential to the nuclear field.

- a. Nuclear forces are very strong close to the centre, but they weaken very rapidly with increasing distance. As we have said already, this is necessary if those nuclear fields should guarantee the cohesion and limitation of the elementary systems.
- b. Electric forces would cause nuclei to disrupt (because they are repulsive among charges of equal sign), but they are on short range dominated by the much stronger nuclear forces. More remotely however the nuclear forces disappear and the repulsive effect of the electric forces can make itself felt. The interplay of the nuclear and the electromagnetic field makes the existence of multiple and independent atoms possible (just as the interplay of gravitational and radiation energy allows stars to exist).

If the universe is to be a system of systems, the strong nuclear forces should not have the power to attract an unlimited number of new elementary particles; otherwise, one unique system could fill a universe. Therefore, like chemical forces, the nuclear forces should be forces that can be saturated! This is in fact the case.

- c. Finally, on this basic level the relational and qualitative nature of the universe should show as strongly as possible a unity. The relational aspect of the universe is manifested through the fields and forces that are supposed to exist in it. The qualitative nature of the universe is manifested through the various substances (such as particles) that we find there. In order to unify both these features into one, we should be able to relate to any force a particle and to any particle a force. This is in fact what occurs: the nuclear

erties, and at least two species of such phenomena (those that exhibit them as well in empty space as in a medium and those that exist only in the presence of matter)

(5) Werner Heisenberg "Nuclear Physics", (Philosophical Library, New York, pp. 225).

forces can be seen as exchange forces: one proton influencing a neutron or inversely, can be described as a neutron emitting neutrinos and electrons that are absorbed by the proton.

We did not have the opportunity of examining the a priori plausibility of quantum mechanics. It is possible to state here that the wave and particle picture of the universe and the impossibility of giving priority to any of them, is in our opinion not the introduction of anything radically new in the picture of the physical world but a very strong expression of the system character of the universe (that has to be both one and multiple, both continuous and discontinuous throughout).

In the field of nuclear physics however, we see the development of the greatest possibilities for systematic deduction in the theory of the elementary particles.

This field is developing rapidly and it is certain that we cannot aspire to discovering the correct scheme in the present state of our knowledge. We can however try to exemplify the type of deduction that could be used by examining a simplified picture of this region.

The features of the elementary particles that we wish to analyse from a metaphysical point of view are the following ones:

1. Every particle that exists implies the existence of an anti-particle (an anti-particle is a particle that for all properties of the particle that have opposites, has the opposite property).
2. There are sets of particles, the number of which remains constant, and other sets of particles the number of which is variable. The first are called fermions, the second bosons.
3. All fermions share the following properties:
 - a no two particles with the same defining characteristics exist (the Pauli exclusion principle).
 - b the spins have not necessarily the value $\frac{1}{2}$ or 0 (as is the case for the bosons).
4. Both classes of fermions and of bosons present several subclasses: the fermions are to be subdivided into baryons and leptons, the bosons into photons, pi mesons and K mesons.

Baryons are either neutron, proton, or hyperon. A hyperon is an unstable heavy particle that disintegrates into particles of other types but consistently into one other baryon. The anti-particles of this class also belong to it. Leptons are either electrons, neutrinos or mu-mesons (the mu-meson disintegrates into other leptons). Bosons are either photons, pi mesons or K mesons. Pi mesons disintegrate into both baryons and leptons, K mesons disintegrate into either pi mesons, or leptons, or combinations of both according to many different formulae.

5. The interactions between those particles are in general such that
 - a they can be described similarly in a right or left directed coordinate system (they have symmetry under mirror-reflexion) and
 - b they are symmetrical under substitution of particles for anti particles.
 But the weak interactions occurring in the emission of fast electrons through radioactive decay (beta disintegration) do not have these features.

As we have stated, it is our aim now to make an attempt at introducing necessity in the complex multiplicity of these features.

1. Some of the reasons that could make the existence of antiparticles comprehensible are as follows. If the universe has to have building blocks that are as analogous as possible to the atomic propositions of a bivalent propositional calculus then for any particle there should be an anti-particle. If the principle of insufficient reason is valid, demanding that all possible structures should be realised (and if the concrete values of the parameters defining an elementary particle cannot be deduced with necessity), then the opposite values of these parameters should be both realised in nature. If the set of elementary particles should have as many symmetries as possible, then for any particle the anti-particle should exist.

The existence of anti-particles enables annulation of their reciprocal characteristics, their complete transformation into energy: if the matter-energy transmutation is to be possible, this dualistic organisation must exist.

2. The elementary level of our universe could be completely static (all types of particles invariant) or completely dynamic (all types of particles variant). But in order to have a system that has sub-systems in all possible dimensions we also have to have creativity in time sub-systems on the time axis. For the same reason we need invariance to keep the system character.

Thus it is normal that on the level of the elements, both types of particles should exist.

3. The Pauli exclusion principle is for a specific type of object an application of the principle of Leibniz, according to which indiscernable particles have to be identical, (this implies that if two particles are different they have to have different values for at least one of their defining parameters). However, our universe seems to comply with the Leibnizian principle only in its invariant elementary features, and not in its variable ones: the bosons do not obey the exclusion principle. This can also be understood because the stabilised portions

of reality should be individualised, while the non-permanent ones may contain exact duplicates.

If we consider the spins of particles as those types of forces that act internally, without modifying the external relations, then it is understandable that those particles that are individualised should have a wider possibility of values for this internal action, than the non-individualised ones.

4. a. Both the class of leptons and the class of baryons present the following structure: the basically charged particle (proton or electron); the uncharged analogue (neutron or neutrino), and the complex particle disintegrating into one of the others, (and as a mirror-image of this structure, the anti-particles of all of these). If we consider electromagnetism as introducing a basic asymmetry in the universe (gravitation is completely symmetrical), then if there should be types of elementary matter associated with each pole of such an asymmetry, this would explain (again on the dualistic basis already so clearly visible in the particle-anti-particle idea) the division into baryons and leptons. If for any elementary particle of a given description and charge there exists another equally elementary particle lacking any charge but sharing all other characteristics with the first, plus a third elementary particle producing as one of its disintegration products, the first one, then it follows that the structure of the baryon and lepton class is explained. However why should both these demands be satisfied? In order to realise the unity of the universe on the level of the elements the elements, even though not containing each other as parts, should be transformable into each other. Thus, for any element there should be another element yielding the first as a disintegration product. This makes the concept of group so important for the disintegration laws of elementary particles (whose disintegrations form groups because they have to manifest the underlying unity), which explain the function of hyperons and mu-mesons. The existence of neutrino and neutron would follow from the necessity that the material properties associated with a given pole of the basic asymmetry should also occur outside any connection with this asymmetry, in order to guarantee for combinations of protons, or of electrons, the necessary stability-properties.

The bosons are characterised by the pi and K mesons that yield the synthesis between the baryons and the leptons (pi mesons disintegrating into both baryons and leptons, and K mesons disintegrating in multiple ways into pi mesons and leptons). In our conception an asymmetry in favour of the lepton class that remains completely inexplicable is the fact

that hyperons produce through disintegration non-baryons, while mu mesons do not produce through disintegration non-leptons, moreover K mesons do not disintegrate directly into baryons.

5. Finally, if the universe has to be orientated, such an interaction as the weak interaction must exist, the lack of conservation of parity is unavoidable. However, it seemed until quite recently to be a feature of a rational universe that no other orientation than the basic time orientation could be accepted. The phenomenon discovered implies only local orientation (not global orientation); and occurs only in weak interactions. It is as if one had to construct unorientated space out of small orientated fragments. We feel that this also should be deducible but do not wish to proceed further.

We hope that, in the light of the preceding comments, the reader will see that some of the most controversial problems of present day physical theory find metaphysical counterparts:

1. The problem of unification of gravitational and electromagnetic energy becomes a special case of the problem of the unification of
 - a) the universe-unifying gravitational forces and
 - b) the local structure-realising forces (or, in other words of symmetric and anti-symmetric forces).
2. The problem of finding a unitary theory for nuclear and macroscopic phenomena becomes a special case of the integration of system laws and elementary level laws (6).

(6) In 1956, S. Yiftah published a book called "Les Constantes Fondamentales des Théories Physiques" (Gauthier Villars, 1956, pp. 124) which summarized the various attempts recently made to derive the values of the most important constants occurring in the basic physical laws.

These fundamental constants are: the charge of the electron (e), the mass of the electron (m), the mass of the proton (M), Planck's constant (h), the velocity of light (c), the constant of gravitation (G), the cosmic constant (l). The fact that modern physics attempts a deduction of the values of these constants from each other is made comprehensible, if one gives a qualitative description of the function of these various constants. We can group h and c together. c is a measure of the transmission of casual efficiency (its maximal velocity), and h is a measure of change in energy level (its minimum). Inevitably there should be a relation between the minimal change in energy and the maximal transport velocity of change. In a stabilizing universe these variables should be inversely proportional: the faster changes are transported, the smaller the elementary changes should be. We could also group e and l together (both are measures of repulsive energy, existent in minimal units or in the universe as a whole).

m and G would belong to the same group: the one determining the strength of gravitational unification in general, the other as the minimal strength such

3. The problems of ergodic theory become a special case of the problems of integration of inter-level laws and level laws.

The interaction of thermodynamics and electromagnetism, of electromagnetism and nuclear forces, and all similar interactions acquire a metaphysical dimension. The world of physics which was so long a closed world to the philosopher, has once more a philosophic meaning. The Hieroglyphs can be read.

7. Biology, Physics and Chemistry : a metaphysical Analysis.

In the preceding chapters of our paper, our procedure could be formalised as follows: we start with a theory W. We abstract from W some qualitative generalisation W'. We derive W' from the definition of "universe", and we show if possible that only W can realize W',.

This procedure gives us an adequate picture of one aspect of metaphysics i.e. of its attempt towards deduction in an explanatory fashion.

However, metaphysics has also some other aspects. It is an attempt towards unification. Here the procedure would be the following: we consider two different theories W1 and W2. We construct abstract skeleton versions W1' and W2' of both, and we attempt a derivation of either W1' from W2' or W2' from W1', or both from each other. If these attempts do not succeed, we try to add W1' to W2' and to derive both from an abstract skeleton version U, obtained by taking their addition as point of departure.

In the realm of physics itself these problems of unification are the most important still unsolved (see page 43). But when we examine the relation of physics to biology, the urgency of these problems becomes even more emphatic.

power can have in a unit. It also appears to be necessary that there should be a dependency between the ratio of m and e, and the ratio of l and G (the ratio of concentration and expansion in the whole should be proportional to the ratio the repulsive and attractive parameters in its building, blocks). That there should be for metaphysical reasons a dependence between the fundamental physical constants is another proof of the fact that the basic metaphysical intuition is the driving force of physical research itself.

We deeply regret that we have not had occasion to indicate the metaphysical significance of the various unitary theories of physics.

As in the case of so many other sections in a metaphysical study of biology, relativity and quantum mechanics, this study must be postponed until we can elaborate further on this subject.

A living system is a system (a) organised in a complex hierarchy of parts (b) existentially dependent upon each other c) in constant interaction and exchange of matter and energy with an environment (metabolism) d) capable in certain circumstances of reduplicating itself (reproduction). e) capable also of imperfect reduplication and of reduplication of this imperfect copy (evolution).

How should the physical universe be in order to make living systems possible and necessary? This question expresses our demand for unification, demand intentionally formulated on the level of the object language and not on the level of the metalanguage.

Our research consists in asking what is the difference between a universe in which life is possible and a universe in which life is impossible, and what is the difference between a universe in which life is necessary and a universe in which life is not necessary?

Thus our aim is to study the necessary and sufficient conditions for the existence of *open* systems in temporarily *stable equilibrium*, capable of *adaptation*, of *reproduction* and of *evolution*. In order to arrive at this aim: 1. We shall have to study the conditions of possibility and necessity of self replication (perfect and imperfect), assimilation, adaptation and the structure of those forms of matter that could serve as building blocks for systems of this type.

2. We shall have to study this in order to deduce their existence from certain physical laws or in order to deduce certain physical laws from their existence.

We shall attempt a sketch of various methods to prepare the deduction required.

1. In first approximation, we do not yet use the full definition of the living system, nor the full extent of physical laws but only very simple models of both. II. In second approximation we attempt a derivation on the basis of the idea of a universe, of those aspects of chemistry that enable us to show the necessary appearance of self-reduplicating systems. (1).

7. I. *First approximation: Woodger's axiom system for "things", cells and organisms as compared to Carnap's C-T system for Space-Time Topology* (2).

(1) The inquiry which we undertook could be pursued in various directions. One of those with the most possibilities would be the attempt to show the system form of the taxonomy of plants and animals; the system of all living beings as a set of systems with various types of symmetry can be fairly easily shown as an ordered cosmos derivable from simple construction laws and compared with the system of chemical substances.

(2) We take the elements of Woodger's system from "The Technique of Theory Construction" (Encyclopedia of Unified Science, vol. II, n° 5, Chicago

In order to show the connection between space, time, topology and elementary biology, we need to know the properties of "things", i.e. of those objects that can have parts (organisms are, at least, things).

As most important properties we require the following:

1. The relation "being a part of" is transitive.
2. Every class has one and not more than one sum (the sum of a class is a thing that has as parts all the elements of the class and only those).
3. The relation "being a part of" is reflexive.
4. The relation "earlier than" is antisymmetric;
5. The relation "earlier than" is transitive.
6. If the sum of K is earlier than the sum of L, then every element of K is earlier than every element of L, and neither K nor L are void.
7. Every thing has momentary slices (a momentary slice being a space time region no part of which occurs earlier than any other part of it).
8. Every thing has at least one initial slice and at least one final slice.
9. The time relation over the slices of things is
 - a) a series and
 - b) a continuous series.

Defined by means of these postulates, we have in the theory of things a one level theory, with two basic relations: "earlier than" and "part of", the one a quasi-order relation (earlier than), and both relations related to each other, and to the theory of classes.

Cells and organisms will be specific types of things.

1. All organic systems are things
2. Organic systems can only be produced by other organic systems (and all organic systems are produced by other organic systems).
3. If x and y are organic systems and x produces y then either the initial slice of y is part of the final slice of x (production by means of division), or the final slice of x is part of the beginning slice of y (production by means of fusion).
4. If x produces y through fusion, x does not produce anything else through fusion.
5. If x produces y through division, then there is another organic unit z also produced by x through division (z not identical with y).
6. If x produces y through fusion there is another z that also produces y through fusion.

1939) and the description of the C-T system from Carnap's "Introduction to Symbolic Logic and its applications" (English Edition, Dover Publications 1958.

If we compare the axiom system for the thing concept to the one for organic unit, we see three basic relations: part of, earlier than, and produces. The third relation, typical for the biological axiom system, has the following two features

- a) it has a better connection with the "part relation": when x produces y then x and y have parts in common (this is not the case with "earlier than" with reference to y) and
- b) moreover it is also closely connected with the "earlier than" relationship: when x produces y then there is a part of x that is earlier than a part of y.

If we imposed on all our axiom systems the demand that our approximate order relation and our approximate equivalence relation (earlier than, and part of) should be as closely connected as possible, then the introduction of a relation analogous to the "producing relation" would satisfy such a demand.

It is possible definitely to derive from a demand for unity the demand for as strong as possible a connection between *order* and *equivalence*. (3)

But the production relation is not only characterised by this connection. In the axiom system presented, if a system produces another, this occurs either by means of a division, or by means of a fusion, never by means of both these methods simultaneously.

If only fusion were allowed, after some time only one organic unit, would be left and the production process would stop. If only division were allowed, as a result the production process would stop, or the descendents would be at arbitrary qualitative distance from their predecessors.

Thus we need these counteracting agencies that are division and fusion to keep the domain and co-domain of the production relation a) homogeneous and b) non void.

The two axioms of division and fusion are stability axioms for the "producing" relation and for its field.

In a sense we can call this Woodger's deduction of the biological axioms from unity and stability postulates, on the condition that the thing-formalism be admitted (as we indicated, it can be seen that the properties of the thing concept follow from the requirement to have a theory analogous to the class inclusion theory but with only one type of object in it: type ho-

(3) In a completely different context, the reader will find the interaction between order relations and equivalence relations: Bastin Kilminster's work (note 4, to chapter 8) is an examination of it.

mogeneity and the possibility of subdivision and reunion would be sufficient to explain the function of the theory of things.) (4)

Woodger stresses the fact that his division and fusion relations are hierarchy-producing relations. A hierarchy is nothing more than a one-many relation such, that the co-domain of it has as elements all and only those points that can be reached from the unique initial element of the relation by means of some relative power of the relation. All descendents of a cell by division and all ascendants of a cell by fusion form a hierarchy.

Let us now add to the cells we are discussing in the axioms system presented until now, sets of cells, the sums of which can constitute organisms under certain conditions.

If we call organisms those sets of contemporary cells that have a structure of dependence relations isomorphic to a hierarchy, then the existence of thus defined organisms would follow from the requirement that there should be stationary systems, whose structure should be isomorphic to the dynamic structure of the production relation (in either of its two versions).

This requirement of correspondence between the static and dynamic structure would be another special case of the demand for correspondance of the invariants and the variations (other special cases have been mentioned when the mass-energy relation has been discussed). (5)

In this way, by an introduction of a definition which Woodger and Carnap themselves do not use — (the definition of organism), we can derive the rest of Woodger's system from requirements that already justify the earlier part of its structure.

To summarize: the biological properties axiomatised by Woodger seem to be consequences of the demand to have a system, both stable and dynamic, whose part-whole relationship is connected to its dynamic structure.

It is not difficult to show the similarities of Woodger's biological system and Carnap's axiomatization of relativistic time-space.

For Carnap's space-time topology we intend to give an abstract characterization of its global structure and we shall see how both biology and physics develop into one unified system.

The space time system of Carnap is built upon two basic relations: the K relation (spatio temporal coincidence for two world points) and the Z relation (the relation "earlier than" but only defined for moments of the same particle). Thus we have a series of space-time points and we have objects situated on these space-time points. The two relations K and Z are in

(4) If compared to the theory of sets the theory of things has a metaphysical advantage: the complexes formed from the units are of the same logical nature as the units themselves. The degree of unity is greater.

(5) See chapter 5.

some ways opposed: K is symmetrical, transitive and reflexive (an equivalence relation) and Z is transitive, antisymmetrical and anti-reflexive (an ordering relation). We can assert that if we want a set of objects with both an equivalence relation defined upon them (for unity and assimilation) and an ordering relation (for asymmetry and dynamics) here we have a realisation of this demand (similar to the one in Woodger's system, though not identical).

K and Z must exclude each other and an axiom provides for this. This exclusion is necessary if we want to distinguish the static and the dynamic.

The fact that Z has no first or last member and is dense would be implied by the demand for an unlimited dynamical character of the system, both through interpolation and extrapolation. Any other decision would impose a restriction on the productive possibilities of the system.

The elements that stand in any power (positive or negative) of Z to a given element form the elements genidentical with this element. This relation of genidentity built up out of the Z relation is an equivalence relation and here we find a strong difference with the biological axiom system: the Gen relationship does neither converge nor diverge.

The set of objects that are genidentical is ordered by the earlier-later order.

The set of all elements genidentical with a given element may be compared with the set of all parents and offspring of a given element in the biological axiom system: here as there, there is a dynamic aspect (Z) and an equivalence aspect (K). But, due to the absence of division or fusion the dynamic relation leaves the different world points completely disconnected.

We need a generalisation of the dynamic ordering over the whole universe. This global order was obtained in the biological axiom system through the division and fusion. Here it is given through the signaling relation. A signal goes from one world point a to another b when the first one coincides for a moment with a second, then some later moment of that second coincides with a third and so on until the b is attained.

The relative product of any positive power of the relative product of K with Z , with K ($(K/Z)^n/K$) defines the signal relation.

This signal relation is irreflexive and antisymmetrical. From the last property it follows that no infinite velocity of transmission can exist. This restriction postulate is a postulate analogous in its function to the postulate refusing fusion of more than two elements or simultaneous division and fusion: it keeps dynamic distinction between the elements.

In exactly the same way as the structure of the organism is a momentary cross section mirroring its growth, the structure of the momentary time slices in C-T is a mirror image of the structure of the whole line of a

given world point. Due to the finite velocity of signals there will be only a finite set of world points that can be reached from any given global world point. Any cross-section of this set including only points that can neither reach each other nor be reached from each other is a moment in time.

We can construct the space time system as realising in another way the same requirements realised by the biological axiom system. But here the elements are non composite; being non composite the link dynamism-structure cannot refer to the part-whole relations. Yet this link is given not for the parts (that are non composites) but for the whole whose simultaneity structure (the inclusion relations for neighbourhoods of points) is mirroring the various codomains of the signalling relation of points earlier in all world lines.

Now we arrive at the main point of this discussion: we have a global characterization of the space time structure (a structure with local equivalence and ordering relations, upon which a general equivalence relation is built through a negation of the local ordering relations). We also have the biological structure. We aim at a unification. How could this unification come about?

The unification can be realised in various ways:

- a) we can define the fundamental terms of the biological axiom system within the physical axiom system and try to derive the axioms from definitions so given.
- b) we can add the biological system to the physical system and try to characterize the form of this composite whole in such a way that this composition also derives from the very requirements that can be said to be at the origins of the two constituents.
- c) we can define the fundamental terms of the physical system in terms of the biological system and try to derive the fundamental physical laws from the biological laws.

In the first and third case we can also try to characterize the global algebraic structure of the so constituted total, formal system to show from what type of metaphysical postulates we could derive the necessity of the existence of such a system.

Let us try to setch all three of these attempts.

1. Definition of biological terms by means of physical terms. We see that one of the basic concepts of the theory of organisms as related by the Y relation is the concept of thing and part of a thing.

Let a thing be a set of momentary world points, having the following characteristics.

- a) the set is continuous and connected

b) the set is convex

c) the set is closed.

The axioms for things are realized for connected convex closed sets in the space time topology.

We thus can say that the theory of things, given a suitable definition, can be introduced into the theory of physical space points. It is the theory of the connected closed subsets of the momentary spaces. That such a theory is to be developed results from the application of the idea of quotient-classes. We apply the order "earlier—later" in the "thing" theory to sets of points sufficiently connected to have some properties in common with the elements of the space.

But the addition to the AS system of a theory of "thing" does not yet yield the biological axiom system. The biological axiom system is the theory of equivalence relations (being member of the same organism) of ordered sets of "things".

In a formal way we can say that the theory of organisms is here an expression of the fact that the 'things' built up out of momentary world points are to be cut up and divided again. If they were to remain joined together permanently they would constitute a new universe of discourse. The need to conserve the old units and yet to consider as new units the connected sets of old units expresses itself here through the fact that the redivision and reunion of the old units must occur.

This explains the metaphysical significance of the union of the theory of space-time points with the theory of 'things' and organisms as represented here, though only in outline, through Woodger's concepts. Let us however see if we cannot define the production relation. "x produces y" means "either part of the world lines, the sum of which constitutes for a given interval x, constitute, in a later interval, y, or part of the world lines that constitute for a given interval y constituted in an earlier interval x. (where worldlines are equivalence classes under genidentity).

The space time structure of an organism is of the following nature: it is a spatiotemporal extended set of space time points, it is a thing; and its earlier parts are isomorphic to either a part of an earlier organism, or to the union of parts of two organisms.

We can derive the existence of such extended structures of space time points from the following demands:

P¹: No set of points connected at t should remain connected permanently.

P²: At least some class of connected point sets should at any time have representatives,

P³: This class should be such that the disappearance of any of its members

should, through the structure itself of these members provoke the appearance of another.

P^1 follows from the requirement that no complex should have the properties of an element. P^2 follows from a stability postulate. P^3 follows from an autonomy postulate combined with a stability postulate.

Let us now consider the third type of unification: could we define space time points as either elements of a total organism that is the universe or on the basis of the theory of sets of organisms that would be 'things'?

We have to define "earlier" and "later". That can be done by using the fact that an organism, produced by means of another organism cannot precede any part of that other. We can also define space-time points as those parts of organisms that will never in an unlimited series of fusions and divisions be divided or fused with others. For such "parts" the axioms of the space-time system will undisputably hold. Having defined "points" and "time", the other principal concepts will follow. However there is no question that starting basically with the space-time point system the introduction of the biological system clearly has more justification than the introduction of the space time system on the basis of the biological.

In "Woodger's Technique of Theory Construction" there is a paragraph with the title "The process of generalisation" wherein he states that essentially his postulates about cells are statements about temporally ordered sets of non momentary things, able to transform into each other through the two compensatory processes of division and fusion (formally union of sets and difference of sets, or intersection with complements). Thus, although he claims to have discovered two essentially specific characteristics of organisms, even Woodger is willing to consider them as abstract algebraic properties, whose metaphysical deduction consists in the exhibition of the type of systematic unity they give to the system in question.

To sum up this part of our paper, which is intentionally formal and abstract, the unity of the K-Z and Y-Org system defines upon a quotient set of the K-Z system an approximate realization of the K-Z order, with the sum of Genid and the signalling relation being isomorphic to the production relation Y.

It seems to us, one of the forms of an inquiry into metaphysics must be this examination of the form of unified systems. However it now is essential to show that not only on this abstract level, but also in a more concrete fashion a metaphysical analysis of life is possible, connecting it to a global picture of the physical world.

2. *Second approximation: Chemistry and Biology:
a metaphysical analysis.*

Any universe should have a physics: this means that there must be relations valid for the whole of this universe and for every part of it.

This is not enough, however, to assure its existence as a universe. There must be at least one level of analysis on which this universe demonstrates qualitative multiplicity. Complete qualitative homogeneity on all levels would yield a system the subsystems of which could not have emergent qualities. The uniformity of the whole would be too great. So we should demand that on at least one level (not necessarily on all levels or on the fundamental level, as the tradition sometimes demanded) qualitative differences occur. The study of the transformations, the classification and the explanation of these qualitative differences constitute chemistry.⁽⁶⁾

It is sometimes said that Chemistry studies the content of the universe the types of matter to be found in it. This agrees completely with the definition given above, without using the questionable expression "type of matter".

Now, it is our aim to show that any universe whatsoever also needs to have another aspect: namely it should contain parts that are in certain respects similar to the whole: namely they are determined by their structure or form (information—and not energy—guided), and tend to preserve themselves as wholes. On the other hand, this should not prevent them from being parts of the maximal whole we call universe. If such parts should necessarily exist then life is a necessary feature of any system, that can be called a universe. This is another way of saying that a universe is necessarily a system of subsystems, subsystems of all possible types of unity being necessary, and thus also subsystems partially isomorphic to the whole.

We will begin with the description of the qualitative aspects of the chemical side of our universe. For the time being, we forget that there has been a unification of physics and chemistry and concentrate upon the possibility of deduction of certain very general chemical features taken as such.

1. There should be pure substances and there should be mixtures; the pure substances should be either simple or compound and the mixtures should be heterogenous or homogeneous.

If there were only simple substances in the universe, then all transformations among these simple substances would be of purely qualitative type, and transformations have to occur if the basic unity of the universe is also to be manifested in the relation between its contents.

Neither structure nor quantity could determine the qualitative trans-

(6) For the difficulties connected with a definition of chemistry, see the first pages of any standard handbook (eg. Principles of Chemistry, J. Hildebrand, New York, The Mac Millan Company, 1947,, pp. 446).

formations. The necessity of relating the qualitative and relational properties of our universe makes it inevitable to have compound substances also.

There must not only be homogeneous substances. It must be possible to link mechanically qualitatively different types of matter; without them being internally modified. If not, all external relations would be impossible; this would practically exclude stability of complexes. As there is no reason why the possibility of linkage should be lacking at any level of magnitude there must be homogenous mixtures in which the smallest elements of each component are mechanically linked to each other, and also heterogeneous mixtures.

2. There must be different states of matter. Classically three states are known: solid, liquid and gaseous. It may seem trivial but let us ask: what would be a purely solid, or a purely liquid or a purely gaseous universe? A Solid has a unique form, a liquid has a variable but well determined form, and a gas has no determined form (it expands freely). Purely gaseous and liquid universes would have no determined structure, and purely solid universes would have no possibility of widespread relationships.

There is no purely solid, purely liquid or purely gaseous life and there could not be: for the universe (and parts of it) to be a system the three states of matter should be present.

After having deduced that atomic structure of matter, we shall see that the existence of the three states of aggregation, yielding minimal and maximal freedom of motion, to the molecules, permits us to know these molecules (either as independent units in gases or through the restrictions they impose upon each other in solids). Thus, the existence of these aggregation-states is a condition of knowability also.

3. If this division of types of matter in function of their stability and of the degree of autonomous interrelationship between content and structure is indeed basic, then it should be clear why solubility, evaporation, solidification and melting points are for any given type of matter such important parameters. It should be clear as well why it is very important that various substances can exist in the three aggregation states.

4. Even though we know that the law of conservation of mass is not satisfied in atomic reactions where matter can be transformed into energy and vice-versa, there still must be some level on which the interaction of types of matter leaves a quantitative feature invariant. If this were not the case, epistemologically there would be no way to construct past out of future, nor future out of past. Even more important: this conservation property shows that the compound pure substances can as such be transformed in the course of a chemical reaction, without the transformation of elements into each other.

5. If matter had a continuous structure, infinitesimal changes could occur from moment to moment without disturbance and these changes, when cumulative, could transform any system contingently. We could say that matter should be discontinuous for the same reason that language should have discontinuous building units: for reasons of preservation of form and content. The discontinuity of energy follows from the discontinuity of matter by means of the matter-energy equivalence which has already been deduced.

From this discontinuous structure of matter, it follows that in any chemical compound the various types of matter that enter into it, should obey the law of definite proportions: a) matter being structured discontinuously, whole natural numbers should measure the relationship of elements in compounds b) matter being specific, this specificity should be shown by its relationship to other matter (otherwise the unity of the qualitative and relational properties will be lost) These two principles imply the law of definite proportions (7).

The demand for specificity in their mutual relationships does not imply that one proportion should be typical for two types of matter that form together different compounds. It is only necessary that these various proportions, if they exist, must be simply related to each other. This is stated by the law of simple multiple proportions.

6. If there are many levels in reality there must be many levels of composition of matter. As there are compound pure substances, there must be elementary units for these compound pure substances, capable of existing alone. They themselves should be built up out of simple elementary units. These intermediary units are molecules. Any chemical complex which has the possibility to act as a unit, can be called a molecule.

7. It is a consequence of the idea of a gas that in the state of aggregation of matter in which minimum restrictions are imposed on any molecule by any other molecule, the number of molecules in a given unit of volume does not depend upon the qualitative nature of these molecules in a substance with maximal freedom of mobility for the interacting molecules, molecules that are thus as free as possible from influences pertaining to their qualitative natures.

The law of Avogadro stating that equal volumes of gases at the same temperature and pressure contain the same number of molecules is analytically a result of the fact that completely free molecules will depend only on the paths open to them. These paths will have to be determined

(7) For these various laws (conservation of mass, of simple multiple proportion), see p. 20 and 22 of the handbook quoted, note 6.

- a) by their internal energy (temperature)
- b) by the restrictions of the environment (pressure).

The existence of gases follows from the need to have molecules active as such and not necessarily compelled to given positions by their surroundings; the truth of the law of Avogadro follows from this definition of gases (8).

8. We hope that the results mentioned show the possibility, of giving systematic deductions for certain qualitative features of chemical laws. Until now this idea has been much more developed in the study of physics. If we abandon the phenomenological point of view which we have chosen to use up to this point in this chapter we can do much more, to introduce a model for the atoms and molecules of the various types of matter, the properties of which we have to study. Once again, we shall try not to introduce the whole of quantum theory. We only mentioned this mechanical system in the paragraph devoted to the metaphysical analysis of mechanics and we want to see how far we can get if we start, so to speak, between the two extremes of phenomenological chemistry and quantum theory, namely: introducing a model of the atom and some laws for it but deducing them from non quantum theoretical considerations.

The picture of the atom we have at the present moment is a dualistic one and can be seen as the projection upon the structure of matter of the simultaneous demand for variability and stability. The atom has a very stable part, its nucleus, and a more unstable part, responsible for the large majority of all chemical interaction, the surrounding electrons. Both nucleus and electrons are wavelike in character, but the nucleus is much closer packed than the surrounding electrons. Nearly all the mass is contributed by the nucleus, as it should be: the intrinsic invariant properties of the atom should be connected with its stable portion. It is also natural that there should be a part in the nucleus that is connected with the outer shell (the electron) by an electric force: the proton. There should also be another part that has no such connection: the neutron. The stable part of the atom is thus made up firstly out of the link with the variable electron, and secondly of the part of the kernel that has no relationship with the external part. (9)

(8)The formulation of Avogadro's principle, can be found in any elementary text. Hildebrand cites it on p. 53.

(9) Once more we must insist on the fact that the duality wave-particle is also a fundamental metaphysical fact: all subsystems should extend over the whole of the universe and simultaneously be more strongly present in some parts of it.

The idea of the wave packet, damping out through interference of waves out

9. The form of the distribution of the variational element in the atom (the electron) should be dependent upon the following parameters (10)

- a) the intensity of its link to the stable element
- b) the variability of its link to the stable element
- c) the nature of this variability with respect to the stable feature of it.
- d) The intrinsic cyclical variations of each variable element.

These four parameters are exactly the ones that are in classical quantum theory represented by

- a) n (determination of the distance between electron and nucleus)
- b) l (determination of the form of orbit: sphere, double sphere, quadruple ellipse etc.)
- c) m (determination of the direction, with respect to the space axes, of the orbit) and
- d) spin of the electron (its rotational moment with respect to itself.)

We cannot deduce the numerical values that these parameters can take, nor can we indicate the number of electrons possible upon each of these orbits without presupposing too much of quantum theory. In general however, we can say that the variety of matter present in the universe and the set of qualitative differences apparent in it, is due to the fact that all possible values of the combinations of these parameters are realised.

The chemically important electrons will be the ones on the outer shell (with largest variability).

of phase is profoundly significant. Nearly all oscillations of each wave, except on the specific place where all happen to have peaks are neutralised: the subsystems are thus isolated by means of the interaction of waves pervading the whole universe.

If the universe is a set of waves, the distance between two identical states (the period), allows a definition of frequency, (the number of periods run through in a unit of time.) Let us now take the sums of all those frequencies for a given time unit. This would be a measure of the total variability of the system in a time unit. If the system is homogeneous in time, this quantity should be invariant. The importance of the wave parameters derives from the two following facts

- a) there is in the concept of wave a synthesis of variation and invariance
- b) the interference of waves allows the use of global properties of the universe to define sub-systems, which are practically isolated. The invariance of functions of period and amplitude derives from a combination of these two facts and the properties of space-time.

(10) Linus Pauling "The Nature of the Chemical Bond" Third edition, Cornell University Press, 1960, pp. 644 can be employed as sources for what follows. As an excellent introduction "La Structure Moléculaire" (Que Sais-je, n° 602, 1959, pp. 117) can be referred to. For more specialised information on chemical details, we refer to the works of Pauling; Hildebrand, and Pullmann.

If there is any chemical reactivity in the universe (and there should be as we have seen,) there must be atoms whose outer shells have not enough or have too many electrons to be in a stable state. In order to guarantee this it would suffice to postulate a tendency to occupy all possible orbits by at least one electron, and not to have too many electrons on a subset of the set of orbits. The Pauli exclusion principle and the Hund rule state exactly those properties. They can thus be seen to ensue from the demand of a realisation of reactivity.

10. If there are complex types of matter there must be at least two basically different principles of construction for them.

- a) the constituents can be such that their valence electrons are linked to each other by means of forces: a force structure (ionic bond)
- b) the constituents are such that their valency electrons are partially shared among the different constituents: a substance structure (covalent bond).

Both the ionic and the covalent bond should exist in nature if the equivalence of matter and energy is to be respected, and if we should have compounds of partial identification and of complete differentiation (compromise again between a completely unitarian and completely pluralistic structure).

The covalent bounds may be completely symmetric, or asymmetric. Both these types should exist in order to have hierarchical or non-hierarchical links of partial identification.

II. Before investigating the analysis of the deducible features of chemical reactions, we want to show that the basic classifications of types of matter into metals and metalloids, into acids and bases are also an a priori necessity.

Acids are the type of substance that, when reacting with water, produce the electrically charged hydrogen ion. Bases are substances that when reacting with water produce the electrically charged OH ion.

If we remember that hydrogen is the element of maximal simplicity (one electron on a spherical orbit), then we consider acids as elements that decompose other substances so as to produce the minimal element, while bases are such that they relate the minimal element to other elements (O being one of them). This generalisation of the distinction between the two types of materials is expected because of the many generalisations appearing in chemical literature. We can call acid any H producing substance and base any H linking substance. The formula for water obtains in that hypothesis a metaphysical significance: one of the most universal solvents is a synthesis of the analytic and syntetic principle, of acidity and alkalinity.

If there is to be a analysis and synthesis, there should be acids and bases. If these terms are well defined they should indeed, as they do, neutralise each other.

The opposition between metals and metalloids is an opposition between the mobility of the electrons linked to the metal or metalloid atoms. Indeed in metals these electrons are quite free to move about, in metalloids they are completely restricted. That we should have in a stable compound both the possibility of conserving internal variability and excluding it, is a necessity derivable from our always recurring basic theme: the conciliation of stability and development.

12. Finally we come to the study of chemical reactions (the change in constitution of chemical compounds). A basic duality is definitely a priori deducible: there should be reactions that produce order and reactions that destroy order. If we may consider heat as a measure of degree of order, then this implies that there should be reactions absorbing heat (endothermic) and reactions evolving heat (exothermic). There is also another basic duality which can be deduced: there should be reversible and irreversible reactions. If there were no reversible reactions all equilibria should be static equilibria, and the synthesis of stability and development would be impossible. If there were no irreversible reactions, no development would occur. The study of chemical equilibria is as important as the study of mechanical equilibria, and its metaphysical meaning is clear: the idea of universe implies a minimum of stability. The law of Le Chatelier is a definition of stability of equilibrium rather than a law of nature: if a reaction—chain is in equilibrium and a modification is introduced, there will be a tendency to restore the equilibrium. What is more important is that the chemical universe is so constructed that very simple means can be used to restore this equilibrium: the velocity of a reaction is proportional for instance to the product of the concentration of the reacting substances. This symmetrical function, that reduces to zero when any of the reactors disappear, facilitates control of the reaction velocity.

Other factors increasing the velocity of reactions are

- a) the increase of the disorganisation (making new organisations possible: heat)
- b) the increase in the instability of the existing systems: (activation through provocation of electric charges.)

The fact these factors are such that they increase the reaction velocities is thus deducible from the fact that the transformation of one system into another should be easier

- a) if both systems are unstable
- b) if both systems are in contact
- c) if both systems have unstable relationships.

All three of these factors must be important if we have to have both internal and external determinants for interaction. From those three deter-

mining factors for the velocity of reactions, it follows that catalysis is possible; id est: that substances can increase the velocity of reactions without being modified by this intervention (if they can, through their presence, increase the amount of concentration of others by offering contact surfaces, or if they can increase instability by evoking charges). Without catalysis, (id est without the possibility of influencing without being influenced itself), the degree of complexity of dynamic equilibria the systems in our universe could attain would be much less than it is now.

To summarize: from the definition itself of what a chemical reaction is, (an increase or decrease in the number of variable elements of a system, or more concretely: more or less electrons in the outer shell) follow the factors increasing or decreasing its speed, and as a consequence, follows that catalysis is possible.

13. The aim of all these remarks is not only to show that chemistry also lends itself to metaphysical analysis. Our ultimate purpose is to understand the existence and structure of life.

Most of our earlier statements will be relevant to that effect. But before applying them we must examine the basic characteristics of the central organic element: carbon. Carbon is a quadrivalent element: its outer shell can be saturated by taking four extra electrons (thus it will be saturated by eight electrons), carbon itself already having four electrons in the outer shell. This means that carbon can combine itself with carbon indefinitely. (11)

It is the first that has this property in the series of light elements (low atom number = low complexity). This explains the importance of this element: it is the element that can be called self-combinatory, and the simplest of such elements.

If we study the combinations of the simplest self-combinatorial element with H, O and N then we study its combinations with univalent, bivalent and trivalent elements (12). Thus: we study its combinations with at least one element of each valency smaller than its own.

Among the list we find the basic element hydrogen, the simplest of the elements, with one electron only. Linus Pauling mentions on page 91 of

(11) We give here a simplified version of the facts: as a perusal of Pauling will show, complicated resonance phenomena are present in the carbon compounds. These phenomena could also be submitted to a metaphysical deduction, but we want to stay here on a more elementary level.

(12) For the chemical facts on living systems used, we refer to A. I. Oparin "The Origin of Life" Dover Publications, reprint 1953, J. H. Rush "L'Origine de la Vie" (translation from the English, Payot, 1962), A. Dauvillier "L'Origine Photochimique de la Vie" (Masson et Cie, 1958), René Tiollais "La Chimie Organique" (Que Sais-je, 485) and Pauling's work already quoted.

his book that nitrogen and oxygen are distinct from the other elements through the exceptional stability of their multiple bound formations. The study of the combinations of the self-combinatorial element with the basic element and with those elements that give exceptionally stable multiple bound formations is the centre of organic chemistry. The status of organic chemistry in chemistry as a whole is thus determined. Is it a priori deducible that there should be a self-combinatorial element? There should be one if the tendency towards decomposition of other matter and the tendency towards selfdecomposition are to balance each other in at least one substance. This could be connected to the balance analytic-synthetic (mentioned when we spoke about the acid-base opposition). That this balance should exist in the whole universe is in any case more easily deducible than that it should exist in one type of material.

Once the existence of the self combinatorial element is deduced, we could deduce the fact that it should also combine with the basic element (this would allow the self combinatorial element to involve the maximum of matter and would thus relate the balance for one type of matter with the balance for the universe as a whole). There is also the fact that it should combine with those elements that have particularly stable complex formations (this would guarantee the existence of the complexes formed).

Three more facts about C are also of an extreme significance a) C is at equal distance of metal and metalloid (at equal distance of bound and free electron status)

b) C has only covalent bounds (thus it is not through electrostatic attraction that C combines but through sharing, a much more exact link.)

c) C is resonating among two basic different forms: it does not actually have four atoms on the outer shell, but these four atoms appear as a linear combination of two different shells. That the self combinatorial element has resonance properties (this introduces statistical indeterminacy in the stability of this atom itself) will allow a margin of security, that, as we hope to be able to show, is related to the possibility of evolution.

Formally, the whole of organic chemistry could be founded upon the following postulate: all possible combinations of the self combinatorial atom with the three mentioned elements exist, and in these combinations, all complexes that can possibly behave as simple structures will do so and give rise to new series. This postulate can be given a rational justification if it is seen as a consequence of the following requirement: the universe tends to have maximal creativity (i. e. maximum difference in order types). This maximum creativity is guaranteed without any doubt by the maximum possibility for C combinations to combine with each other, always keeping the self combinatorial properties.

Thus, on purely formal bases we shall have

- a) linear combinations
- b) cyclic combinations (open chains or closed rings)
- c) closed combinations connected with linear or with closed combinations, or with both.

That there should be closed combinations derives from the fact that the complexes should also have self combinatorial character, and thus should also have the possibility to form cyclic compounds, and the fact that there should be linear combinations follows from the requirement of keeping open combinatorial possibilities.

On a purely formal basis as well we should be able to infer that combinations with double and triple bounds should be able to exist to guarantee added stability. All these combinations should be possible, linking C with H, C with N and O, and then C with complexes of H, N and O. It would be a fascinating task to show that the very many ideally systematic complexes of organic chemistry could be deduced from postulates of maximum of combinatorial freedom on different levels, combined with the requirement of stability.

But our only reason for mentioning these facts here is to reach a conclusion in reference to living systems. When we observe the chemical composition of living systems then we arrive at the following conclusion from the very postulates that imply the existence of the self combinatorial element, and the existence of the self combinatorial complexes of the self combinatorial element, follow the existence of those substances that characterise living organisms, and of those processes that are hypothetically supposed to be at the origin of life.

14. Indeed, what are the basic substances making up living systems? They are carbohydrates, fats, proteins, water, nucleic acids and various specialised catalysts, called enzymes.

It is possible to study the metaphysical meaning of the simultaneous presence of these bodies. Our justification for this reasoning lies in the following establishment of fact: if we look into the statistical distribution of elements in cosmic radiation then after H and He, the three life bearing elements C, O and N are the most frequent. Thus, there must be a relationship between the universe as a whole and the life present in it. This relationship might eventually be clarified through a study such as the one we are now briefly undertaking.

- a) the carbohydrates (sugars) present in living systems are systematically related to the methane series: they are CH combinations in which 5 hydrogen atoms are replaced by OH combinations and two by O (or combinations of these).

b) the fats are to be considered as combinations of derivates from two substitutions, performed on two different members of the methane series.

The first substitution originates from propane through substitution of 3 H, by OH glycerine and the second from methane by substitution of H through OH and 2 H through O, formic acid. The two together give a typical fat.

c) the proteins are combinations of plus minus 24 amino acids.

An acid is a combination containing COOH elements.

An amine is a combination containing NH_n elements.

(the latter being of an aromatic or cyclic character).

An amino acid contains a combination of C both with NH and with OOH.

d) the nucleic acids are polymers, formed by two spirals consisting alternately of sugars and phosphates. These two spirals are linked together by means of two types of lateral chains. The lateral chains are each composed out of one member of the purine group, and one member of the pyrimidine group. The pyrimidine group is formed by closed cyclic structures, having in the ring at least two non carbon elements. The purine group is formed by double rings linked together, each of the two being heterocyclic with more than one non-carbon atom.

e) water: the composition of water is in itself extremely particular.

Pauling shows that the unique electron of the hydrogen atom is closer to the oxygen nucleus than to the hydrogen nucleus. This asymmetry causes both the solvent character of water (the electromagnetic charge caused by the asymmetry is able to break the electrostatic fields in other substances), and the fact that the nucleus of the hydrogen atom is open and exerts a specific type of attraction, much weaker than the types of chemical bond known elsewhere.

We could reformulate these facts as follows.

The self reduplicating open systems in dynamic equilibrium that are living systems, have the following constituents:

a) combinations of the self-combinatorial element with both combinations of the two simplest elements with each other, and with the element second in simplicity (O has the atomic weight immediately following H).

b) combinations of two such combinations.

c) amphoteric substances. These are basic through one of their constituents, acid through another one of their constituents and having this double property through combinations of C with all three of the privileged elements already described as such.

- d) a double symmetric structure, the form of which (the spiral) seems the consequence of two counteracting forces in constant oscillation and producing chains through their stable alternant dominance. The constituents of this doubly symmetric structure are
- a) substances of type a and phosphates, id est substances not belonging to the privileged four and
 - b) links composed of heterocyclic elements, double or simple (id est: combined once more with themselves or not).
- e) a combination of the two simplest elements, combination that has the essential property of favoring most important reactions and of presenting the very weak but very important hydrogen bond.

This more general description of the constituents of living matter permits an indication of the type of deduction of life which could be possible if there is to be a system that keeps its own individuality through interaction with the variable environment. It follows that this system must have as basic building blocks such elements as are able to react with the greatest varieties of substances (the most important classification of substances being the acid-base classification, the system forming and system disintegrating classification, the self preserving system should contain amphoteric substances in contact with the self combinatorial atom). This means that the presence of matter of the type of the amino acids is deducible, as a necessary condition of life. On the other hand, if it is admissible that all possible types of self combinatorial complexes of the self combinatorial atom will be formed then this combination of two combination types of this atom will necessarily be found once in the universe.

A necessary condition of life will thus be realised, if we may accept a hypothesis that also allows the explanation of large parts of non biological chemistry.

Moreover it is true that if we have systems with double symmetry (like the double spiral system) both poles of which tend to stabilise themselves, when isolated, through the building-up of their symmetrical counterpart, then we have a self reduplicating system. But from the moment that we have a self combinatorial system, we have in a sense a self reduplicating system. The only necessary adjunction is that we have enough complexity in the other building blocks to attain a reactivity which is more widespread than can be shown by a unique substance (even when it is C). It is inevitable that a structure such as DNA will be produced if the tendency to produce self combinatorial complexes of self-combinatorial complexes may be postulated. *Again a necessary condition of life is a necessary consequence of those principles that explain the chemical world itself.* DNA, in a purely formal fashion is a pair of linear structures of C and non C elements, con-

nected by means of linear structures of cyclic structures of C elements. *The synthesis of openness and closedness, of C and non-C elements, and the formal whole being a cycle of lines realised through lines of cycles shows how much the general structure of reality is reflected in it.*

We could make similar observations on the presence of water (the universal or quasi-universal reaction-favorising element), the presence of the energy storage in fats and sugars (combinations of C with simple elements or combinations of such combinations: the basic operations are substitution of simples, substitution of complexes, iteration of these operations and addition of the product of these operations). On the basis of these remarks, we come to a conclusion that is a generalisation of the one Oparin reaches when studying the origin of life: when we accept that, upon complex combinations of C, the operations of analysis and synthesis can be performed that allow to reach exactly these same combinations starting with C itself, then we reach those substances that are necessary and, taken together, sufficient conditions of life (13). This attempt to analyze life metaphysically, using in order to do this its chemical structure, neglected completely evolution. Our whole paper is an attempt towards a structural study. We hope to be able in the future to add to this structural sketch for a metaphysical system, a genetic dimension (showing that any system whatever when left alone long enough, will drift into a form similar to the one our universe exhibits).

(13) Oparin, p. III, op. cit.: "all the transformations of organic matter which can be demonstrated within the living cell are based on three principal reaction types: First, *condensation*, i.e. the lengthening of the carbon chain, and the reverse process of splitting the chain between two adjacent carbon atoms; second: *polymerisation*: i.e. the union between two organic molecules through an atom of oxygen or nitrogen, and hydrolysis, the reverse process of splitting up such unions; third: the process of *oxidation* with its invariable accompaniment of reduction (oxidation-reduction reactions). These quotations illustrate our aim in these last pages, i.e. to show that the algebra of these three types of reactions had a specific systematic nature, that could be found in all parts of reality, thus in a sense necessarily being deducible from the idea of a universe itself. In such a universe there should occur complex formation out of the elements (oxidation), complex formation out of complexes, homogeneously (condensation) and complex formation out of complexes, heterogeneously (polymerization), all three accompanied by their inverses.

8. Cosmology and Cosmogony : their metaphysical Aspects.

In the study of the structure and the evolution of the physical universe as a whole, the sciences transcend their normal limits and begin to construct their own metaphysical system.

The existence of cosmogony shows that, while continuing to use the same methods of empirical verification and mathematical deduction, science has developed, at least one recognised discipline that has a typical metaphysical problem as its central object of inquiry.

It is certain that many will deny this contention, claiming that cosmology and cosmogony have by no means properties which distinguish them radically from the other well-known physical disciplines. We are sure however that they are mistaken: cosmology is the study of a *unique* object, the universe and cosmogony is the study of the *development* (or *history*) of this same *unique object*.

In this sense cosmology is radically distinct from physics, that aims at study of the laws valid for the behavior of a large set of objects, the material entities. Here cosmology resembles geology, geography and human history. But the unique object "universe" is a very specific unique object. It has time as one of its features and characteristics: time has to be explained in any complete description and explanation of the universe. In this sense, cosmology and cosmogony cannot be historical in the same sense as geology and geography are historical: for these inquiries the genetic explanation can be basic because there are other objects outside of the ones we are analysing and because time can be presupposed as a framework within which the events we study are taking place. The universe to the contrary is an object whose genetic explanation must be a consequence of its systematic definition and inversely. The universe is a unique and comprehensive object: it does not depend upon any other objects and includes in itself all other objects.

Finally, we are parts of this universe and if we are to believe that we can know this same universe as such (a postulate that is naturally presupposed by all attempts towards cosmology and cosmogony) we must suppose that in the local phenomena of our spatio-temporal neighborhood the global structure of the system expresses itself. The unity of the universe is thus essential to the possibility itself of cosmology and cosmogony.

Cosmology is thus the study of a unique, unified, autonomous and comprehensive system. This is also the object of metaphysics. In this part of our paper we want to show how the method of cosmology as it exists is determined by its affinity with metaphysical inquiry.

Arthur Milne, Herman Bondi, D.W. Sciama (1) and many others have expressed the following opinion: classically the physical sciences express their laws in a set of differential equations, leaving the initial conditions that will evolve in accordance with these differential equations undetermined. Cosmology, however, aims at overcoming this duality that introduces a radically contingent irrationality. It tries to derive the initial conditions from chosen differential equations and also to derive the differential equations from the study of the initial conditions. Is this possible and in how far is it possible? This is the basic contemporary methodological question of cosmology, and it is clear that this difficulty is a consequence of the need to explain a unique, all comprehensive object, whose explanation can thus not be an external explanation. If one wants a clear proof of the affinity between metaphysics and cosmology, it is to be found here.

The proof will be even more convincing when we show that the forms of reasoning that are actually used by those who build up cosmological models, and the concepts they utilise, can be generalised as special cases of basic metaphysical concepts. This we propose doing at once, stressing however that analogy is not identity. Cosmology is not metaphysics. It is not metaphysics because it takes the universe as a set of stars or of star systems. The Universe is seen from, let us say, a given distance and at this distance stars and star systems are the elements observed in it. The metaphysician tries to see the universe, (again speaking analogically) from all possible distances simultaneously. A new dimension is thus for him added to the problem. But the analogy is profound enough and even the choice of perspective made by the astronomer-cosmologist is not without metaphysical justification.

Indeed what is a star and what is a nebula or system of stars?

A star is a gaseous concentration of matter opposed to the much more rarified milieu of external space. A star system is a set of such concentrations of matter, closer together and thus causally more interdependent than on the average.

At first sight, it may seem contingent, that there would be such concentrations of matter. However, let us presuppose the following postulates:
a) the universe as a whole must be dynamic

(1) Milne stressed the exceptional position of cosmology in his "Cosmology and the Christian Idea of God" see part 8, note 8. Herman Bondi in "British Philosophy in the Mid-Century", contributes (pp. 195-201) "Some Philosophic Problems in Cosmology", and D.W. Sciama in his book "The Unity of the Universe" (Faber, London, 1959) describes the specific nature of cosmology. All of them agree on the point which is under discussion here.

b) events only occur because there exist asymmetries that tend to become symmetric.

If both these postulates are true, then, whatever may be the properties of the substance that would fill a universe, there must be regions of higher and lower concentration of this substance if a third postulate is accepted. This third postulate should be: c) the asymmetries in the universe that cause phenomena must be of a quantitative, not of a qualitative nature, and the quantities that vary from place to place should be relations.

We shall try to justify these postulates. The first postulate is one of the consequences of the meaning of "universe". We could assume two alternative and different hypotheses to justify the second postulate which has been accepted by Pasteur, Painlevé and many others:

a) events are increasing asymmetry

b) events are preserving asymmetry.

If events were increasing asymmetry then we could neither predict nor control: we could only derive the simpler universe of the past from the more complex one of the future. If events were preserving symmetry then as an event is in any case a change, the cause would be a symmetry between element a_1 and a_2 and the effect a symmetry of equal degree between elements b_1 and b_2 . This would mean a combination of loss of symmetry and gain of symmetry, remaining as such, in its transport of order, unexplained. We could add to these rather epistemological and unmetaphysical considerations, the following more ontological remark: an event is a change in order. Let us say that an event is explained if it is shown that in the total space time order, the presence of this event guarantees the maximum of order. If order is symmetry, then it should be the case that in the later stages, greater order and thus greater symmetry reigns than in the earlier ones.

The argument is far from being definitive but it gives certainly a reason justifying acceptance of our second postulate. Let us now look at the consequences.

To unify the relational and non relational aspect of the universe, any concentration of matter must produce forces exerted by these material elements upon each other, and as a consequence within the concentrations we must necessarily have, matter must be in intense motion. This gives us the thermal energy typical for stars. If the regions of high concentration tend to lose their difference with the environment, there must be loss of energy to this environment. This loss of energy is however counteracted by the forces produced by these high concentrations of matter. There should thus be a way of losing energy that is not a way of losing matter, namely in the form of radiant energy (light). The duality gravitational energy-

(tending towards the centre) and radiant energy (tending towards the external universe from its source) prevents the high concentration of elements in the universe from instantaneously collapsing. We have to have such a stabilised feed back regulation in any region of high concentration if we want to keep these regions in existence for a finite time. The double existence of gravitational and electromagnetic energy is a consequence of the following facts

- a) high concentrations of matter produces energy
- b) this energy tends to dissipate
- c) the system of high concentration tends to continue to exist: so there must be a gravitational force counteracting the radiant energy.

If in any universe where events occur such loci of high concentration must be present, the question arises as to why these concentrations do not increase until they again encompass the whole system? Our answer is simple: the concentrations will continue to grow until the energy produced by them is so great that the elements of matter constituting them will disintegrate into energy. These are the nuclear reactions taking place in the star kernels.

Thus it is deducible that in any universe where concentration is proceeding as far as it is possible, the regions of high concentration will be regions of nuclear transformations.

We do not say all this because we want to produce a deduction of basic astronomy from a priori principles, but because we want to explain why cosmology and cosmogony present themselves as a deduction of the main properties of stars and nebulae. *Stars are the minimal high concentrations of basic matter necessary to introduce any event or development at all* (if our postulate b is accepted).

There must be star systems because if the universe has to have sub-systems (and we have repeatedly used the principle that there is no universal system without subsystems), these systems must be systems of the basic event-producing elements that are the stars.

The three topics of our scientific cosmology: the universe as a whole, the star systems and the stars, are thus not contingently chosen topics but we could say that in any rational cosmos we would find them. Astronomic Cosmology studies the universe on a level just sufficiently differentiated to make becoming possible. This feature shows simultaneously its departure from metaphysics and its metaphysical privilege.

A star is a system with minimal internal structure; with maximal thermal agitation in incandescent gases, constituted by the most elementary matter (hydrogen) and by those products that develop from it as a consequence of the disordered thermal agitation and nuclear disintegration.

We think that by the foregoing remarks the reader will be convinced of the fact that the perspective, basically astronomical, of cosmogony and cosmology has a metaphysical foundation. Now it is time for us to show that, as we stated, the basic type of reasoning that occurs in exact cosmology can easily be interpreted by metaphysical reasoning.

Let us start with an argument the discussion of which has inaugurated modern cosmology.

Heinrich Olbers' 'paradox of finite light', is also mentioned by Gamow and Scjama and a variant of it (a mechanical one) introduces one of Einstein's developments on cosmology (2). Let the universe be an infinite, static system. Then at any point the light of an infinity of sources, or the force of an infinity of masses exerts a influence. This would make motion at every point, and the light intensity at every point infinite, or indeterminate. Thus we must adopt either one of the following radical solutions-*Charlier's solution*, or the solution of the *expanding universe*, or this solution of a *finite universe* (An expanding universe is not necessarily finite even though most of the models featuring expanding also exhibit finiteness). Charlier's solution consists in subdividing the universe in subsystems, so that the mean density of matter within each subsystem is greater than the mean density of matter taken over various subsystems. If we allow the clustering in larger and larger subsystems to go on indefinitely, proportionally on any higher level there is a more and more empty space, and the infinite force or light does not occur. The expanding universe rids itself of the infinite forces through the expansion, becoming faster and faster when one moves away from any given point thus efficiently counteracting the effect of a potentially infinite mass or radiation. The solution of a finite universe in infinite open space is considered by Einstein to be impossible when the universe as a whole is assimilated to a random set of particles: zero density at the boundary would imply zero density everywhere else. This makes Einstein favour either Seeliger's solution of a repulsion force in the far distance properties of light, or a Non Euclidean closed universe.

We mention this problem because we can generalise it. Let us suppose a universe in which any element interacts with any other element. Let

(2) In "Theories of the Universe" edited by Milton Munitz, George Gamow contributes an article on "Modern Cosmology" (pp. 390-404), in which he explains the Olbers paradox, also analysed in chapter VI of Scjama's quoted work and on p. 76 of Whittrow's "The Structure of the Universe" (Hutchinsons University Library, vol. 29). Einstein's important paper "Considerations on the Universe as a Whole" (reprinted in Munitz, op. cit. pp. 275-279) Free Press Glecoe, 1957, refers to an argument, which is analogous

us also suppose a universe in which no asymmetry exists for the universe as a whole (id est: no frontier points in space or time singularising the frontier points and the centre in comparison to the other units). We stress the point that these two suppositions are of a purely qualitative nature without mentioning the type of forces or the types of units, or even the spatial character of the problem. Then the following consequences should be derivable:

- a) the state of any unit is undetermined in interaction with an infinite set of random elements.
- b) the interaction influence tends to cancel itself either through opposite forces (repulsion) or through increase of distance.
- c) the universe is vertically asymmetrical as a whole by the multiplication of an infinite number of levels of subsystems (each of which remains symmetrical).

This deduction is of a metaphysical nature. It could only be formalised in a formalized version of general systems theory. Yet it expresses the qualitative core of the more exact and quantitative Einsteinian analysis of the Olbers paradox (a paradox that ultimately concerns the relation between *unity stability* and *completeness* of the universe).

The fact that we arrive at this trichotomy is important, because the first supposition of the universal interaction is a special consequence of the unity of the universe, the second supposition of the absence of centre or frontier is a consequence of the autonomy and self contained character of the system. Thus the whole inference can be re-expressed as follows: a unified and self-contained universe must either be decreasing its degree of unification, or must be unified in antagonistic fashions (attraction-repulsion), or must be organised in an infinite number of hierarchised sublevels. In this last interpretation nothing specifically astronomical remains and the reasoning is shown as being what in fact it is: metaphysical reasoning.

But one of the main concepts of this series of considerations is that of "self contained system". The self contained system is the system without a frontier, either because it is infinite or because it is a closed set containing all its limit points. As the disadvantages of the infinite system become clear through the analysis of the Olbers paradox, Einstein's preference for the closed non euclidean space is to be seen as another attempt to realise autonomy and self containment (or absence of the frontier asymmetry). In what follows, we presuppose Einstein's tacit rejection of the Charlier solution (even though logically this solution remains possible). But one can see the reasons that made cosmological research reject it: the unity is less well-preserved than in Einstein's closed system, and no attempt has been

made to show that in a hierarchical universe or and content could determine each other.

In order to see how the typically Einsteinian cosmological concepts are simply special cases of our metaphysical parameters of the universe, we should like to explain the meanings of the space curvature and of the cosmological constant in such a way that the relations with more general notions become manifest.

The curvature of a curve is the ratio of the tangents to that curve in two different points of it, divided by their distance. If the tangent, the geometrical counterpart of the derivative, is a measure of the change rate of the function represented by the curve, then the curvature is a measure of the change in this measure of change. The curvature of space in a given point is the average of the curvature of curves through this point.

The cosmological constant is a function of the total radius of the universe. In different world models (Einstein De Sitter) this function has various definitions but always keeps this characteristic property. The cosmological constant introduces repulsion forces, negligible at short distances but non negligible at distances comparable to the radius of the universe.

The very fact that the various world models depend upon those two parameters is important. It means that the structure of the universe is to be determined by a local and a global feature (which is as it should be) and that the local feature at a point is a measure of change of change in the point, while the global feature is a measure of the extension of the whole or of the total amount of possible variety.

If the universe as totality depends upon those basic parameters, then we have as consequence: that the law of gravitation depends upon the quantity of matter and the quantity of matter upon the law of gravitation. Indeed the cosmological constant which in a sense measures the relationship between attractive and repulsive forces depends upon the radius and the radius is determined by the curvature: the total possible variety is determined by the change in change of variables. Whittrow op. cit. page 80, quotes Eddington in saying "some mechanism seems to be needed whereby either gravitation creates matter or all the matter in the world conspires to define a law of gravitation". The reader will recognise that this conception of the universe is precisely that defined by the metaphysical demand proper to all cosmological inquiry: that form and content of the universe should determine each other.

The circle would be really closed if we could accept the idea that for every universe in which the form and the content determine each other, we should have as determining parameters a local and a global parameter, roughly analogous to λ and R (λ being the curvature, R the radius).

On a metaphysical basis it would not be difficult to develop a preference for universes with positive curvature on the average, the rate of change not increasing when one proceeds but on the contrary decreasing. However we want to stress the importance of the fact that for the Einstein universe, a universe nearly completely determined by metaphysical requirements of unity, coherence, reciprocal content-form determination, the universe is necessarily unstable. So whenever we describe consistently a closed and unified universe it is a dynamic universe.

At this point we may, perhaps abandon ourselves for a moment to pure speculative thought, in this paper that, even though it speaks about highly speculative matters, always attempts to remain as close as possible to the actual scientific results, proceeding more inductively than deductively.

If a universe is a dynamic universe it may be quantitatively dynamic as to its quantitative relationship or qualitatively dynamic, changing its qualitative features as well.

If a universe is a dynamic universe it may be infinite or finite in time, and either periodically changing or irreversibly changing. If evolution is periodic, it may contain one or n periods and the periods may have constant or variable length.

Among all these possible universes, which universe would satisfy maximally our rational requirements derived from the concepts of universe itself? (see introduction)

- a) such a universe should be infinite in time, in both directions.
- b) It should have both qualitative and quantitative development.
- c) Because of the fact that quantitative development would lead a finite universe towards a starting point and an end, it should be a periodic universe (oscillatory).
- d) Because infinite identity of the cycles would mean a dominance of stability over variability, we should have cycles differing from each other both quantitatively and qualitatively. This could mean
 - a) that the cyclical parameters would always be different ones which would presuppose a universe with an infinity of basic qualitative dimensions
 - b) or that the amplitudes of the oscillations would be changing according to superimposed cyclical rhythms, superimposed in an infinite hierarchy.

A universe finite in time would not be self contained: the radical irrationality of the frontier at its beginning and at its end would make it un-understandable. It could not contain the reason of its existence in itself.

A universe without qualitative development would be basically without time, and a universe without quantitative development would separate qualities and relations. The important consequences of both the postulates of

infinity and general development are c and d. If a and b are accepted then c and d should follow.

Naturally this deduction can only have the certainty its premises would possess. However it is perhaps sufficient to show that topics, basic in recent cosmological controversy, are necessary topics in any metaphysical approach to the concept of a universe.

Before the completion of this attempt to show the metaphysical abstract of recent cosmological inquiry, we want to remark on two things; A. We have already stressed the importance of the fact that according to Einstein's introduction of the cosmological constant in the law of gravitation, content and form of the universe determine each other. This seemed to us to be a very important point because in this case the cosmological demand that laws and objects obeying these laws should determine each other was for once satisfied.

This very demand has been taken up again in the work of D. W. Sciama, some features of which we want to mention here to show the fruitfulness of a metaphysical principle.

D.W. Sciama starts from the principle which in fact is Leibniz's principle of sufficient reason: no aspect of the universe should be accidental. He then poses the following question: let us compare the universe in an evolutionary development: to the universe in a steady state! The problem is: how to infer the existence of galaxies? If the universe is an irreversibly evolutionary system, so Sciama tells us, then out of an homogeneous system at the beginning the heterogeneous system it is at the present moment can only arise if in the primeval homogeneity random differences in concentration and turbulence did occur that, through growth, give rise to the present state. These random differences remain inexplicable. If however, Sciama continues, we start with a population of galaxies, then we can postulate

- a) dimensions for these galaxies
- b) laws of nature governing the interaction between galaxies and interstellar masses, both conceived in such a way that any generation of galaxies will be just large enough and small enough to give rise by attracting the interstellar masses drifting by, to new galaxies exactly similar to those occurring in the first generation.

The point of this deduction is that the properties of the galaxies and of the laws of nature are determined exactly by the demand for stable conservation of the total population. This holds, notwithstanding the fact, also inevitable, that, if the population is to remain constant, despite decomposition and attraction, then in order to have in homogeneities we should have a universe where locally gravitation reigns and globally repulsion

If only for one set of galaxy parameters and for one set of laws of nature, the mentioned stability is possible, then the total rejection of contingency implies a given universe. If everything is to be determined by law, then only one set of laws can be true.

This would be the realisation of Spinoza's and Leibniz's ideal: and it is this end that modern cosmology pursues.

D. W. Sciama also accepts a second principle with important consequences; the universe should be a unified system. This means that anything that occurs locally should be globally determined. The inertia of a mass is a local phenomenon. The idea to make this inertia depend upon the global distribution of all masses in the cosmos to a certain extent fixes the laws of gravitation in the cosmos and the form of the cosmos (for instance this cosmos should have spherical symmetry).

The exact results of these deductions are perhaps not completely necessary (Sciama refuted only a particular evolutionary conception of the universe and we are not sure in how far other properties of the universe except the galaxy distribution would be determined by a content form postulate). *The important fact is that the deduction of specific contents and laws for the universe from the postulates of unity and necessity has been made.* These we consider as examples of metaphysical deduction, not yet completely aware of themselves as such because there was no metaphysical deduction given for concepts such as galaxy and inertia, a task that is not beyond our powers (see pp. 68-69 of this paper).

B. Present day cosmology is absorbed in the struggle between those who favour and those who reject the cosmological principle and the perfect cosmological principle.

The cosmological principle states that seen from any given point the universe should, as a whole, present the same picture.

The perfect cosmological principle states that seen from any given time the universe should as a whole present the same picture.

These two very general principles imply certain far reaching consequences for the nature of the universe.

Could these principles be defended on the basis of a metaphysical definition of what is a universe? Certainly they seem to guarantee stability and unity. But they also seem to exclude creativity and really qualitatively different subsystems. The negations of the two cosmological principles even seem to be deducible from a sound metaphysical basis; i. e. from any given point of view the universe should present a different aspect to the observer. To guarantee the universe systematic unity each element should have a singularised position in the whole.

At any different moment the universe should also present a different aspect to the observer in order to guarantee the existence of real development.

The demands for stability and development, for unity and multiplicity, dualistically opposed, seem to make the choice necessary between the principles and their negations. However, guided by the principle of necessity, we can find a way out of this dilemma.

For any level for which the negations of the two principles hold there should be two levels for which the assertion of the two principles holds: one level giving a decomposition into larger units and one into smaller units. This implies that the universe should contain an unfinite number of levels.

The consequence of accepting this meta-principle would be that the way in which the universe looks different at every point can be known at every point or at least at one point. It is often said that the possibility of cosmological research depends on the truth of the two cosmological principles. This seems to us to be false: it is sufficient that the differentiation of the universe and of the perspectives on it is such that the law of this differentiation could be derivable, on a more homogeneous level.

The future task seems to be to inquire into the consequences of the mixed cosmological principles (and the results arising out of the acceptance of those mixed cosmological principles should be analogous to the one reached in the course of our short attempt in speculation on page 73).

We hope that the examples given in this chapter show sufficiently that the development of a qualitative and relational cosmology in which examine the logical consequences of various metaphysical postulates without presupposing quantification and the laws of physics would be in idea, intention and often even in language very close to the cosmological discipline active at the moment. This is what it was our intention to show.

9. Anthropological Deduction of Fundamental Physics.

There can be no better partial proof for the validity of a metaphysical system than a deduction of the fact that such a system will necessarily occur. We should be able to show the necessary existence of a being that envisages its own universe exactly as we do in the metaphysical system under examination. Taking the fundamental nature of our knowledge as a starting point we should be able to derive that, given this knowledge, we shall necessarily develop an image of our universe identical to the metaphysical system we examine. In a universe in which we are able to

reach a deduction of the subject starting with the object (attempted in earlier parts of this paper) and of the object starting with the subject (tried out here) we shall have realised the postulate of unity that is fundamental to our concept of universe: in each partial system we should show the properties that make all other partial systems necessary.

Thus even from the definitely ontological and non-epistemological point of view that we have adopted in the present paper, we need as well an epistemological deduction of the general content of our world picture, related closely to the Kantian "transcendental deduction", executed with more recent formal techniques. A. S. Eddington is the scholar who made the most consistent attempt to derive as great a part of physical theory as he could manage, from epistemological premises. We are trying in this part of our paper to give a more general, less quantitative restatement of his theories. We shall pay attention to the fact that this epistemological deduction be inserted in a more general anthropological framework: we are trying to show now that if man is at all possible, the universe has to have a certain structure, and not only that, if knowledge is at all possible, the universe has to have this structure.

The definition of man we intend to use must naturally be of a sufficient generality. We take the following: man is a complex error controlled regulator, restoring its continually disturbed equilibrium through compensatory actions executed by many superimposed feedback cycles, obeying criteria of efficiency, which are not predetermined forever.

If man has this fundamental property, then two basic parameters of the regulator system should have high enough values: the amount of information given to man (without constant need for adjustment, the regulator loses its reaction possibilities), and the redundancy of this information (with too much variety and novelty introduced into the stimuli, the regulator is no longer adequate to its world). The balance information-redundancy is thus a basic condition for the existence of man and for its continuation. For more exact definitions of both these concepts, one should consult specialised works (1).

In virtue of his complex cyclic system, man, being able to develop in himself a model for his environment, has to represent in this model both the redundancy and the variety of this environment, whose relationship will essentially determine the relation of these two parameters in man himself.

(1) See W. Ross Ashby (*An Introduction to Cybernetics*: Wiley publications 1957). The duality information-redundancy, which is taken here to be basis for man in general, has been used much earlier as basic parameter of language by George Kingsley Zipf.

This has a basic consequence: the model of the environment will contain means, enabling man to reduce the quantity of information he has to acquire and also means which will enable him to preserve this quantity.

The classification of the stimuli, disturbing the human system, and the ordering of them in series both serve these ends: the order makes each stimulus or disturbance individual, giving to it a specific place, the classification neglects the singular character of the element, keeping only enough of its qualities to attribute it to a given class.

But no order is sufficient to reach the full individual content; so many orders must be used simultaneously. Yet it is impossible to always keep in mind all the singularities of the objects: many different classifications are of a vital importance.

This implies that the operations of reordering and reclassification are the basic operations of the human mind, if we are correct in attributing its basic significance to the polarity information-redundancy.

But, if man is a stable open system that has to stabilise itself through the patterns of this very organisation, then this duality (information-openness and redundancy-stability) has indeed all the importance that we attribute to it.

Basing our conclusion on very general anthropological data we reach most of Eddington's deductions, bearing on basic physical laws. (2)

Let us add one other general fact about man. The act of observation is a reaction of man against a physical disturbance imposing itself on the human system and relevant to the loss or restoration of a state of dynamic equilibrium. This implies that all observables are relations, relations between the normal equilibrium state of the relevant variables, and the real values they happen to have at the moment. Man being a historical system, keeping records of past situations, has to use earlier observations to correct the present situation. This means that the basic knowledge situation has, in its most simple state, a fourfold structure: the relation between normal and present state, that constitutes the observation in question, gives two elements and the relation between other norms and events, that constituted earlier observations gives two more. These fourfold structures are the

(2) We refer to the following books for information on Eddington's ideas. Eddington "Fundamental Theory", Cambridge, University Press, 1946. Noel B. Slate "The Development and Meaning of Eddington's Fundamental Theory" Cambridge University Press, 1957. Finally we refer to "The Nature of the Physical World (by A. S. Eddington, publ. Everyman's Library, reprint 1942) "The Philosophy of Physical Science" (Cambridge University Press 1939), and "New Pathways of Science" in its French translation (Herrmann, 1936).

simplest building blocks of our knowledge, knowledge that obviously can have much more complex forms, but that has at least this multiplicity.

In the genetic psychology of intelligence, developed by Jean Piaget (3) and the school of Geneva, the development of intelligence is very clearly the development of the collaboration of classification and seriation. From a fragmentary, and unique classification, separated and distinct from an equally fragmentary and unique seriation, the mind develops until it reaches the possibility of a combination of multiple and complete classifications and multiple and complete seriations in one whole. The interpretation of this final state entails the mastery of those mechanisms, which are necessary to reconcile redundancy and information.

In this paper it is not our aim to prove this point. We can only refer to the relevant literature (3) and make use of the conclusions stated. However, if this aspect of the problem is as fundamental as we consider it to be then to a certain extent it will determine our conception of reality and we confirm our point of view if we examine the details of Eddington's "Fundamental Physics". As Eddington tells us himself, this attempt intends to show *how the physical world must necessarily appear if this world is the one that is revealed by measurement*. But to measure, as Piaget repeats again and again, means both to order and to classify: to classify as equivalent to the standard unit certain parts of the objects measured and to order the number of times the unit has to be iterated to exhaust the extension of the measured object. Thus we could perhaps interpret Eddington's intention in the following fashion: *how should the universe be in order for unlimited combination of complete and multiple classification and seriation to be a possibility?*

The readers will perhaps object to the fact that we use Piaget's definition of measurement to analyse Eddington's theory. Eddington's definition of measurement, though equally derivable from the conception of man as a control system does not refer explicitly, to the synthesis of classification and seriation. However, it does, in our view, refer implicitly to it and all doubts will disappear regarding the affinity of both points of view when we analyse more deeply the nature of Eddington's E algebra.

Having accomplished this task, we will give in outline Bastin and Kilminster's (4) generalisation of Eddington's theory with a view to showing

(3) To quote one work from many: "Introduction à l'Épistémologie Génétique" (Press Universitaire de France), 3 volumes, will support this statement.

(4) E.W. Bastin and C. W. Kilminster: "The Concept of Order" I. The Space Time Structure" (Proceedings of the Cambridge Philosophical Society, vol. 50, part 2, pp. 278-286, 1954 and "Eddington's Theory in terms of the Concept of Order" (ibidem, vol. 50, part 3, pp. 439-448), 1954.

that in this generalisation, it is the fundamental dilemma of classification and seriation that plays the main part. These two indications taken together will be sufficient, so we hope, to convince the reader that Eddington's work can be understood from an anthropological and cybernetical point of view.

To explain the nature of Eddington's E-algebra: let us suppose that our basic domain consists of four binary variables; four entities about which we only know that they can exist or not exist. These would be the basic entities, necessary to define the very concept of measurement (and also in function of what we said on page 81, the basic units of every epistemic situation).

Boolean algebra tells us that four binary variables can determine sixteen different states ($16 = 2^4$).

In the presence of a vector, the elements of which are binary variables, we can perform reordering operations or transformation operations: we can change the order of the one's and zero's, or we can replace one by zero, zero by one, in all or some occurrences of these symbols.

Both in Piaget's and Eddington's work these two types of operations are basic: in the INRC algebra N is the transformational, R the reordering operator (5). In Eddington's "New Pathways for Science", the S operators (french translation p. 348) are the reordering operators (the R operators of Piaget) and the D-operators are the transformation operators. (the N operators of Piaget).

Eddington's E operators are those operators that can be obtained from S and D operators by applying S and D operators of different indices one after the other. In Piaget's terms: these E operators are mixtures of N and R: they are particular C operators. Thus, this synthesis of reordering and reclassification is the defining characteristic of Eddington's basic E group (as it is of Piaget's C).

We choose some S and D operations with specific characteristics, due to the fact that the four elements upon which the operations are performed are units, defining measured object and measuring standard. These specific conditions are not of major interest to us here but can be deduced from this aspect (the S operations for instance contain all permutations that conserve the vicinity of the first and second, third and fourth element).

(5) Refer to Piaget "Traité de Logique" for the definition of the INRC algebra, and for very closely related considerations to Eddington's work, see the applications of the INRC algebra to three binary variables in "Essai sur les transformations des opérations logiques : " Les 256 opérations ternaires" (PUF).

If we examine Bastin and Kilminster's work, generalising and systematising Eddington's attempts, then the affinity to Piaget's ideas (and thus to a cybernetic anthropology) becomes even clearer.

Let us consider a set of variables. Let us suppose that this set of variables can be ordered. At the same time let us suppose that the order is not complete, in the sense that there exist equivalence-classes under an equivalence relation, these classes being such that no two members of them are ordered by the ordering relation. But, even though in such a universe we have both order and equivalence, the unification of both is not yet obtainable: let us then suppose that whenever we have an equivalence class there exists another ordering relation than the basic one, ordering all members of this class and only the members of this class. Moreover let us suppose that whenever we have an order, there is an equivalence class containing the field of the ordering relation.

The simplest structure in which the requirements given by these postulates can be satisfied non trivially is the following one:

In a universe U , there exist two classes U_1 and U_2 but not more than two. All members of U_1 appear in an order R before all members of U_2 , and no members of U_1 stand in R before other members of U_1 (just as no members of U_2 come in R before other members of U_2). Moreover we have two other ordering relations, complete this time and defining a complete order on U_1 and U_2 . There is also the equivalence class U , including U_1 and U_2 . We thus can conclude that the simplest possible structure in which order and classification are completely combined contains 3 equivalence sets, and 3 ordering relations. Moreover in order to be non trivial and as simple as possible this totality must contain at least two elements in U_1 , and at least two elements in U_2 (four elements and no more).

This is not exactly the same structure as the S in Bastin Kilminster (1) but the reasoning leading up to it is basically the same (see note 4, refer 1).

There is reason why we should not confine ourselves to this conceptual structure. Every element of our measuring situation should once more be considered to be existent (and measurable as such). Thus we are immediately led to a consideration of the quadruple EFGH algebras of Eddington and the quadruple S, S^4 algebras of Bastin and Kilminster. This reasoning will necessarily lead us to infinite iterations of the same simple structures. But we can limit our research to finite cuts in this hierarchy.

Eddington's fundamental Physics consists in the study of certain levels in this infinite hierarchy. In this respect Bastin and Kilminster are of the same opinion. The very formulation we just gave shows clearly that there can be no reason in principle to stop on any one level.

Eddington wanted to deduce how the universe should necessarily look if we consider it as the set of measurables. We must replace this, and we think Eddington would agree, by the following formulation: let us deduce how the universe will necessarily look at one moment in the conceptual development of the idea of a universe as a set of measurables.

Moreover, the assumption that we consider only binary variables for our basic units is not necessary. The fact that we consider only extensional combinations is equally contingent. But both these decisions are simplicity decisions: they show something about the universe, namely that the approximation obtained on the basis of these decisions is not completely inadequate.

However, it may well be that the reader is of the opinion that, even though we have shown that the anthropological basis for the deduction of Eddington and Bastin-Kilminster is now evidently related to Piaget's psychology, we have not yet made clear that on this very general basis an important part of physics can be deduced.

Basically we do not wish to return to developments which we have attempted to sketch qualitatively in the preceding parts of our paper. It is evident that the dialectic of stability and variability, of unity and plurality, so important in our former reasoning, is a generalized version of the dialectic redundancy-information, order-classification, theme developed in the present paragraph.

This reference should be enough and yet we want to do slightly more. We want to show that some of the more important physical results of Eddington follow fairly directly from our interpretation of his work.

The E algebra has a matrix interpretation and a geometrical interpretation (rotations and translations). The fact that any operation on a four matrix (such a matrix represents any change in two measurables and is thus an element of EE) can be represented by means of a multiplication of four by four matrices, follows naturally from the concept itself of these matrices. These matrices are meant to represent the effect of one change in measurables upon another change in measurables: id est the basic connection of our universe. In Eddington's matrices however we find the following operations: O, I, -I, i, and -i. Multiplication by O is a classificatory operator (replacement of 1 by O) the I also (preservation of quality), the -I is a reversal operator (change of direction, complete reversal of a vector.) The i and -i are best understood by means of their spatial representation: the imaginary i connects with rotation. The i are analogous to Piaget's C operator (combination of change in one dimension and in another dimension). *That the geometrical representation of the E algebra is a group of rotations means the same, as if we said that the E algebra is an algebra combining reordering and reclassification, in all possible combinations.* Combining p. 142 and p. 138 of Fundamental Theory

(see note 2) one can give a deduction of the basic physical quantities as basic combinations of reclassifications and reorderings (matrices having positive or negative 1 or i , in left-right or right-left diagonals, in symmetrical or anti-symmetrical places).

We should realise the full significance of the preceding comments: a) Eddington represents physical quantities by means of O , -1 , i , $-i$ matrices. His empirical discovery is that the various types of physical energies can be so represented b) afterwards he observes that these energies are, taken together, an E algebra.

This is the concrete implementation of the fact that our model of the universe is such, that we have all possible combinations of information and redundancy, order and classification.

The deduction of the cosmical number, undertaken by Eddington, is again an application of the same principles. If the universe should impose its own measuring unit as an objective property it should be finite and discontinuous. So let us suppose this to be the case. How many elements should it contain? It should contain as many elements as there are possible dissociations (as there are classes in the classification having the smallest classes and as there are objects in the most complete order). But each of these elements is characterised by a certain combination of values for the basic characteristics (characteristics that are themselves measurable). This permits a development of the following trend of thought: for the sixteen basic states of four measurement units, let us consider as properties, functions which select in those sixteen basic states those that verify them and those that falsify them. This gives us 256 possible properties. Now let us assume that there are as many particles as there are different combinations of these properties. This gives us the number 2^{256} , the basic estimate of Eddington's cosmic number. The cosmic number is proportional to this but still contains three other components (6).

(6) See the last chapter of "Fundamental Theory" for the deduction of the cosmical constant, id est: the number of elementary particles in the universe, "The evaluation of the cosmical number". This deduction shows that the simple assumption of bivalency of the basic variables, and of quadruplicity of the measuring situation can be used to infer the eminently synthetic fact that there are n elements in the universe. Eddington has been strongly criticized for this attempt on the ground that it either leads to idealism, or to a neglect of the analytic-synthetic distinction. John W. Yolton in "The Philosophy of Science of A. S. Eddington" has shown clearly that his position does not in the least imply idealism but derives directly from Russell's structural realism: "only structure can be known". As to the distinction "analytic-synthetic", the statement that four bivalent elements are in some sense basic to all assertions about the universe, is synthetic and thus may without any risk imply many other synthetic statements.

One of these other components is the number 136.

This number is once more of the highest significance. It is the number of operators that are their own inverses in the double E group, EF.

Finally we must not forget that Eddington includes in his theory the necessary uncertainty of the four poles of the measurable, and the uncertainty as to the localisation of the origin of any coordinate system one might wish to use. These multiple uncertainties determine a minimum distance in Eddington's statistic approximation to the universe and imply the existence of forces necessary and sufficient to preserve this minimum distance. Thus, natural energies are for him consequences of the fact that nature is necessarily only approximately known. Instead of using only one E, or EF or EFGH system, potentially he uses many of them given in a certain *order* of approximation and *classified* together when only subliminally distinct. Eddington deduces as much from the basic uncertainty of measure, as from its essential nature. Man must, in his world-model, take as much into account the balance information-redundancy as the uncertainty of all information.

We hope that all these facts will at least suggest to the reader how, starting from his very general epistemological bases, Eddington arrives at the physical universe (7).

It is important in an anthropological deduction of the type we are analysing here, not to start out with too partial a view of man, and, as a consequence, end up with too partial a view of the type of organisation the human mind wants to impose upon the universe. Let us show briefly how other results have been obtained.

Milne also has given a "fundamental physics"; he also has tried to deduce physics from epistemology (8). He comes to the very different conclusion

(7) A very important parallel can be made between Piaget and Eddington, who are both influenced by relativity theory showing how close they are to each other in their interpretation of the centration problem. It is well known (see "Les Mécanismes Perceptifs", PUF, 1961), that man, when concentrating in perception upon a given point, over estimates the focalised parts of his field of vision, and learns, in maturing, to compensate for this by multiple centrations. In Eddington's "Fundamental Theory", his conceptions of the uranoid (as an environment without electromagnetic tension, of zero temperature and without systematic motion) is typically the conception of the background in perception theory. At the same time this very isolation implies a compensatory field correcting for the artificial separation produced, and is thus typically the element centred in the perceptual context. His chapter II on "Multiplicity Factors" could be a chapter in the psychology of knowledge. For him, the world is such that perception and knowledge are possible and this determines the universe to a large extent.

(8) As regards Milne, refer to "The Fundamental Concepts of Natural Philosophy", Proceedings of the Royal Society of Edinburgh, sec A, vol. 62, 1943-

that there is an infinite world as opposed to Eddington's finite world. Why is this the case?

Milne's universe is the universe that has simultaneously infinite openness and infinite stability: nothing changes but everything moves, nothing occurs qualitatively but continuously things appear and disappear. In this flow of time, we see the perfect reversibility of the adult human mind, which is in accordance with Piaget's adult stage. It is as it were the image of a system that can no longer be disturbed and still remains open. The world seen as obeying the perfect cosmological principle (see former part of this paper) is indeed the limit towards which at every point the mind tends, but a limit which the mind, by its very nature cannot reach. Eddington's epistemological basis (the concept of structure and the concept of knowledge as transport of structure) leaves room for an infinite development, and at every point of this development some more or less complex counterpart of the E system will be present. But Milne's world, consequence of Milne's epistemology, is a point towards which the development of our world view always tends, and from which it also drives us away and repulses us.

We have no time to study in such detail the system of Milne as we studied that of Eddington; but we can see the difference between them as follows: The world of Eddington is such as it should be to be measurable throughout. The world of Milne is such that any observer can calculate the measurements made by any other observer, in such a way that the calculation rule is constant. Both bases for deduction are necessary and both follow from essential features of man in his relation to the external world and to other men. But the two world pictures are incompatible (8).

Would this contradiction be solved if another concept of communication were introduced, changing the meaning of Milne's deduction or if another concept of measurement were introduced changing the meaning of Eddington's deduction? This is work for the future. These incompatible results show clearly, so it seems, that we should connect psychology and fundamental physics so as to be able to base our inferences no longer on one aspect of human nature, but on its full description. If this were done the anthropological deduction would become an answer to the following questions

a) in what possible universe can a complex retroactive feedback systems with anticipatory compensation exist?

1944, part 1, pp. 10-24. This article gives an account of the epistemological presuppositions of Milne's attempt. His most recent book on the topic is "Modern Cosmology and the Christian Idea of God" (Oxford 1952), and earlier full expositions "Kinematic Relativity" (Oxford, 1948), or "Relativity, World Structure and Gravitation" (Oxford, 1935).

b) what necessary features will the model of the universe which such a system develops necessarily possess, in virtue of it being a model of the environment of an open system in dynamic equilibrium?

To this basic question, unaware of its nature, Eddington and Milne try to give a partial answer. The very formulation of the problem, as it now stands, leads us to the last prerequisite for metaphysics we have to study, and to the foundation of all our earlier chapters: general systemstheory (9).

10. Metaphysics and General-Systems Theory.

Metaphysics, the theory of the universe considered as a whole, did not have the opportunity of attaining its normal development. This assertion has been forcefully defended by Herman Wein in his "Zugang zu Philosophischer Kosmologie" (1); According to Wein the universe is a cosmos, the ordered and organised system of all that is.

But neither our science nor our ideology have allowed us to study such a cosmos. Our science either studied simple phenomena presenting few variables, or mass phenomena of a statistical nature. Up to the past few decades the theory of complex ordered systems was neither logically nor mathematically usable.

Our ideology either concentrated on God, or on Man, excluding both from the cosmos or, when this failed, it withdrew towards rejection of all extravert attention in axiology or epistemology.

At the present time however both the scientific and the ideological scene have changed. Biology has matured; it studies mathematically complex organised beings and thus the study of the region between the simple and the statistical systems was initiated. The immediate consequence was the development of something much more fundamental: to wit, of the theory of systems

(9) In a sense, one could say that the anthropological deduction, the method of which has been sketched here, is the opposite of the system theoretic deduction of the following chapter, and yet they presuppose each other. The present chapter stresses the importance of the subject as the one that follows will stress the importance of the object.

These two opposite orientations, present, but latent, in the earlier more concrete chapters here become aware of each other. Now we ask how Eddington's own deduction can be reinterpreted, so that it be clear that a rigorous deduction of features of the physical world as

a) prerequisites for the existence of human knowledge

b) projections upon the universe of the nature of human knowledge, is possible, and how has it been partly accomplished by Eddington's work.

This was the main reason for our attempt to link him with Piaget.

(1) Herman Wein: Zugang zu Philosophischer Kosmologie-Überlegungen zum philosophischen Thema der Ordnung in nach-Kantischer Sicht — R. Oldenbourg Verlag Munchen, 1954, 184 pp.

as such. Indeed, a system is a set of n elements, interdependent and organised. The universe taken as cosmos is a system; cosmology is the study of the system-form of the whole.

Ideology also has changed: Man is seen as part of nature because he is more and more at home in it. God is either rejected or put into closer relationship with the cosmos. The dualism between the epistemological-axiological and the cosmological also disappears because it becomes clear that knowledge and valuation can only be seen clearly as aspects of the natural system that is Man as an historical being.

The main instrument however for this study of complex organisations (and a necessary preparation for metaphysics) will have to be the general theory of systems, the cosmos being such a peculiar complex organisation (2).

Theory of systems is not metaphysics or philosophical cosmology; theory of systems is a more general discipline. However metaphysics presupposes a theory of systems.

- a) Theory of systems allows a comparison between the system form and system interaction of the various regions of reality, taken not in isolation but as particular cases of the system idea.
- b) Theory of systems allows a definition of the system-form of the whole, that has the unique ability of containing all those system types and system interactions.

It is natural and fitting that it was a mathematical biologist, Ludwig von Bertalanffy who drew attention recently to this discipline.

It is also natural and fitting that some thinkers inspired by modern economy are most in agreement with his point of view: Kenneth Boulding, in the United States and Lektorsky-Sadovsky, in USSR (3).

The main problem that the new discipline has to face is the definition itself of its central concept: the concept of system.

At least three definitions compete in the various volumes of "General Systems" (4).

(2) See "General Systems, Yearbook of the Society for the Advancement of General Systems Theory, edited by Ludwig von Bertalanffy and Anatol Rappoport, Publications of the Society for the Advancement of General Systems Theory published annually from 1956 onwards.

(3) General Systems Theory I, "General Systems Theory—The Skeleton of Science" (pp. 11-17) and "Towards a general Theory of Growth" pp. 66-75, both by Kenneth Boulding; General Systems V "On Principles of System Research", pp. 171-179, by v. A. Lektorsky and V. N. Sadovsky.

(4) General Systems I, "General System Theory" (p. 1-10) by L. von Bertalanffy and "Definition of Systems" (A. D. Hall and R. E. Fagen). General Systems, V "A Relational Theory of Biological Systems" by Robert Rosen (p. 29-44) (1960).

Ludwig von Bertalanffy considers a set of equations of the following form:

$$dQ_1/dt = f_1(Q_1, \dots, Q_n)$$

$$dQ_n/dt = f_n(Q_1, \dots, Q_n)$$

In this case the variations of any variable, which is measured by its derivative with reference to time depend upon the values of all other variables. When this interdependence occurs Bertalanffy calls the set $Q_1 \dots Q_n$ a system.

The form of the function f is left open, and thus the definition given is much more general than the one where, for instance the typical equation has the following form:

$$dQ_1/dt = aQ_1 + bQ_2 + \dots + zQ_n.$$

The Bertalanffy equations are however both too special and too general to yield a satisfactory definition of system.

They are too general: because of the fact that the concept of function demands only that for a given value of the independent variable the set of possible values of the dependent variable be a subset of the set of its possible values. Many different values of the independent variable can determine the same value of the dependent one and the fixation of the independent variable does not completely determine the values of the dependent variable, for multi-valent functions.

We should analyse the concept of "dependence" and try to formulate some restrictions, arising out of this analysis in order to select those functions among all possible function types, that could be said to express "causal dependence" or "ontological dependence" among the variables related by them.

The definition of Bertalanffy is also too special. First, it should be stated that the Q variables are quantitative variables. Many real variates are not measurable but only serial or classifiable. If we are to obtain a real generalisation, then the derivatives of the Q 's should be replaced by other measures of change, applicable also to non-quantitative variates. Secondly, we should be able to make the Q 's dependent upon functions of these Q terms. Some of the more important function types would be:

- a) functions relating various Q 's to each other
- b) integrals of Q values over time
- c) higher order derivatives of the Q 's.

When all three of these generalisations were present we would have non-linear dependence upon integrals and derivatives of higher order, and various classifications of functions regarding continuity and derivability would become important.

C. G. Hempel, studying the system concept developed by Bertalanffy has stated that the theory of systems is only a vague chapter of minor importance

in the theory of functions, and thus cannot be an independent science (5).

When we examine Bertalanffy's concept of system which is, at the same time too specialized and too generalized, we incline towards the opinion that Hempel was right.

However we must not lose our confidence too easily. It is possible, with reference to these unsatisfactory system concepts, to develop certain definitions that will help us to improve them. Let us show what we mean! (6).

We can compare the partial derivatives of the functions with respect to their various independent variables.

When some of these partial derivatives are large and all other small, we speak about centralised systems; when all have equal or comparable values we speak about decentralised systems. When some partial derivatives are positive, the system tends towards centralisation with respect to these variables; when they tend for some partial derivatives to be negative then the system tends towards segregation, again relative to these variables. When the variables are functions of the difference between the actual values of the independent variables and some predetermined value, we can speak of finalised systems. When the partial derivative of the function with reference to one variable is inversely proportional to another variable, then we can speak of competition among the sub-systems. These concepts can now be used as instruments of clarification. The idea of a system as an interdependent whole implies:

- a) the derivatives for all variables should depend upon all other variables and the partial derivatives should never be too small for any independent variable.
- b) the system should be in an equilibrium of positive facilitation and negative competition, of centralisation and segregation. None of these phenomena should be absent and none should be prevalent. Only thus can the totalitarian interdependence be realised dynamically.

Here, it is not our purpose to give a complete definition of the system concept, in terms of functional equations. But we have said enough to show that

(5) *Human Biology*, 23, 1951: L von Bertalanffy, C. G. Hempel R. E. Bass and H. Jonass: "General Systems Theory" a new approach to the Unity of Science".

(6) "An Outline of General Systems Theory" (*British Journal for the Philosophy of Science*) (vol. I, p. 139 and ff.) by L. von Bertalanffy, gives some of the definitions of these concepts, but does not use the general function concept as a general rule. Instead he represents f explicitly as a linear function and arrives at the definitions meant by restrictions on the values of the coefficient.

the reservations which Hempel expressed about the non-specificity of the theory of systems as an independent totality of inquiry are not founded on fact. By means of integral equations, non linear functions, and higher order partial derivatives we can eliminate all realisations of Bertalanffy's equations which would not agree with our intuitive concepts of system. The only negative aspect of this situation is, that in the sphere of classical well-known mathematics, only approximate models of systems can be found, while Bertalanffy hoped to be able to deal with the system concept in the simplest part of classical analysis (linear equation theory).

Thus it is advisable to look at the two more abstract definitions of system which are also to be found in the "General Systems Yearbooks".

Hall and Fagan define a system as a set of objects, together with the relationships between those objects their attributes. Without any doubt, this definition is once more much too general. Indeed, the relations are unrestricted. We shall have to restrict them, using our insight into the meaning of the intuitive concept of "system".

A system is a set, such that this set has an environment and such that the relations within the set, within the environment and from members of the set to members of the environment are relations falling into three different and specific classes.

If it is desirable to specify further the type of relations in question and the type of their differences, we can refer to the following properties of relations:

- a) within the set there should be (provided the set has n members) an n adic relation that cannot be reduced to the relative product of a certain number of m adic relations (with m smaller than n).
- b) in the environment all relations should have lesser multiplicity.
- c) the environment should affect the system and the system the environment but in asymmetrical fashion: the system should affect to a greater extent the environment than it is affected by it and the environment-induced changes within the system should concern rather the values of variables than the relations between them.

We could thus perhaps define the concept of system by means of the concept of structure: a system is a set having a structure as a whole, a structure more invariant and invariant in another way than the structure of either the environment or the totality constituted by system and environment.

Once more, the concept as present in the "General System Yearbooks" is much too much undetermined to yield a specific science, but we can use the ideas presented and suggest to develop a better approximation.

The classification of systems can be developed using the basic concepts of theory of relations noting what types of symmetry are present in it, what type of differences between system and environment occur).

A definition that uses the same ideas basically has been given by Rosen. Rosen uses graph theoretical language. Let there be given a series of objects connected by lines. Any object has a certain number of input and output lines and any output line is determined after a certain period of time by the earlier situation of the input lines. The inputs of an element that are not outputs of another element are environmental inputs and the outputs of an element that are not inputs to another element are environmental outputs. The dependent set of an element is the set of outputs that disappear when this element is taken away (in Rosen's terminology: the set of environmental outputs disappears under these conditions.) Rosen, just as Bertalanffy and Fagan wanting to be as general as possible is content to call any unit-link set, a system. As before, we wish to consider various more demanding system concepts

- a) a system is a set of units and links in such a way that the total output set of the system belongs to the dependent set of any unit of the system
- b) *weaker*, a system is a set of units such that at least one output of all units belongs to the dependent set of any unit or
- c) *still weaker*, a system is a set of units and of links so that at least one output of every unit belongs to the dependent set of at least one unit or, d) *stronger*: any output of any unit belongs to the dependent set of at least n units.

We hope that the reader will be able to see that the theory of systems is by no means the indifferent and undetermined chapter of analysis or relation theory which Hempel considered it to be, but instead a very specific chapter of analysis and relation theory, a chapter in which in a precise form the various concepts of unity in diversity that are inherent in the concept of system, can be studied and compared.

General System Theory will only serve this function however if, realising the requirement formulated by Lektorsky and Sadovsky, we use the concepts put forward by the pioneers of General Systems Theory in developing a more fruitful concept.

In this more promising general theory of systems, we are able to develop a general classification of system types, of interaction types between systems, and of development of systems-types deriving from each other.

The world or universe or cosmos is the all encompassing system. *Id est*: it is a system containing systems of all possible types, and interactions of all possible types among systems.

The metaphysical problem thus could be reformulated as follows: what is the system form of the system that contains all these sub-systems and all these interactions? How should we consider the universe in such a fashion that it can have a high degree of systematicity, and simultaneously contain as many types of subsystems and interactions as possible? This question is

in fact rephrasing: what is the system that has maximal unity and maximal complexity simultaneously?

The answer to this problem is not known, the theory of subsystems and of system interaction is even more in its infancy than the theory of system classification. The first task is an analysis of the system form of groups, persons, organisms, cells, molecules, atoms, stars, galaxies, planets, fields, biospheres and so forth. The metaphysician will characterize them as special cases of the stronger system concept he has built out of Bertalanffy's building blocks, and will find in his taxonomy the same type of satisfaction that the chemist found in the table of Mendeleiev, if all cases of his taxonomy of possible systems are fulfilled by the systems actually occurring in the universe.

Thus it is not astonishing that we are also reaching for a less demanding and more inductive method of making general system theory of use to general metaphysics.

Kenneth Boulding's provocative work could here be of use (7).

It consists of an attempt:

- a) To make an analysis of certain features to be found in all systems
- b) To develop a linear order of systems according to their increasing complexity.

Based on both these descriptions of a very general synthetic nature, we can then ask the question: what is the system form of the universe, in order that

- a) all systems in it exhibit these features
- b) the levels in it show this linear order.

Kenneth Boulding provides no answer to this last question but demands explicitly that it should be asked (8).

(7) Following the articles already quoted, we should mention "The Image", Ann Arbor Michigan, 1956, pp. 175, by Kenneth Boulding. In his second chapter "The Image in the Theory of Organisation", p. 19-31, he gives the following types of systems T1: elements and relations constant: crystal; T2: elements variable, relations constant (planetary system); T3: variation controlled through the invariant part (thermostats); T4: open control systems (cells) taking elements from environment; T5: complex sets of T4 systems, with periodically changing system forms; T6: T5 systems with changing relations to environment, internally controlled (animal life); T7: completely self reflected systems.

This classification which could be developed and corrected is important because the concrete systems are characterised by reference to the way in which they are systems (id est separate, self dependent, complex and organised).

(8) page 16 of "General System Theory — The Skeleton of Science" Boulding mentions very briefly transcendental systems.

It is too early to develop even on this inductive basis a system-theoretic metaphysical system, but we can already make some observations.

If we may believe that the linear order of systems sketched by Boulding is exhaustive (see note 7), then it seems that our universe is a structure in which for any pair system-environment, there is a system in which this environment is part of the system, and in which for any pair invariant-variable, there is a system in which the invariant structure consist of an invariant relation between the two earlier mentioned aspects, both variable by now.

The reader may verify this by comparing static systems and dynamic uncontrolled ones, dynamic controlled ones, closed and open systems, simply open systems and systems whose form and degree of openness is dynamically controlled (again: see note 7).

If the generalised description we have given of this series is correct and if the series is exhaustive, then the metaphysical problem takes the following form: explain why the universe is such that it has this series of subsystems which realizes the unification of the diverse by diversifying itself in so many subsystems each of which unify elements diversified in others. We could not answer this problem at the present moment but the use of the description of the various regions of reality in system theoretic terms becomes apparent (9).

(9) One of the ways in which a whole is organised is the presence in it of symmetries and asymmetries (and of symmetrical asymmetries, or asymmetrical symmetries). One of the ways in which the relation of a system to its environment can be described is the indication of the symmetries and asymmetries it creates. It goes without saying that such a description presupposes a clear and general definition of symmetry, applicable in very different domains (and this again presupposes a good general definition of order). Metaphysics could thus include a study of the symmetry combinations to be found in the universe and of the order types present in it. Lancelot Law Whyte in "The Unitary Principle in Physics and Biology" (Holt, 1949), sketches very briefly such a metaphysics. He adds to a system theory concentrating unilaterally upon the theme of symmetry and asymmetry, a postulate (the universe evolves towards maximal symmetry) that inspires his work. This postulate however is in no way necessary to write the symmetry chapter of general system theory. L. L. Whyte's work is very provocative but suffers from insufficient analysis of the basic symmetry concept.

In the extremely unequal book of Leo J. Baransky "Scientific Basis for World Civilization: Unitary Field Theory" (Christopher Publishing House Boston USA, 1960), Whyte's ambitious attempt is taken up again, with special reference to the socio-psychological aspects he developed in "The Next Development in Man", (1950, New American Library) "Aspects of Form" (Pellegrini, New York) and "Accent on Form" (Harper, New York, 1954).

This work has been anticipated by R. Ruyer's book "Esquisse d'une Philosophie de la Structure" (Alcan 1930), that in a very general fashion describes

What follows from the study of Boulding's series of levels also follows from the study of his main features of system interaction.

Systems belong to groups of analogous systems and are inserted in aggregates of systems of higher and of lower degree of organisation. They compete and cooperate. They grow out of systems of lower degree of organisation and belong themselves to the growth of other systems while preparing the development of still other ones.

The relevance of such very general statements can be clarified with reference to the work of Neyman and Scott who realised the somorphic nature of the growth of star populations and animal populations (10).

It also can be clarified with reference to the fact that various growth laws are possible (accelerating, decelerating and stable) so that one of them can be the universal law. If accelerating growth were the universal law, all properties would become or tend to become universal; extreme instability would follow if decelerating growth were universal (all increase would tend to stop), and if stable growth were universal we would sooner or later have a universal conflagration.

Moreover quantitative growth has to be transformed into relational growth with increase in complexity. The growth law of the universe as a whole is as dependent upon those properties as any other growth law but should explain simultaneously the presence of phenomena in accordance with the other laws of growth.

If we try to systematise those properties found by Boulding we see once more that the system form of the universe is the realisation of homogeneity through heterogeneity; the variety of levels, the environment composed out of unorganised aggregates of similar systems, and of mixtures of systems of higher and lower degree of organisation.

The study of alternative universes would here be of particular use and particularly easy.

the system form of the universe by means of the relation-structures present in its different parts. Using less empirical data but without question in the same spirit, the categorical analyses of Nikolai Hartmann in his "Philosophie der Natur" move towards realistic structuralism. The study of the exact place these different attempts would take within the framework of a general systems theory would be without doubt a worth while study. It is clear that the present article is an attempt to take up the trends of thought found in Ruyer, Hartmann and L.L. Whyte.

(10) Jerzy Neyman and Elizabeth L. Scott "On a Mathematical Theory of Population conceived as Conglomerations of Clusters" (General Systems, vol. III, 180-192).

Now we must arrive at our conclusion that the general theory of systems can be the basis of metaphysics. *This should be accomplished deductively in the analytical study of the most comprehensive systems and inductively in the search for the system form of the system that has as its subsystems those found in experience.*

This is not a contingent fact. If we examine the definition of metaphysics in our introduction, and the various concepts of stability-variability, unity and diversity, used in the various attempts towards deduction made in our intermediary chapters, then we shall understand that these concepts can only be clarified through the definitions that a general theory of systems could provide for them.

Metaphysics can be a science, on the basis of a general theory of systems.

11. Conclusion

We do not deny that many of our observations have been vague and indefinite. This uncertainty and vagueness, inevitable in a first attempt to unify and synthesise so much, never eliminated completely our vision of the world as a system. Now that we arrive at the final point of our article, having seen some unity between the laws of fall of solid bodies and the laws of the electromagnetic field, having understood to a certain extent why there should be stars and also why there should be life, having made some connexion between psychology of intelligence and the types of physical energy present in the universe, we cannot avoid the conclusion that this attempt to see the beauty of the whole, is to our mind the very core of philosophy. The joy we felt, being able to leave the isolation of the philosopher, the sad confinement of the solitary mind, for however short a period, to mingle with reality itself, without abandoning for one instant our most specific purpose, this joy, even though we cannot take it as proof for our assertions, will be our best reason to continue this research.

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Leo APOSTEL.