

V.—CRITICAL NOTICE.

Die Analyse der Empfindungen und das Verhältniss des Physischen zum Psychischen. Von Dr. E. MACH, Professor an der Universität, Wien. Mit 36 Abbildungen. Zweite vermehrte Auflage der Beiträge zur Analyse der Empfindungen. Jena: Verlag von Gustav Fischer, 1900. Pp. 237.

THE first edition of the present work under the title *Contributions to the Analysis of the Sensations* was published in 1886, and consisted in a series of specific analyses of the various sensations, introduced and rounded off in the first and last chapters respectively by discussions of a more general kind.¹ The book in its earlier form had thus a certain symmetry of its own, despite the fact that it was largely, even at this its first appearance, a mere compilation of material published elsewhere. As a highly qualified reviewer—C. Stumpf—remarked at the time, Mach had put together in the edition of 1886 a number of scattered studies, previously incorporated in his published works, and added to these a series of new facts and points of view. In the early nineties, I believe, an English translation was made of this work by Mr. C. M. Williams and published by the Open Court Publishing Company, Chicago. This was in itself a second edition, as it included the insertion of a new chapter—the second chapter in the present edition—and other notes and alterations. In the present edition are added four other chapters, in addition to many new sections and paragraphs.² The new chapters are interpolated between the

¹ Good reviews of the first edition may be found, among other sources:—

1. In the *Deutsche Literaturzeitung*, Nr. 27, 3 Juli, 1886, by C. Stumpf.

2. In the *Philosophische Monatshefte*, Bd. xxiii., p. 207, by ELLER.

3. In the *Revue Philosophique*, 1887, p. 80, by Lucien Arréat.

² The new chapters are those entitled: 'Ueber vorgefasste Meinungen,' 'Mein Verhältniss zu R. Avenarius,' 'Physik und Biologie,' 'Causalität und Teleologie,' 'Der Wille,' and 'Empfindung, Gedächtniss und Association.'

Of the other new insertions, the following are those of most interest and importance:—

P. 3, footnote, an illustration from personal experience.

P. 23, § 14, with the exception of the last three paragraphs.

P. 46, § 3, paragraph 2, on the principle of Psychophysical Parallelism.

P. 82, § 9, on the distinction between right and left.

P. 86, § 13, on the æsthetic aspect of certain spatial sensations.

old in a somewhat puzzling and irregular way, and the original symmetry of the old edition almost completely lost. What is also lost sight of in this intershuffling of the chapters, new and old, is the unity of idea running through the new, a unity quite sufficient to have justified their being included together either at the beginning or end of the book, whereby the useful compactness of the first edition would have remained unbroken. This unity of idea characteristic of these newer chapters is indicated in the new title given to the book in this second issue. The present volume deals not only with an Analysis of Sensations but also with the relation between the physical and the psychical. The new chapters deal either directly with this relation or indirectly with questions that develop out of it, and show generally that during the fourteen years' interval between the issuing of the two editions the author's time has been largely busied with the study of organic and mental science.

The central idea of the first of these newer chapters is contained in Mach's conviction that the dualism between physical and psychical is an artificial conception, the genesis of which can easily be traced. The physicist works in his own sphere with such abstract concepts that he comes entirely to overlook the sensations whence these concepts have been abstracted. An artificial gap is thus created between the physically conceived objects and their

P. 90, § 1, Historical résumé of the theory of spatial vision.

P. 140, § 11, paragraphs 2, 3, on an experimental discovery of the author's.

P. 157, § 1, with the exception of the first paragraph.

P. 174, § 6, on Helmholtz and his critics.

P. 177, § 8, on Stumpf's criticism of Helmholtz's Theory.

Pp. 197-203, §§ 18-21, § 21, containing the author's view of the value of Helmholtz's Theory.

In the last chapter the more interesting novelties are: §§ 2, 10, 12 (the three last lines), 14, all except the first seven lines, the last paragraph of § 16, the two last paragraphs in §§ 17 and 19, and paragraphs 5, 7, 8, 9 in § 21.

The changes in arrangement consist:—

1. In restoring to the text nearly all the longer footnotes in the first edition.

2. In a consequent rearrangement of the sectional divisions.

3. In certain changes in type. Of these latter the two most interesting instances occur: on p. 19, where the words 'So ist ein mannigfaltiger Zusammenhängender Inhalt des Bewusstseins um nichts schwerer zu verstehen, als der mannigfaltige Zusammenhang in der Welt,' are transferred from ordinary to special type, and on p. 115, where the word 'Eine' is transferred from special to extra-special type.

4. A few excisions, very few, have been made from the first edition. Thus a somewhat long and technical footnote (pp. 162, 163 in first edition) is missing in the second edition at the foot of p. 230, where it would otherwise have figured.

5. The Index at the close of the volume is also a new feature of the second edition.

relations, on the one hand, and the sensations they awaken on the other. These latter are therefore looked upon by the physicist as something completely extra-physical, fundamentally different from physical objects and relations. The psychologist accepting from the physicist this treacherous prepossession born of the methods of physical inquiry takes Sensations as his peculiar subject-matter and assigns the objects of the physicist to a realm entirely beyond the closed sphere of sensations.

The main flaw in this whole procedure lies, according to Mach, in the physicist's conception of his concepts. These concepts are not in reality mere abstractions severed from the sensations which they serve to combine and to unify, but connote only certain definite regular connexions between the sensed elements themselves. The data of Physics so conceived not only cease to be fundamentally different from the data of Psychology but are seen to be identically the same. Physics and Psychology differ in the species of regular connexion between the sense-elements which they respectively investigate, differ that is in their purpose and point of view, but they both agree in starting from the same data.

Now, what are these data, 'these simplest of the building-stones out of which the physical and also the psychological world are built up'? (p. 31). They are the simple elements out of which our sense-presentations—what we call material objects—are compounded. They are the series of colours, tones, smells, tastes, touch sensations, time and space sensations, etc. Thus 'green' or the 'odour' of a rose are elements. Mach's position here is eventually the same as that of common sense; the only difference is that Mach has the analytic instinct that common sense does not possess. The simple elements for common sense are *things*, things that can be seen and handled and give out pleasant sounds, can be tasted, smelt and moved. These are for Mach *complexes* of simple elements, the simple elements being the sensations out of which these complexes are built up. Still apart from this one difference none other of any note exists. These sensations or simple elements are the ultimate data of experience and must be accepted as such by any one who hopes to do anything profitable in this world. Only the idle metaphysicians can afford to view them with suspicion and seek to pierce beyond them. They are for all other folk, for the scientific as well as for the practical—the two really estimable classes, in Mach's opinion—immediately and unquestionably given to us (p. 34).

The dualistic cleft, then, between the physical and the psychical does not really exist. Any single element, so Mach maintains, belongs at one and the same time to two very different but by no means antagonistic contexts. The element 'green'—not the concept, of course, but the actual sensation—has its place amid all the gigantic complex of similar elements which make up the material world. As such it is a *physical* element, and the relations in which it stands to other elements are what the physicist

must study. But the element 'green' enters also into relations of reciprocal dependence with the observer's body. It is bound up with his retinal processes. As such it is a stimulus that affects the nervous system in certain specific ways which can, in principle at least, be studied by the physiologist. So considered, 'green' is a *psychical* element, a *sensation*.

The chapter that follows the one we have just analysed is mainly devoted to developing these convictions concerning the relations of the physical to the psychical. This is picturesquely done through a personal statement of the author's relation to the late Prof. Avenarius. The comparison is a peculiarly interesting one, and constitutes, perhaps, the most welcome and novel feature of the new edition. Mach confesses at the outset that the relation between himself and Avenarius is as close a one as could possibly be expected to exist between two individuals who had grown up under different influences and pursued different vocations.¹ The closeness of the kinship was, however, concealed by the fundamental difference of style between the two thinkers. The style of Avenarius is rendered crabbed and difficult through the use of a strange terminology. It was asking a great deal of an elderly man, says Mach in his delightful way, that in addition to learning the many languages which different people speak, he should also learn the speech of a private individual. To this difference between the lucid, untechnical language of the one and the highly ponderous and technical speech of the other must be added an essential difference in form of presentment. Avenarius was a systematic philosophical thinker; Mach claims to be neither a philosopher nor a systematist. He repudiates every title, indeed, save that of a man of science. He claims to be a natural philosopher in general and a physicist in particular, but will not allow himself to be called a philosopher, nor even a physiologist or psychologist. Moreover, he has a rooted diffidence of system as of something that tends to squeeze the truth into its own pre-determined mould. He calls his own book an *aperçu*.

Now these differences, though they hindered for long any clear mutual recognition between the two thinkers, were superficial. The points of agreement were, on the contrary, fundamental. Mach lays stress on two of these as essential. In the first place, both he and Avenarius agreed in holding that the essential aim of all scientific labour was to reconstruct the facts of the universe in the most economical way possible. This view is definitely brought forward by Avenarius in a treatise entitled 'Philosophy as That Which Thinks the World According to a Principle of Least Effort,' and by Mach in an essay on the 'Economical Nature of Physics'.

¹ Avenarius started from a realistic standpoint; Mach, after reading the *Prolegomena* at the age of fifteen, from an idealistic standpoint. Avenarius, again, was Professor of Philosophy at Zürich; Mach, Professor of Physics at Prague, and later on, Professor of Scientific Method at Vienna.

Is not the task of Science, writes Mach in another essay,¹ to acquire with the least possible work, in the least possible time, with the least possible thought, the greatest possible part of eternal truth?

The second main point of agreement brings us back again to the main idea which dominates the freshly added matter in this second edition, to the relation, that is, between the physical and the psychical. In this central issue Mach and Avenarius are in perfect agreement. Herr Dr. Rudolf Wlassak, in a letter to Mach, given verbatim in this chapter, makes on this point the following statement: 'The conception of the relation of the physical to the psychical is the same with both Avenarius and Mach. Both arrive at the result that the distinction between the physical and the psychical lies only in a difference in the relations through which an object is dependent on others. . . . If I investigate the dependence of an object A on a second object B, I am pursuing a physical inquiry; if I ask to what extent an object A is changed by changes taking place in the sense-organs or central nervous system, I am pursuing a psychological inquiry.' The writer of this letter then proceeds to develop Avenarius's theory of the origin of dualism through the fallacy of Introjection, and points out that Mach has hardly done justice to this explanation. Mach admits this in an after-note, and states afresh that he does not believe that Introjection played more than a subordinate rôle in the development of dualistic views.²

In the development of the Mach-Avenarian theory of the relation between the physical and the psychical, as given in this interesting chapter, two new points are explicitly brought forward by Mach himself. The first is, that the psychical life may be profitably conceived as a *biological phenomenon* (*Erscheinung*), and the second, that in so far as we consider what is psychical from this point of view, we must look upon it as having a physical foundation and as being physically determined.³ The comparison

¹ On 'The Forms of Liquids,' *Popular Scientific Lectures*.

² See also footnote, p. 19.

³ This second point is discussed by the author in two new additions peculiar to the second edition, to be found on pp. 46 and 229-280 respectively. In the first of these contexts we find that this dependence of the psychical on the physical is involved in Mach's definition of what he means by a principle of Parallelism. Given that a leaf, as seen by the eye, is something psychical in so far as it is considered as dependent on the brain-process involved in the vision, whilst this brain-process itself is something physical in so far as the mutual relations of its elements are concerned, then the principle of Parallelism consists in the statement of the dependence of the first immediately presented group of elements—the visual sensations of the leaf—on the second group of elements—the brain-processes involved.

On the other hand, we are told, on pp. 229-280, that the meaning of 'determination' itself is only made intelligible to us through psychological investigation. It is only through its life as an idea that a fact is

of the physical with the psychical from this new standpoint is carried on in the new chapter that follows on page 62, entitled 'Physics and Biology, Causality and Teleology'. Here Mach uses the term 'biological' in its widest sense; and in contrasting the inorganic with the organic includes under the organic all psychical as well as all vital manifestations. The main results of Mach's investigations are as follows: 1. There is no necessity for setting up a deep-going difference between investigations of a teleological and those of a causal kind. The former is good and useful in its place as an introductory to the latter. History has shown that this has been its true function. 2. By the causal idea Mach means no more than the concept of the dependence of phenomena, or rather, of their elemental characteristics on each other, and this he holds to be identical with the concept of 'function'. In the 'Funktionsbegriff' Physics and Biology find a common working-idea. 3. At the same time this causal or functional concept cannot be applied by Physics to the problems of Biology without first gathering richer meaning through a close study of these same problems. As a dynamical system an organism offers many peculiar features. The functioning of a steam-engine cannot be studied as a substitute for that of a living body. The former may, in a certain artificial way, be made to procure its own fuel and to keep itself warm by means of it, but these properties are possessed by organisms even in their smallest cells, and organisms in addition can regenerate themselves through what they absorb, and grow and multiply. The physicist must, therefore, study Biology if he wishes to understand the full meaning of his own regulative concepts. 4. The *teleological* idea may still be usefully employed in default of the functional in dealing with certain aspects of organic life where animistic conceptions still give the best available descriptive statement. 5. What is, above all, needed to bring into line the study of the organic with that of the inorganic is the discovery within the realm of the inorganic of such fundamental psychical or rather vital properties as *Memory* and *Association*. Such functions as these proved common to both realms would be the starting-point of a new science dealing with the fundamental facts common both to the organic and the non-organic. So far nothing physical has been found to correspond to these psychical fundamentals of memory and association. The only hope of finding them lies in a study of the Physiology of the Senses, for here two forms of observation, the physical and the

taken out of its isolation, brought into contact with other facts, and *determined*, through the demand made upon it, that it shall harmonise with these and not involve anything of the nature of a contradiction. Hence, if Psychology has to recognise the physical basis of psychical life, Physics has no less to recognise that the definite determination of the connexion of the elements with one another, which is its ideal, becomes first intelligible in the light of those very psychical connexions. Thus 'Psychology and Physics lend each other mutual support, and only in their union build up a complete science' (p. 230).

psychological, come into mutual contact, and it is only through this mutual contact that such new facts as those proving the omnipresence of memory and association in some primitive form can possibly be forthcoming. In this last remark with which this chapter concludes we find an interesting commentary on the statement with which Mach opens his preface to the first edition, where he tells us that his repeated incursions as a physicist into Biology and Sense-Physiology was due to his deep persuasion that Science in general, and Physics in particular, must look to Biology, and especially to the Analysis of Sensations, for the next great step towards the elucidation of their fundamental principles.

A fourth new chapter is entitled 'Sensation, Memory and Association'. Here Mach reverts to this problem of an inorganic memory. Every physical event just as truly as every psychical event leaves behind it ineradicable traces. The physical traces are usually ignored, but this is only because of the abstract, schematic character of the physicist's interest and observation. They exist none the less. Indeed it must be so, for the psychical and the physical differ only in their form of observation. Mach does not, however, consider that this argument can justify his inferring in a stone memory of the typically organic kind, memory, that is, which reproduces as well as retains. All he feels justified in concluding is that the inorganic leaves traces of its previous activity in its own structure and that this fact of physical retention is sufficient to prove that in the physical as well as in the psychical realm there can be no such thing as a convertible process. The slight advance which this chapter contributes to the theory of an inorganic memory is contained in these admissions. Mach sums them up when he says that considerations such as these should show that whilst we are still very far indeed from possessing a complete grasp of the meaning of memory in physical terms, it is yet by no means unattainable.

The fifth and last in logical order of the new chapters is entitled 'The Will'.¹ Mach, like Avenarius, does not believe in a specific psychical causality but holds that all the phenomena of will proceed from the action of forces which he calls physico-organic. His own theory of volition he states as follows: Sense-stimuli can be partly or wholly represented by memory-images. All memory-traces retained in the nervous system co-operate with the sensations in discharging, reinforcing, inhibiting or modifying reflexes. Volitional movement takes its rise under these conditions, and may be regarded, in principle at least, as a reflex movement modified by recollections. . . . The essential difference between a volitional and a reflex movement lies then in the fact that the

¹ Of the five added chapters this is the one that best accommodates itself to the order given it by Mach. It follows a chapter in which the term 'will' has been used in a way that renders further elucidation quite necessary. A very similar remark applies, though in a less degree, to the chapter on 'Sensation, Memory and Association'.

determining-element in the former is found in the ideas (*Vorstellungen*) which anticipate the action.

The larger part of this short chapter, which contains many interesting observations, is devoted to the vexed question of Innervation. Mach agrees on the whole with James's peripheral theory of the origin of our sensations of effort, though he does not consider that this Theory has spoken the last word on the subject.

From the point of view of the logical development of Mach's thought, the guiding idea which animates and binds together these five added chapters, finds its natural origin and explanation in certain still more general ideas which are developed in the three 'philosophical' chapters which constituted the 'general' section in the first edition.

If we want to picture Mach in his true light we must start from those words in the preface to the first edition in which he tells us that the work which this volume represents was undertaken in sole obedience to the lively desire he felt for self-instruction.¹ That this is Mach's true attitude is attested on the one hand by the generous recognition he is always ready to give to any one who succeeds in improving upon his own attempts, and on the other by his still more eager readiness to put fact before theory. With this eagerness to find out the truth is associated a corresponding ardour in developing and applying it when found.

Our author had the great good fortune, as he puts it (see footnote, p. 21), to come across Kant's *Prolegomena* at the early age of fifteen. For two to three years after that date he pondered on the *Ding an Sich*, till on a bright summer's day in the open country the thought suddenly flashed upon him that the Thing in Itself was after all a useless burden, a mere idle fiction. This was the turning point in Mach's career. He had become convinced of three things:—

1. That Science was one as the world was one (Monistic moment).
2. That all metaphysical elements must be eliminated from scientific inquiry (Positivistic moment).
3. That Science must be set on a sensualistic basis, seeing that the world itself was made up of sensations (Sensualistic moment).

With the ardour of a young acolyte Mach set himself to apply his new-won insight to his own special province, Physics. The fight was long and strenuous (p. 21) and directed to the establishment of what we may fitly call a scientific monism. In cutting Physics loose from Metaphysics Mach's object was not to make Physics a self-sufficient, abstract, isolated Science, but to make its foundations so broad that they should enable the physicist to pass from his own subject to any other, say Psychology, without passing away from his own basis. Only in this way, according to Mach, could the unity of Science be secured. Hence Mach is

¹ Cf., also p. 52, § 7.

as anti-mechanical as he is anti-metaphysical. The molecular theory of Physics is to him a parochial, *fach*-limited substructure which has to be forsaken so soon as the physicist sets foot within Psychology. Mach's monism is neither metaphysical nor mechanical, but scientific. It is a monism which asserts not that there is *one* explanatory solution of the universe, but that there is only one set of facts, sensations or elements, and only one real problem, that of discovering the laws of their interconnexion.

Mach is then first and foremost a *scientific sensationalist*. This creed is brought out clearly in the last chapter of the present volume which deals mainly with the topic of the adjustment of thought to sense. In the words that follow we have the pith of Mach's belief : 'The sense-apprehended fact is the point of departure and the goal of all the mental adjustments of the physicist'. His reasoning takes the following form :—

The disparity between fact and expectation brings about a disturbance of mental equilibrium which can only be quieted by a renewed mental activity which aims at removing the disparity by adjusting thought to the freshly discovered nature of the object (p. 214, § 7). Thus all science aims at a conceptual representation of sense-given facts, either to serve practical ends or to remove the sense of intellectual discomfort. Now unprejudiced reflexion teaches us that every such need, whether practical or theoretical, is satisfied so soon as our thoughts are able to *copy* completely the true likeness of the facts. This descriptive copying of the facts is thus the end or aim of Physics ; atoms, forces, laws only the means for lightening the supreme task of imitation, means whose worth reaches only so far as they can subserve this end (pp. 209-211).

This process of adjustment of thought to sense has as its aim *Description*, and its method is that of *Conceptual Reaction*. We cannot explain the nature of things, we can only describe the various ways in which they affect one another.¹ Thus we have learnt all we can of a natural event, say an earthquake, when our thought has so contrived to grasp the totality of the facts involved that its representation of these facts can be considered as a substitute for the same. The aim of thought is to describe the facts of sense-perception. In order to do so thoroughly it has frequently to eke itself out with representative symbols and equations ; but these are only means to an end.

Conceptual Reaction is virtually Mach's substitute for Abstraction, and is the name by which he designates the activity of thought in the descriptive interpretation of things. Such activity has two phases, one of *concentration* on certain sense-given elements, followed by an *expansion*-phase due to the fact that the effort of concentration brings the focussed sense-elements into contact with other sense-elements which extend and deepen its meaning. Mach compares this process of conception with that of a chemical reaction, as when a yellow or brown precipitate is

¹ Cf., especially § 16, pp. 224-228.

gained from an originally colourless solution of salt by means of a specific operation. 'The concept of the physicist is a determinate activity of reaction which enriches a fact with new sensational elements' (p. 217).

Turning now to the chapter entitled 'The Main Points of View for the Investigation of the Senses' we find (p. 43) that this whole process of Adaptation of Thought to Sense as it takes place in Conceptual Reaction is guided by two important principles, the Principle of Continuity and the Principle of Sufficient Determination or Sufficient Differentiation. The former has its roots in the still more fundamental principle of Economy, and represents the conservative tendency, whereby habits are formed, of repeating ventures once proved successful and of applying for the elucidation of the new such laws of connexion as have already established themselves in previous experience. The latter represents a tendency of adaptation kept in check by the conservative principle from which it branches. If the old cannot explain the new it must be modified until it can, but no further. All such modifications, to be truly scientific, must be carried out in the spirit of this second principle.

Now as applied to the analysis of sensations these principles can be carried out only in conjunction with the fundamental principle which regulates the connexion between the physical and the psychical, but at the same time it is they which give to the latter its specific form. As interpreted in the light of the principles of Continuity and Sufficient Differentiation the principle of Parallelism requires that each sensation should be invariably accompanied by one and the same nervous process, and further, that each observed change in sensation should be accompanied by a corresponding change in nervous process. Mach means very seriously with this principle and proposes to apply it both in Physics and Psychology as a working-hypothesis of enormous range and power. Thus suppose a sensation has been analysed *psychologically* into so many mutually independent elements, the principle leads us confidently to expect that the corresponding nervous process will admit of being analysed up in a precisely similar way. If again two psychical properties of a sensation, say the pitch and intensity of a tone, are psychically inseparable, we may rely on the corresponding nervous process presenting corresponding physical features similarly inseparable (see § 4, pp. 47, 48).

It is in the light of this principle, so understood, that we can perhaps best see the force of Mach's introductory words in the preface to the first edition, words we have already alluded to. If the principle were true in the way suggested by Mach it would bring Physics and Psychology, through the medium of Sense-Physiology, into the closest possible touch. Given sufficient knowledge each would be continually suggesting by analogy principles and laws for the guidance of the other. It must also

be borne in mind that in the application of this principle Mach, like Avenarius, holds firm to the conviction that it is the physical which determines the psychical and not *vice versa*. Finally, the importance which Mach attaches to this principle, and its equally obvious importance to all physicists if true, readily explains the fact that, in connexion with the sensationalistic *Grundanschauung* which supports it, it is the dominating idea in the new material of this second edition.

In the first chapter of this book, entitled 'Antimetaphysische Vorbemerkungen,' we gain just that insight into Mach's point of view which we require to complete the insight already gained. We see more clearly, in the first place, what Mach means by his scientific, sensationalistic monism and how he proposes to justify it. In § 10, pages 14, 15, we see this monism stated in the following form: Our perceptions, our images, our will, our feelings, in short the whole inner and outer world, are built up out of a small number of elements of the same kind (*gleichartigen Elementen*). This comprehensive statement is based on the following considerations. The constituents that enter into our trains of imagery are fundamentally the same as those that make up our sensations or perceptions,¹ what differs is only the form of association. Images in fact are not linked together after the same fashion as our sensations. Again, as all sensations pass gradually off into pain or pleasure, and as pain and pleasure make up the essential content of all the so-called feelings, and as the will is itself a modified sensation of movement, we see that feelings and volitions are also at bottom sensations. All the psychical life is therefore fundamentally sensational. And, finally, as the physical universe is made up of these very same elements, only considered in their varying relations to one another, we arrive at the monistic solution quoted above.

Of the intimate nature of these sensation-elements we can know no more than what is sensorially given to us. Each element, indeed, in its ultimate sensational character apart from its special connexions with other elements is an element in itself (*an sich*); it has its own given nature which sensation accepts without idly questioning whence. It has been said that Mach's 'facts' are 'relations'. This is true if by 'facts' we mean the data of scientific inquiry. It is not true if by 'facts' we mean the ultimate elements themselves as presented in sensation. These are not knowable relations, they are the ultimate unanalysable sense-elements between which these relations subsist. And yet Mach certainly does not conceive of these relations as superposed externally like a shifting network over the elements, but as concrete elements-in-relation varying their sensational appearance in some respect with each change in the relation. When he says of a colour that it is green in itself, he does not mean that the very same patch of green may not become in-

¹ Mach uses these two terms indifferently.

stantly yellow in the light of a sodium flame, but that wherever and whenever green is seen it presents itself as a sensationally-unanalysable-element-in-some-given-relation. Science must leave the unanalysable, elemental characteristic alone and apply itself solely to the analysable relations in which it stands to other elements in relation. 'Colours, tones, spaces, durations . . . are for us the ultimate elements whose given inter-connexions we have to investigate.'

Mach's monism is not a philosophical monism for the charmingly simple reason that he does not believe in the existence of any real metaphysical problem. Thus the old problem of the One Thing with its many qualities is the merest delusion. For the thing is one only as long as our purpose does not require us to consider it as multiple, and multiple only so long as our purpose does not require us to consider it as one. If we try to follow out the *two* purposes of thought *together*, which is like trying to move in two directions at once, we get our metaphysical problem, but only on a basis of self-contradiction (p. 5). So again the fiction of the thing in itself comes from our supposing that since we can abstract from this property or from that without destroying the relative permanence of the object, we may abstract from all its properties and still have something permanent left.

All metaphysical conceptions then must go. The so-called material bodies are mere complexes of elements, whose apparent thinghood and independence can be easily explained. For out of the primitive web of phenomena what is relatively permanent slowly asserts itself in the process of mental growth, impresses itself upon the memory, and expresses itself in speech; and the first complexes to make themselves felt in this way are the so-called 'bodies'. 'Things' have no scientific right of existence. It is the same with the 'self' or ego—'Das Ich ist unrettbar' (p. 17). The Ego is a changing complex made up of two complexes: (1) Body, (2) Psychical States, which stand in constant relation to each other.

We are left then with a purified scientific monism which is itself, like everything else, only justified in the light of a special end: the end of Science whose sole conceivable purpose is to give to man the completest possible information as to how he is to find his way about through the labyrinth of the universe (p. 26). If the end in view is merely *practical*, body and ego may be lawfully rehabilitated. They are convenient fictions, and in so far as they possess practical utility Mach feels tenderly towards them. Our author will bear with any dualistic view or with any other scientific fiction so long as it is held solely in the interests of practice. Within the practical sphere such views have *permanent* worth. Yet, and this is Mach's last word, the worth of a theory is relative only to the interest which it subserves (p. 27). 'No standpoint has absolute permanent value; each is important only in relation to a specific end.'

With the exposition of his more general views in *Natural Philosophy* Mach couples a series of most original and most interesting analyses of a purely scientific kind. These deal solely with the sensations of sight and hearing, and with the spatial and temporal and motor sensations that go with them.

The first of these analyses is entitled 'The space sensations of the eye'. Visual sensations, we read, may be analysed into sensations of colour and space-sensations (or sensations of form, though Mach does not use this term), for two objects may either agree in colour and differ in form, or else differ in colour and agree in form. Mach holds that our sensations of colour are chemically conditioned, whereas the sensations of space are mechanically conditioned. The former theory, according to which the light-vibrations are of the nature of chemical and not merely physical oscillations, presents this special feature of interest, that it is in apparent contradiction with Clerk-Maxwell's electro-magnetic theory. Mach's treatment of space-sensations is especially interesting. The two main points emphasised in the earlier chapter devoted to this subject are: (1) that geometrical congruence does not imply physiological or optical similarity. The former is to a large extent a perception helped out by the understanding (*Verstandessache*), the latter a mere question of similarity in *sensation*. Our author considers that attention was originally attracted to the straight line as an object of geometrical inquiry through its physiological or optical simplicity rather than through its property of being the shortest distance between two points. Still the optical and the geometrical are very closely related, and there can be no truly scientific geometry which does not aim at doing justice to both aspects. The Greeks emphasised the one; the Hindus, in their principles of symmetry and similarity, emphasised the other. Modern science must emphasise both.

The second main point in this chapter is the connexion of space-sensations with the motor apparatus of the eye. This apparatus is symmetrically adjusted for horizontal movements to left and right, but not so for vertical movements up and down, for in this latter case gravity aids the downward and impedes the upward movements. This fact of symmetry is of fundamental importance. For perfect symmetry means perfect optical congruence and the impossibility of making distinctions based on differences in sensation. Similar sensations are, in fact, connected with symmetrical motor functions. Thus whilst children are constantly confusing the letters *b* and *d*, *p* and *q*, they do not confuse *b* and *p*, *d* and *q*. The fact that we are able to distinguish between right and left with such precision Mach attributes to the original presence in the body, and brain in particular, of a very slight deviation from symmetry (asymmetric), sufficient however to secure our initial preference for left-handed or right-handed movements, as the case may be, the rest following according to the laws of use and disuse. In an interesting section, § 9, new to

the second edition, Mach gives evidence in support of his theory of an original 'asymmetry'. Thus he had it on the authority of an old officer that troops marching through a snowstorm in the dead of night, deprived of all external landmarks, would in their endeavour to keep straight ahead move in a circle of large radius, eventually returning to the same place from which they started.

In a second equally instructive chapter, entitled 'A Further inquiry into Space-sensations,' Mach connects the preceding results with a theory of Innervation (*cf.*, p. 116). In this chapter Mach treats of space-sensations in conjunction with sensations of movement, and indeed treats more directly of the latter than of the former. His main thesis is the unconscious compensating movements of the eye in rotation, and of the whole body, indeed, when the body turns on its axis. In these compensating movements we find the reason, for instance, why external objects appear to keep still while we turn our heads round. In order to account for these compensating movements Mach postulates a central organ of innervation. As the net result of all his own researches and experiments our author considers that he is justified in concluding that every sensation of movement and space is reducible to *one* quality of sensation, the *will* to execute the movements of the eye, or the innervation itself. In a remarkable phrase, modified however in a second edition footnote, Mach tells us in fact that 'The will to execute the movements of the eye, or the innervation, is the space-sensation itself'. It is not surprising that Prof. Stumpf found these equations quite unthinkable. But we must remember that with Mach an act of will is simply a modified sensation of movement (*cf.*, p. 12, § 2 and the chapters on the Will).

In the chapter dealing with visual sensations (p. 125) Mach treats in detail a number of visual phenomena, especially those of monocular vision and perspective, and seeks to bring them under certain general physiological laws, mainly three in number, the law of Probability or Likelihood, the law of Parsimony,¹ and the law of Contrast.² Mach also detects in these phenomena the presence of a principle of sensation closely analogous to that of the conservation of energy (*cf.*, p. 135).

It is natural that one who believes in space-sensations should also believe in time-sensations. Mach believes firmly in a specific sense of time. Two bars of music with the same rhythm, but completely different in sound, are at once recognised as having the same time-form, just as in the case of two spatial objects of different colour and similar form, the similarity of form is at once recognised. In each case we are dealing not with an affair of the understanding, but with an immediate sensation. We appreciate these time-sensations, according to Mach, in the form of the working of attention,—a strange theory which Mach supports by the very questionable assertion that to attention that is riveted

¹ See pp. 137, 138, 142, 145.

² Pp. 140, 141.

and strained time passes slowly, but quickly when the attention is only lightly engaged. Moreover, Mach seems to think that the maintenance of the blood-circulation might possibly be the physiological equivalent of this constantly experienced sensation of time. He gives striking examples in support of his thesis, but they are not convincing. Finally, he draws attention to the interesting fact that there is no such thing as *symmetry* in the province of rhythm and time. Thus two bars of music spatially symmetrical, as seen by the eyes, do not give any such feeling of symmetry when heard successively by the ear.

In his treatment of tone-sensations, Mach accepts in the main the results of Helmholtz, and endeavours simply to complete his theory in certain respects.¹ In particular Mach accepts in a modified form Helmholtz's physiological explanation of the organ of Corti. The fact that the successive tones are not only different but are arranged in a continuous series suggests however that each tone is a mixture of two partial sensations, one clear, the other dull, the relative proportion of clear and dull in any tone depending on its vibrational value. In this way we secure a continuity among tones analogous to that which obtains among colours. Again the fact that we can hear several tones together leads Mach to accept the suggestion of a Tone-space (*Tonraum*) in which these tones lie side by side. Finally, the fact that we can recognise as similar two intervals such as *cg*, *c'g'*, leads him to ascribe certain *Zusatzfärbungen*, or complementary colourings to each tone which would owe their origin to the susceptibility of each nerve-ending not only to its own specific rate of vibration but to vibration-rates that are multiples or sub-multiples of its own.

In the work we have just been considering we have an excellent example of the working philosophy of a man of science. It is an attempt to consolidate through Philosophy the interests of Science, and that in two ways: (1) by purifying it of all that is metaphysical; (2) by bringing its various parts into fruitful contact with one another. It is based on the conviction that the facts we have to understand are the relations in which sense-phenomena stand to one another, the permanent relations existing between the elements of sense, and that there are no other facts or anything else capable of being understood. This being the case, the function of Philosophy consists solely in reflecting critically upon the functions of Science and pointing out its sources of purity and strength. To be pure, the irrelevant must be weeded out, the irrelevant being just the metarelatational, that is, the metaphysical. To be strong, the various scions of science, represented in last resort by the twin sciences of Physics and Psychology, must lend each other mutual aid.

Now, there is something very salutary and bracing about an effort of this kind, and were it undertaken with a due recognition

¹ See especially § 21 and the last paragraph of § 17.

of its necessary limitations, it would stand for a great achievement. At times the reader will imagine that his author has grasped the restriction well, for he is frequently asserting that his sole aim is to purify and unify Science so as to render it the most efficient and economical instrument possible. At other times we see quite as clearly that it is not only within the garden of Science that Metaphysics plays the part of a weed but that it is the absolute weed, the weed *an sich*; and that sensationalistic monism is by no means a mere useful hypothesis for enabling Physics and Psychology to share the fruit of each other's labours but a self-evident *Grundanschauung*, a substitute for all future metaphysic.

And yet, though Mach does not himself see any difference between these two positions, the difference undoubtedly exists. As a general theory of scientific method Mach's philosophy is excellent. Physics *quid* Physics, *quid* abstract science of modes of movement, has nothing to gain from good metaphysics and may be much hampered by bad metaphysics; hence the sooner it is demetaphysicised the better. Moreover, as a fruitful source of analogies Mach's conception of the rigid parallelism between psychical and physical should, under good control, be scientifically most valuable, in the dim future at any rate, and none the less valuable, for being so rigidly conceived. Finally, the primacy which Mach assigns to the concrete sense-phenomena over the symbols through which we seek to understand them, or to adjust our thought to them, as Mach puts it, is excellent evidence of Mach's soundness of method.¹ Indeed we might say a great deal more to justify Mach's philosophy considered as a working theory of scientific method. He has felt the needs of his science and has seen how to supply them.

Unfortunately there is still the other and the weaker side to consider. In performing its function as the Mentor of Science, Mach's philosophy commits itself to the following statement which we hold to be fundamentally vicious and misleading: 'There is nothing anywhere save sensations and the relations between them'. And yet this is the keynote of the whole position which an unfeeling critic—much to the author's amazement, who had hoped he was merely a physicist—stigmatised as sensationalistic, phenomenistic, positivistic monism. We propose to focus our criticism on the one central aspect of sensationalistic monism.

In the first place we must note that Mach's reduction of the universe to a complex of sensations is effected in a most casual and threadbare manner. § 11 is a masterpiece from this point of view. There we find the intractable feelings, pleasure and pain, appropriated for the sensationalistic Theory on the sole ground that all sensations, as ordinarily understood, are able to pass gradually off into states of pleasure and pain; and all other feelings may, we read, be similarly appropriated, since every

¹ Cf. also the excellent remarks on p. 217, § 9.

feeling is essentially a pleasure or a pain. The will again is itself a complex of sensations of movement modified by recollected images, these images being themselves modified sensations. Finally, the elements of the outer world are only our sensations considered in their relation to one another, so that the whole inner and outer world is just a mass of sensations and nothing more.

But not only is the reduction most insufficient and unconvincing, it seems at first sight quite unnecessary. Mach repeatedly tells us that the sole thing Science can do is to investigate the laws according to which elements are related to each other, and that only metaphysicians with plenty of leisure will ever think of inquiring into the actual nature of these elements. That nature is given. Why then this inquiry whereby the nature of volition and the nature of feeling is reduced without more ado to the nature of sensation? Is not the nature of pain given as pain and the nature of volitional effort as volitional effort? And cannot the relations subsisting between two volitions or two pleasures be analysed just as fruitfully when their own nature is left to them as when they are first disfigured into sensations?

The reason for this inconsistency is not easy to trace. It seems probable, however, that Mach felt instinctively that it was only in sensation that the physical and the psychical really do come into obvious contact, and that it is only on the supposition that all psychical qualities are fundamentally sensational that any physicist would allow that both he and the psychologist had the same subject-matter, though differently viewed by each.

With the qualitative differences in *sensations* Mach does not tamper. He allows a restricted number of these fundamental differences in quality (p. 15), and he is far indeed from aiming at reducing all sensations to more or less of one another so as to give the universe over to the mathematical physicist. Still it is hard to see why a volition or a pain should be more obviously reducible to sensational quality than the sensational varieties themselves to one fundamental sensation, say that of touch. In fact Mach's whole sensationalistic position is merely stated, it is not explained, or even clearly described. The only light he gives us as to what he means by a sensation is when he tells us that sensations are the elements of the universe considered in their relation to the elements of the individual's body, and not in their relation with one another.

But not only is there no attempt made to analyse the meaning of a sensation psychologically, but Mach has no Theory of Knowledge. On page 208 we read these words: 'Considerations turning on the Theory of Knowledge can indeed do no harm to any one, still . . . the physicist, for example, has no ground for allowing himself to be overmuch disturbed by such reflexions. Sharpness in observation and a happy instinct are very safe guides for him. His ideas, in so far as they prove inadequate, are best and

quickest set to rights by the facts themselves.' Mach rigidly follows his own advice. His first happy instinct is to entirely identify the subject of experience with the empirical self. Thus on page 17, in an insertion new to the second edition, he alludes to the common belief that an experience without a subject is unthinkable, and argues against the prejudice on the ground that the Consciousness of Self may have many grades and be constituted by the most haphazard medley of recollections; and he adds: 'The subject is built up out of sensations and then reacts upon them'. Our sensations then, according to Mach, are the thinkers: they fulfil the functions usually attributed to the Ego or subject.

This confusion between the Subject and the Self is so central a defect in non-metaphysical philosophies that it may be useful to consider it in some detail.

That Mach is right in denying any fixed line of separation between self and not-self cannot be doubted. The self may or may not include one's own body, dress, property. In a sense all that affects the interests of the self ceases in so doing to be a not-self to it. But the subject that makes the distinction between the self and the not-self is surely *qua* subject, incapable of being an object at all.

A green leaf is not exhausted by being analysed out into its properties and relations. Its distinctively sensational character is not in any way explained by the process. We can experience the greenness of a green leaf but we can never know its greenness. So we can analyse a pleasure when once we have experienced it, but we can never know a pleasure, we can only feel it. So a volition must be willed before it can be known, and what is known of a volition is not the volition as it is experienced. So the experience of the self may be analysed once it is there, but even when analysed it can only be seized on its relational side, not as an experience of the subject but as the object of a thinking experience of the subject. The subject that experiences is therefore not the self as it is known in contradistinction to the not-self. On the other hand it is surely no metaphysical agency in the old atomic sense, still less a mere postulate. Why not call it 'the self experiencing,' and allow that the deepest conviction of what is meant by self must be gathered from this point of view. Mach would look upon this 'self experiencing' as an unknowable Thing in Itself. There seems to me to be a happy vein of truth in this disparaging term. My knowledge of an experience of mine can never be a substitute for that experience, for to experience is to enter into new relations and not to discover the meaning of relations already entered into.¹ The experience *qua* experience is therefore unknowable, but it is not unknowable in the sense of lying outside experience but only in the same

¹ Except, of course, in so far as such discovery of meaning is entering into new relations.

sense that the blue sky I stare into is, *quid* sensation, unknowable. It is mentally unfathomable. If Mach considers the Ego as subject to be a mere metaphysical bubble, so then are the sensations, and so, too, the world which is built up out of them.

And indeed we find Mach adopting some such view as the above when he comes to speak of sensations in themselves. These are his words: ' . . . All forms, colours, etc., are in themselves one and the same (*gleichartig*), in themselves they are neither psychical nor physical'. The meaning ascribed above to '*gleichartig*' is gathered from another expression in the same section, when he says that the elements 'are always the same (*dieselben*), and of one kind only (*nur von einerlei Art*), presenting themselves now as physical elements, now as psychical elements, according to the kind of connexion in which they appear' (§ 3, p. 46). These elements in themselves, which are neither physical nor psychical, must surely be the sensational experience itself *quid* sensational experience, an experience which admits as little of a psychological explanation as it does of a physical explanation.

Mach's sensationalism then, in so far as it is metarelatational, is a tacit recognition of the rights of metaphysics, and above all of the necessity of a searching Theory of Knowledge. A *Nachbemerkung* to this effect would have been very welcome. Still a reviewer's last word on this excellent book must be one of gratitude and appreciation. There is no reason whatsoever, on the appearance of this second edition, for modifying in any way Prof. Stumpf's verdict when in his notice of the first edition, fourteen years ago, he described it as highly original, stimulating and instructive; or indeed that of Prof. James, who referred to it as a work of genius. Perhaps however it would be truer to call it the work of a genius.

W. R. BOYCE GIBSON.