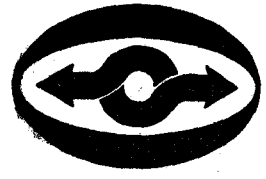
Edmund Husserl

Translated, with an Introduction, by



The Crisis of European Sciences and Transcendental Phenomenology

An Introduction to Phenomenological Philosophy

David Carr

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Contents

Translator's Introduction / xv

PART I THE CRISIS OF THE SCIENCES AS EXPRESSION OF THE RADICAL LIFE-CRISIS OF EUROPEAN HUMANITY

§ 1. *Is there, in view of their constant successes, really a crisis of the sciences?* / 3
§ 2. *The positivistic reduction of the idea of science to mere factual science. The "crisis" of science as the loss of its meaning for life.* / 5
§ 3. *The founding of the autonomy of European humanity through the new formulation of the idea of philosophy in the Renaissance.* / 7
§ 4. *The failure of the new science after its initial success; the unclarified motive for this failure.* / 10
§ 5. *The ideal of universal philosophy and the process of its inner dissolution.* / 11
§ 6. *The history of modern philosophy as a struggle for the meaning of man.* / 14
§ 7. *The project of the investigations of this work.* / 16

PART II CLARIFICATION OF THE ORIGIN OF THE MODERN OPPOSITION BETWEEN PHYSICALISTIC OBJECTIVISM AND TRANSCENDENTAL SUBJECTIVISM

§ 8. *The origin of the new idea of the universality of science in the reshaping of mathematics.* / 21
§ 9. *Galileo's mathematization of nature.* / 23
a. "Pure geometry." / 24
b. The basic notion of Galilean physics: nature as a mathematical universe. / 28
c. The problem of the mathematizability of the "plena." / 34
d. The motivation of Galileo's conception of nature. / 37

e. The verificational character of natural science's fundamental hypothesis. / 41
f. The problem of the sense of natural-scientific "formulae." / 43
g. The emptying of the meaning of mathematical natural science through "technization." / 46
h. The life-world as the forgotten meaning-fundament of natural science. / 48
i. Portentous misunderstandings resulting from lack of clarity about the meaning of mathematization. / 53
k. Fundamental significance of the problem of the origin of mathematical natural science. / 56
l. Characterization of the method of our exposition. / 57

§ 10. *The origin of dualism in the prevailing exemplary role of natural science. The rationality of the world* more geometrico. / 60

§ 11. *Dualism as the reason for the incomprehensibility of the problems of reason; as presupposition for the specialization of the sciences; as the foundation of naturalistic psychology.* / 61

§ 12. *Over-all characterization of modern physicalistic rationalism.* / 65

§ 13. *The first difficulties of physicalistic naturalism in psychology: the incomprehensibility of functioning subjectivity.* / 67

§ 14. *Precursory characterization of objectivism and transcendentalism. The struggle between these two ideas as the sense of modern spiritual history.* / 68

§ 15. *Reflection on the method of our historical manner of investigation.* / 70

§ 16. *Descartes as the primal founder not only of the modern idea of objectivistic rationalism but also of the transcendental motif which explodes it.* / 73

§ 17. *Descartes's return to the* ego cogito. *Exposition of the sense of the Cartesian epochē.* / 75

§ 18. *Descartes's misinterpretation of himself. The psychologistic falsification of the pure ego attained through the epochē.* / 78

§ 19. *Descartes's obtrusive interest in objectivism as the reason for his self-misinterpretation.* / 81

§ 20. *"Intentionality" in Descartes.* / 82

§ 21. *Descartes as the starting point of two lines of development, rationalism and empiricism.* / 83

§ 22. *Locke's naturalistic-epistemological psychology.* / 84

§ 23. *Berkeley. David Hume's psychology as fictionalistic theory of knowledge: the "bankruptcy" of philosophy and science.* / 86

§ 24. *The genuine philosophical motif hidden in the absurdity of Hume's skepticism: the shaking of objectivism.* / 88

§ 25. *The "transcendental" motif in rationalism: Kant's conception of a transcendental philosophy.* / 91

§ 26. *Preliminary discussion of the concept of the "transcendental" which guides us here.* / 97

§ 27. *The philosophy of Kant and his followers seen from the perspective of our guiding concept of the "transcendental." The task of taking a critical position.* / 98

PART III THE CLARIFICATION OF THE TRANSCENDENTAL PROBLEM AND THE RELATED FUNCTION OF PSYCHOLOGY

A. The Way into Phenomenological Transcendental Philosophy by Inquiring back from the Pregiven Life-World

§ 28. *Kant's unexpressed "presupposition": the surrounding world of life, taken for granted as valid.* / 103

§ 29. *The life-world can be disclosed as a realm of subjective phenomena which have remained "anonymous."* / 111

§ 30. *The lack of an intuitive exhibiting method as the reason for Kant's mythical constructions.* / 114

§ 31. *Kant and the inadequacy of the psychology of his day. The opaqueness of the distinction between transcendental subjectivity and soul.* / 116

§ 32. *The possibility of a hidden truth in Kant's transcendental philosophy: the problem of a "new dimension." The antagonism between the "life of the plane" and the "life of depth."* / 118

§ 33. *The problem of the "life-world" as a partial problem within the general problem of objective science.* / 121

§ 34. *Exposition of the problem of a science of the life-world.* / 123
a. The difference between objective science and science in general. / 123
b. The use of subjective-relative experiences *for* the objective sciences, and the science *of* them. / 125
c. Is the subjective-relative an object for psychology? / 126
d. The life-world as universe of what is intuitable in principle; the "objective-true" world as in principle nonintuitable "logical" substruction. / 127
e. The objective sciences as subjective constructs—those of a particular praxis, namely, the theoretical-logical, which itself belongs to the full concreteness of the life-world. / 129
f. The problem of the life-world not as a partial problem but rather as a universal problem for philosophy. / 132

§ 35. *Analysis of the transcendental epochē. First step: The epochē of objective science.* / 135

§ 36. *How can the life-world, after the epochē of the objective sciences, become the subject matter of a science? The distinction in principle between the objective-logical a priori and the a priori of the life-world.* / 137

§ 37. *The formal and most general structures of the life-world: thing*

PART II
Clarification of the Origin of the Modern Opposition between Physicalistic Objectivism and Transcendental Subjectivism

§8. *The origin of the new idea of the universality of science in the reshaping of mathematics.*

THE FIRST THING we must do is understand the fundamental transformation of the idea, the task of universal philosophy which took place at the beginning of the modern age when the ancient idea was taken over. From Descartes on, the new idea governs the total development of philosophical movements and becomes the inner motive behind all their tensions.

The reshaping begins with prominent special sciences inherited from the ancients: Euclidean geometry and the rest of Greek mathematics, and then Greek natural science. In our eyes these are fragments, beginnings of our developed sciences. But one must not overlook here the immense change of meaning whereby *universal* tasks were set, primarily for mathematics (as geometry and as formal-abstract theory of numbers and magnitudes)—tasks of a style which was *new in principle,* unknown to the ancients. Of course the ancients, guided by the Platonic doctrine of ideas, had already idealized empirical numbers, units of measurement, empirical figures in space, points, lines, surfaces, bodies; and they had transformed the propositions and proofs of geometry into ideal-geometrical propositions and proofs. What is more, with Euclidean geometry had grown up the highly impressive idea of a systematically coherent deductive theory, aimed at a most broadly and highly conceived ideal goal, resting on "axiomatic" fundamental concepts and principles, proceeding according to apodictic arguments—a totality formed of pure rationality, a totality whose unconditioned truth is available to insight and which consists exclusively of unconditioned truths recognized through immediate and mediate insight. But Euclidean geometry, and ancient mathematics in general, knows only finite tasks, a finitely closed a priori. Aristotelian syllogistics belongs here also, as an a priori which takes precedence over all others. Antiquity goes this far, but never far enough to grasp the possibility of the infinite task which, for us, is linked as a matter

of course with the concept of geometrical space and with the concept of geometry as the science belonging to it. To ideal space belongs, for us, a universal, systematically coherent a priori, an infinite, and yet—in spite of its infinity—self-enclosed, coherent systematic theory which, proceeding from axiomatic concepts and propositions, permits the deductively univocal construction of any conceivable shape which can be drawn in space. What "exists" ideally in geometric space is univocally decided, in all its determinations, in advance. Our apodictic thinking, proceeding stepwise to infinity through concepts, propositions, inferences, proofs, only "discovers" what is already there, what in itself already exists in truth.

What is new, unprecedented, is the conceiving of this idea of a rational infinite totality of being with a rational science systematically mastering it. An infinite world, here a world of idealities, is conceived, not as one whose objects [1] become accessible to our knowledge singly, imperfectly, and as it were accidentally, but as one which is attained by a rational, systematically coherent method. In the infinite progression of this method, every object is ultimately attained according to its full being-in-itself [*nach seinem vollen An-sich-sein*].

But this is true not only in respect to ideal space. Even less could the ancients conceive of a similar but more general idea (arising from formalizing abstraction), that of a formal mathematics. Not until the dawn of the modern period does the actual discovery and conquest of the infinite mathematical horizons begin. The beginnings of algebra, of the mathematics of continua, of analytic geometry arise. From here, thanks to the boldness and originality peculiar to the new humanity, the great ideal is soon anticipated of a science which, in this new sense, is rational and all-inclusive, or rather the idea that the infinite totality of what is in general is intrinsically a rational all-encompassing unity that can be mastered, without anything left over, by a corresponding universal science. Long before this idea comes to maturity, it determines further developments as an unclear or half-clear presentiment. In any case it does not stop with the new mathematics. Its rationalism soon overtakes natural science and creates for it the completely new idea of *mathematical natural science*—Galilean science, as it was rightly called for a long time. As soon as the latter begins to move toward successful realization, the idea of philosophy in general (as the science of the universe, of all that is) is transformed.

1. *Objekte*. There is no difference in meaning between *Objekt* and *Gegenstand* as Husserl uses these terms and hence no reason for following Dorion Cairns (*Cartesian Meditations* [The Hague: Martinus Nijhoff, 1960], translator's note 2, p. 3) in trying to distinguish them in translation.

§ 9. *Galileo's mathematization of nature.*

FOR PLATONISM, the real [1] had a more or less perfect methexis in the ideal. This afforded ancient geometry possibilities of a primitive application to reality. [But] through Galileo's *mathematization of nature, nature itself* is idealized under the guidance of the new mathematics; nature itself becomes—to express it in a modern way—a mathematical manifold [*Mannigfaltigkeit*].

What is the meaning of this mathematization of nature? How do we reconstruct the train of thought which motivated it?

Prescientifically, in everyday sense-experience, the world is given in a subjectively relative way. Each of us has his own appearances; and for each of us they count as [*gelten als*] that which actually is. In dealing with one another, we have long since become aware of this discrepancy between our various ontic validities.[2] But we do not think that, because of this, there are many worlds. Necessarily, we believe in *the* world, whose things only appear to us differently but are the same. [Now] have we nothing more than the empty, necessary idea of things which

1. *das Reale*. I have used "real" almost exclusively for the German *real* and its derivatives. For Husserl this term refers to the spatio-temporal world as conceived by physics (or to the psychic when it is mistakenly conceived on the model of the physical). The more general *Wirklichkeit* has usually been translated by the etymologically correct term "actuality."

2. *Seinsgeltungen*. *Geltung* is a very important word for Husserl, especially in this text. It derives from *gelten*, which is best translated "to count (as such and such) (for me)," as in the previous sentence, or "to be accepted (as, etc.)" or "to have the validity (of such and such) (for me)." *Gültigkeit* is the more common substantive but is less current in Husserl. Thus "validity" ("our validities," etc.) seems an appropriate shortcut for such more exact but too cumbersome expressions as "that which counts (as)," "those things which we accept (as)," etc., in this case, "those things that we accept as existing." I have used "ontic" when Husserl compounds *Sein* with this and other words, e.g., *Seinssinn, Seinsgewissheit*.

exist objectively in themselves? Is there not in the appearances themselves a content we must ascribe to true nature? Surely this includes everything which pure geometry, and in general the mathematics of the pure form of space-time, teaches us, with the self-evidence of absolute, universal validity, about the pure shapes it can construct *idealiter*—and here I am describing, without taking a position, what was "obvious" [3] to Galileo and motivated his thinking.

We should devote a careful exposition to what was involved in this "obviousness" for Galileo and to whatever else was taken for granted by him in order to motivate the idea of a mathematical knowledge of nature in his new sense. We note that he, the philosopher of nature and "trail-blazer" of physics, was not yet a physicist in the full present-day sense; that his thinking did not, like that of our mathematicians and mathematical physicists, move in the sphere of symbolism, far removed from intuition; and that we must not attribute to him what, through him and the further historical development, has become "obvious" to us.

a. "Pure geometry."

Let us first consider "pure geometry," the pure mathematics of spatiotemporal shapes in general, pregiven [4] to Galileo as an old tradition, involved in a process of lively forward development —in other words, in generally the same way we still find it: [on the one hand] as a science of "pure idealities" which is, on the other hand, constantly being practically applied to the world of sense-experience. So familiar to us is the shift between a priori theory and empirical inquiry in everyday life that we usually tend not to separate the space and the spatial shapes geometry talks about from the space and spatial shapes of experiential actuality, as if they were one and the same. If geometry is to be understood as the foundation for the meaning [*Sinnesfundament*] of exact physics, however, we must be very precise here as elsewhere. In order to clarify the formation of Galileo's thought we must accordingly reconstruct not only what

3. *Selbstverständlichkeit* is another very important word in this text. It refers to what is unquestioned but not necessarily unquestionable. "Obvious" works when the word is placed in quotation marks, as it is here. In other cases I have used various forms of the expression "taken for granted."

4. *vorgegeben*. Implying "already there," as material to be worked with. This term is much used later on as applied to the life-world.

consciously motivated him. It will also be instructive to bring to light what was implicitly included in his guiding model of mathematics, even though, because of the direction of his interest, it was kept from his view: as a hidden, presupposed meaning it naturally had to enter into his physics along with everything else.

In the intuitively given surrounding world, by abstractively directing our view to the mere spatiotemporal shapes, we experience "bodies"—not geometrical-ideal bodies but precisely those bodies that we actually experience, with the content which is the actual content of experience. No matter how arbitrarily we may transform these bodies in fantasy, the free and in a certain sense "ideal" possibilities we thus obtain are anything but geometrical-ideal possibilities: they are not the geometrically "pure" shapes which can be drawn in ideal space—"pure" bodies, "pure" straight lines, "pure" planes, "pure" figures, and the movements and deformations which occur in the "pure" figures. Thus geometrical space does not mean anything like imaginable space or, generally speaking, the space of any arbitrarily imaginable (conceivable) world. Fantasy can transform sensible shapes only into other sensible shapes. Such shapes, in actuality or fantasy, are thinkable only in gradations: the more or less straight, flat, circular, etc.

Indeed, the things of the intuitively given surrounding world fluctuate, in general and in all their properties, in the sphere of the merely typical: their identity with themselves, their self-sameness and their temporally enduring sameness, are merely approximate, as is their likeness with other things. This affects all changes, and *their* possible samenesses and changes. Something like this is true also of the abstractly conceived shapes of empirically intuited bodies and their relations. This gradualness can be characterized as that of greater or less perfection. Practically speaking there is, here as elsewhere, a simple perfection in the sense that it fully satisfies special practical interests. But when interests change, what was fully and exactly satisfactory for one is no longer so for another; and of course there is a limit to what can be done by means of the normal technical capacity of perfecting, e.g., the capacity to make the straight straighter and the flat flatter. But technology progresses along with mankind, and so does the interest in what is technically more refined; and the ideal of prefection is pushed further and further. Hence we always have an open horizon of *conceivable* improvement to be further pursued.

Without going more deeply into the essential interconnections involved here (which has never been done systematically and is by no means easy), we can understand that, out of the praxis of perfecting, of freely pressing toward the horizons of *conceivable* perfecting "again and again," *limit-shapes* [5] emerge toward which the particular series of perfectings tend, as toward invariant and never attainable poles. If we are interested in these ideal shapes and are consistently engaged in determining them and in constructing new ones out of those already determined, we are "geometers." The same is true of the broader sphere which includes the dimension of time: we are mathematicians of the "pure" shapes whose universal form is the coidealized form of space-time. In place of real praxis—that of action or that of considering empirical possibilities having to do with actual and really [i.e., physically] possible empirical bodies—we now have an *ideal* praxis of "pure thinking" which remains exclusively within the realm of pure limit-shapes. Through a method of idealization and construction which historically has long since been worked out and can be practiced intersubjectively in a community, these limit-shapes have become acquired tools that can be used habitually and can always be applied to something new—an infinite and yet self-enclosed world of ideal objects as a field for study. Like all cultural acquisitions which arise out of human accomplishment, they remain objectively knowable and available without requiring that the formulation of their meaning be repeatedly and explicitly renewed. On the basis of sensible embodiment, e.g., in speech and writing, they are simply apperceptively [6] grasped and dealt with in our operations. Sensible "models" function in a similar way, including especially the drawings on paper which are constantly used during work, printed drawings in textbooks for those who learn by reading, and the like. It is similar to the way in which certain cultural objects (tongs, drills, etc.) are understood, simply "seen," with their specifically cultural properties, without any renewed process of making intuitive what gave such properties their true meaning. Serving in the methodical praxis of mathematicians, in this form of long-understood acquisitions, are

5. *Limesgestalten.* Husserl has in mind the mathematic concept of limit.

6. *apperzeptiv.* Husserl uses this term in the Leibnizian sense to denote a self-conscious act (but not necessarily an act of reflection) under a certain point of view or "attitude" (*Einstellung*), here the mathematical.

significations which are, so to speak, sedimented in their embodiments. And thus they make mental manipulation possible in the geometrical world of ideal objects. (Geometry represents for us here the whole mathematics of space-time.)

But in this mathematical praxis we attain what is denied us in empirical praxis: "exactness"; for there is the possibility of determining the ideal shapes in absolute identity, of recognizing them as substrates of absolutely identical and methodically, univocally determinable qualities. This occurs not only in particular cases, according to an everywhere similar method which, operating on sensibly intuitable shapes chosen at random, could carry out idealizations everywhere and originally create, in objective and univocal determinateness, the pure idealities which correspond to them. For this, [rather,] certain structures stand out, such as straight lines, triangles, circles. But it is possible—and this was the discovery which created geometry—using these elementary shapes, singled out in advance as universally available, and according to universal operations which can be carried out with them, to *construct* not only more and more shapes which, because of the method which produces them, are intersubjectively and univocally determined. For in the end the possibility emerges of producing constructively and univocally, through an a priori, all-encompassing systematic method, *all* possibly *conceivable* ideal shapes.

The geometrical methodology of operatively determining some and finally all ideal shapes, beginning with basic shapes as elementary means of determination, points back to the methodology of determination by surveying and measuring in general, practiced first primitively and then as an art in the prescientific, intuitively given surrounding world. The undertaking of such measurement has its obvious origin in the essential form of that surrounding world. The shapes in it that are sensibly experienceable and sensibly-intuitively conceivable, and the types [of shapes] that are conceivable at any level of generality, fade into each other as a continuum. In this continuity they fill out (sensibly intuited) space-time, which is their form. Each shape in this open infinitude, even if it is given intuitively in reality as a *fact*, is still without "objectivity"; it is not thus intersubjectively determinable, and communicable in its determinations, for everyone —for every other one who does not at the same time factually see it. This purpose [of procuring objectivity] is obviously served by the *art of measuring*. This art involves a great deal, of which the actual measuring is only the concluding part: on the one

hand, for the bodily shapes of rivers, mountains, buildings, etc., which as a rule lack strictly determining concepts and names, it must create such concepts—first for their "forms" (in terms of pictured similarity), and then for their magnitudes and relations of magnitude, and also for the determinations of position, through the measurement of distances and angles related to known places and directions which are presupposed as being fixed. The art of measuring discovers *practically* the possibility of picking out as [standard] measures certain empirical basic shapes, concretely fixed on empirical rigid bodies which are in fact generally available; and by means of the relations which obtain (or can be discovered) between these and other body-shapes it determines the latter intersubjectively and in practice univocally—at first within narrow spheres (as in the art of surveying land), then in new spheres where shape is involved. So it is understandable how, as a consequence of the awakened striving for "philosophical" knowledge, knowledge which determines the "true," the objective being of the world, the empirical art of measuring and its empirically, practically objectivizing function, through a change from the practical to the theoretical interest, was idealized and thus turned into the purely geometrical way of thinking. The art of measuring thus becomes the trail-blazer for the ultimately universal geometry and its "world" of pure limit-shapes.

b. The basic notion of Galilean physics: nature as a mathematical universe.

The relatively advanced geometry known to Galileo, already broadly applied not only to the earth but also in astronomy, was for him, accordingly, already pregiven by tradition as a guide to his own thinking, which [then] related empirical matters to the mathematical ideas of limit. Also available to him as a tradition, of course—itself partially determined in the meantime by geometry—was the art of measuring, with its intention of ever increasing exactness of measurement and the resulting objective determination of the shapes themselves. If the empirical and very limited requirements of technical praxis had originally motivated those of pure geometry, so now, conversely, geometry had long since become, as "applied" geometry, a means for technology, a guide in conceiving and carrying out the task of systematically constructing a methodology of measurement for

objectively determining shapes in constantly increasing "approximation" to the geometrical ideals, the limit-shapes.

For Galileo, then, this was given—and of course he, quite understandably, did not feel the need to go into the manner in which the accomplishment of idealization originally arose (i.e., how it grew on the underlying basis of the pregeometrical, sensible world and its practical arts) or to occupy himself with questions about the origins of apodictic, mathematical self-evidence. There is no need for that in the attitude of the geometer: one has, after all, studied geometry, one "understands" geometrical concepts and propositions, is familiar with methods of operation as ways of dealing with precisely defined structures and of making proper use of figures on paper ("models"). It did not enter the mind of a Galileo that it would ever become relevant, indeed of fundamental importance, to geometry, as a branch of a universal knowledge of what is (philosophy), to make geometrical self-evidence—the "how" of its origin—into a problem. For us, proceeding beyond Galileo in our historical reflections, it will be of considerable interest to see how a shift of focus became urgent and how the "origin" of knowledge had to become a major problem.

Here we observe the way in which geometry, taken over with the sort of naïveté of a priori self-evidence that keeps every normal geometrical project in motion, determines Galileo's thinking and guides it to the idea of physics, which now arises for the first time in his life-work. Starting with the practically understandable manner in which geometry, in an old traditional sphere, aids in bringing the sensible surrounding world to univocal determination, Galileo said to himself: Wherever such a methodology is developed, there we have also overcome the relativity of subjective interpretations which is, after all, essential to the empirically intuited world. For in this manner we attain an identical, nonrelative truth of which everyone who can understand and use this method can convince himself. Here, then, we recognize something that truly is—though only in the form of a constantly increasing approximation, beginning with what is empirically given, to the geometrical ideal shape which functions as a guiding pole.

However, all this *pure* mathematics has to do with bodies and the bodily world only through an abstraction, i.e., it has to do only with *abstract shapes* within space-time, and with these, furthermore, as purely "ideal" limit-shapes. *Concretely,* however,

the actual and possible empirical shapes are given, at first in empirical sense-intuition, merely as "forms" of a "matter," of a sensible plenum; [7] thus they are given together with what shows itself, with its own gradations, in the so-called "specific" sense-qualities: * color, sound, smell, and the like.

To the concreteness of sensibly intuitable bodies, of their being in actual and possible experience, belongs also the fact that they are restricted by the [type of] changeability that is essential to them. Their changes of spatiotemporal position, or of form- or plenum-characteristics, are not accidental and arbitrary but depend on one another in sensibly *typical* ways. Such types of relatedness between bodily occurrences are themselves moments of everyday experiencing intuition. They are experienced as that which gives the character of *belonging together* to bodies which *exist together* simultaneously and successively, i.e., as that which *binds* their being [*Sein*] to their being-such [*Sosein*]. Often, though not always, we are clearly confronted in experience with the connected elements which make up these real-causal interdependencies. Where that is not the case, and

* It is a bad legacy of the psychological tradition since Locke's time that the sense-qualities of actually experienced bodies in the everyday, intuited surrounding world—colors, touch-qualities, smells, warmth, heaviness, etc., which are perceived as belonging to the bodies themselves, as their properties—are always surreptitiously replaced by the [so-called] "sense data" [*sinnliche Daten, Empfindungsdaten.* Both terms must be translated by the same expression.—TRANS.]; these are also indiscriminately called sense-qualities and, at least in general, are not at all differentiated from [properties as such]. Where a difference is felt, instead of thoroughly describing the peculiarities of this difference, which is quite necessary, one holds to the completely mistaken opinion (and we shall speak of this later) that "sense-data" constitute what is immediately given. What corresponds to them in the [perceived] bodies themselves is then ordinarily replaced by their mathematical-physical [properties]—when it is precisely the origin of the meaning [of these properties] that we are engaged in investigating. Here and everywhere we shall speak—giving faithful expression to actual experience—of *qualities* or *properties* of the bodies which are actually perceived through these properties. And when we characterize them as the *plena* of shapes, we also take these shapes to be "qualities" of the bodies themselves, indeed sense-qualities; except that, as *αἰσθητὰ κοινά* they are not related to sense-organs belonging to them alone, as are the *αἰσθητὰ ἴδια.*

7. *einer sinnlichen Fülle.* I have used the word *plenum* to translate this strange use of *Fülle:* the sensible content which "fills in" the shapes of the world, the "secondary qualities" that are left over after pure shape has been abstracted. Cf. the related but not identical use of *Fülle* in *Logische Untersuchung* VI, § 21.

where something happens which is strikingly new, we nevertheless immediately ask why and look around us into the spatiotemporal circumstances. The things of the intuited surrounding world (always taken as they are intuitively there for us in everyday life and count as actual) have, so to speak, their "habits"—they behave similarly under typically similar circumstances. If we take the intuitable world as a whole, in the flowing present in which it is straightforwardly there for us, it has even as a whole its "habit," i.e., that of continuing habitually as it has up to now. Thus our empirically intuited surrounding world has an *empirical over-all style.* However we may change the world in imagination or represent to ourselves the future course of the world, unknown to us, in terms of its possibilities, "as it might be," we necessarily represent it according to the style in which we have, and up to now have had, the world. We can become explicitly conscious of this style by reflecting and by freely varying these possibilities. In this manner we can make into a subject of investigation the invariant general style which this intuitive world, in the flow of total experience, persistently maintains. Precisely in this way we see that, universally, things and their occurrences do not arbitrarily appear and run their course but are *bound* a priori by this style, by the invariant form of the intuitable world. In other words, through a *universal causal regulation, all that is together in the world* has a universal immediate or mediate way of *belonging together;* through this the world is not merely a totality [*Allheit*] but an all-encompassing unity [*Alleinheit*], a *whole* (even though it is infinite). This is self-evident a priori, no matter how little is actually experienced of the particular causal dependencies, no matter how little of this is known from past experience or is prefigured about future experience.

This universal causal style of the intuitively given surrounding world makes possible hypotheses, inductions, predictions about the unknowns of its present, its past, and its future. In the life of prescientific knowing we remain, however, in the sphere of the [merely] approximate, the typical. How would a "philosophy," a scientific knowledge of the world, be possible if we were to stop at the vague consciousness of totality whereby, amidst the vicissitudes of temporary interests and themes of knowledge, we are also conscious of the world as horizon? Of course we can, as has been shown, also thematically reflect on this world-whole and grasp its causal style. But we gain thereby only the empty, general insight that any experienceable occurrence at any place

and at any time is causally determined. But what about the specifically determined world-causality, the specifically determined network of causal interdependencies that makes concrete all real events at all times? Knowing the world in a seriously scientific way, "philosophically," can have meaning and be possible only if a method can be devised of *constructing,* systematically and in a sense in advance, the world, the infinitude of causalities, starting from the meager supply of what can be established only relatively in direct experience, and of compellingly *verifying* this construction in spite of the infinitude [of experience]. How is this thinkable?

But here mathematics offers its services as a teacher. In respect to spatiotemporal shapes it had already blazed the trail, in two ways in fact. *First:* by idealizing the world of bodies in respect to what has spatiotemporal shape in this world, it created ideal objects. Out of the undetermined universal form of the life-world, space and time, and the manifold of empirical intuitable shapes that can be imagined into it, it made for the first time an objective world in the true sense—i.e., an infinite totality of ideal objects which are determinable univocally, methodically, and quite universally for everyone. Thus mathematics showed for the first time that an infinity of objects that are subjectively relative and are thought only in a vague, general representation is, through an a priori all-encompassing method, objectively determinable and can actually be thought as determined in itself or, more exactly, as an infinity which is determined, decided in advance, in itself, in respect to all its objects and all their properties and relations. It can be thought in this way, I said—i.e., precisely because it is constructible *ex datis* in its objectively true being-in-itself, through its method which is not just postulated but is actually created, apodictically generated.[8]

Second: coming into contact with the art of measuring and then guiding it, mathematics—thereby descending again from the world of idealities to the empirically intuited world—showed that one can universally obtain objectively true knowledge of a completely new sort about the things of the intuitively actual world, in respect to that aspect of them (which all things necessarily share) which alone interests the mathematics of shapes, i.e., a [type of] knowledge related in an approximating fashion to its own idealities. All the things of the empirically intuitable world have, in accord with the world-style, a bodily character,

8. Reading *erzeugte* for *erzeugende.*

are *res extensae,* are experienced in changeable collocations which, taken as a whole, have their total collocation; in these, particular bodies have their relative positions, etc. By means of pure mathematics and the practical art of measuring, one can produce, for everything in the world of bodies which is extended in this way, a completely new kind of inductive prediction; namely, one can "calculate" with compelling necessity, on the basis of given and measured events involving shapes, events which are unknown and were never accessible to direct measurement. Thus ideal geometry, estranged from the world, becomes "applied" geometry and thus becomes in a certain respect a general method of knowing the real.

But does not this manner of objectifying, to be practiced on one abstract aspect of the world, give rise to the following thought and the conjectural question:

Must not something similar be possible for the concrete world as such? If one is already firmly convinced, moreover, like Galileo—thanks to the Renaissance's return to ancient philosophy—of the possibility of philosophy as *epistēmē* achieving an objective science of the world, and if it had just been revealed that pure mathematics, applied to nature, consummately fulfills the postulate of *epistēmē* in its sphere of shapes: did not this also have to suggest to Galileo the idea of a nature which is constructively determinable in the same manner in all its *other aspects*?

But is this not possible only if the method of measuring through approximations and constructive determinations extends to *all* real properties and real-causal relations of the intuitable world, to everything which is ever experienceable in particular experiences? But how can we do justice to this general anticipation, [and] how can it become a practicable method for a concrete knowledge of nature?

The difficulty here lies in the fact that the material plena—the "specific" sense-qualities—which concretely fill out the spatiotemporal shape-aspects of the world of bodies *cannot,* in their own gradations, be *directly* treated as are the shapes themselves. Nevertheless, these qualities, and everything that makes up the concreteness of the sensibly intuited world, must count as manifestations of an "objective" world. Or rather, they must continue to count as such; because (such is the way of thinking which motivates the idea of the new physics) the certainty, binding us all, of one and the same world, the actuality which exists in itself, runs uninterrupted through all changes of subjective in-

terpretation; all aspects of experiencing intuition manifest something of this world. It becomes attainable for our objective knowledge when those aspects which, like sensible qualities, are abstracted away in the pure mathematics of spatiotemporal form and its possible particular shapes, and are not themselves directly mathematizable, nevertheless become mathematizable *indirectly.*

c. The problem of the mathematizability of the "plena."

The question now is what an *indirect mathematization* would mean.

Let us first consider the more profound reason why a direct mathematization (or an analogue of approximative construction), in respect to the specifically sensible qualities of bodies, is impossible in principle.

These qualities, too, appear in gradations, and in a certain way measurement applies to them as to all gradations—we "assess" the "magnitude" of coldness and warmth, of roughness and smoothness, of brightness and darkness, etc. But there is no exact measurement here, no growth of exactness or of the methods of measurement. Today, when we speak of measuring, of units of measure, methods of measure, or simply of magnitudes, we mean as a rule those that are already related to idealities and are "exact"; so it is difficult for us to carry out the abstract isolation of the plena which is so necessary here: i.e., to consider —experimentally, so to speak—the world of bodies exclusively according to the "aspect" of those properties belonging under the title "specific sense-qualities," through a universal abstraction opposed to the one which gives rise to the universal world of shapes.

What constitutes "exactness"? Obviously, nothing other than what we exposed above: empirical measuring with increasing precision, but under the guidance of a world of idealities, or rather a world of certain particular ideal structures that can be correlated with given scales of measurement—such a world having been objectified in advance through idealization and construction. And now we can make the contrast clear in a word. We have not two but only *one* universal form of the world: not two but only *one geometry,* i.e., one of shapes, without having a second for plena. The bodies of the empirical-intuitable world are such, in accord with the world-structure belonging to this

world–a priori, that each body has—abstractly speaking—an extension of its own and that all these extensions are yet shapes of the one total infinite extension of the world. As world, as the universal configuration of all bodies, it thus has a total form encompassing all forms, and *this* form is idealizable in the way analyzed and can be mastered through construction.

To be sure, it is also part of the world-structure that all bodies have their specific sense-qualities. But the qualitative configurations based purely on these are not analogues of spatiotemporal shapes, are not incorporated into a world-form peculiar to them. The limit-shapes of these qualities are not idealizable in an analogous sense; the measurement ("assessing") of them cannot be related to corresponding idealities in a constructible world already objectivized into idealities. Accordingly, the concept of "approximation" has no meaning here analogous to that within the mathematizable sphere of shapes—the meaning of an objectifying achievement.

Now with regard to the "indirect" mathematization of that aspect of the world which in itself has no mathematizable world-form: such mathematization is thinkable only in the sense that the specifically sensible qualities ("plena") that can be experienced in the intuited bodies are closely related in a quite peculiar and *regulated* way with the shapes that belong essentially to them. If we ask what is predetermined a priori by the universal world-form with its universal causality—i.e., if we consult the invariant, general style of being to which the intuited world, in its unending change, adheres: on the one hand the form of space-time is predetermined, and everything that belongs to it a priori (before idealization), as encompassing all bodies in respect to shape. It is further predetermined that, in each case of real bodies, factual shapes require factual plena and vice versa; that, accordingly, *this* sort of general causality obtains, binding together aspects of a *concretum* which are only abstractly, not really, separable. What is more, considering everything as a totality, there obtains a universal *concrete* causality. This causality contains the necessary anticipation that the intuitively given world can be intuited as a world only as an endlessly open horizon and hence that the infinite manifold of particular causalities can be anticipated only in the manner of a horizon and is not itself given. We are thus in any case, and a priori, certain, not only that the total shape-aspect of the world of bodies generally requires a plenum-aspect pervading all the shapes, but also that *every change,* whether it involves aspects of shape or of

plenum, occurs according to certain causalities, immediate or mediate, which make it necessary. This is the extent, as we said, of the undetermined general anticipation a priori.

This is not to say, however, that the total behavior of plenum-qualities, in respect to what changes and what does not change, follows causal rules in such a way that this whole abstract aspect of the world is dependent in a consistent way on what occurs causally in the shape-aspect of the world. In other words, we do not have an a priori insight that every change of the specific qualities of intuited bodies which is experienced or is conceivable in actual or possible experience refers causally to occurrences in the abstract shape-stratum of the world, i.e., that every such change has, so to speak, a counterpart in the realm of shapes in such a way that any total change in the whole plenum has its causal counterpart in the sphere of shapes.

Put in this way, this conception might appear almost fantastic. Still, let us take into account the long-familiar idealization of the form of space-time with all its shapes, carried out (in large areas, though by no means completely) for thousands of years, together with the changes and configurations of change relating to this form. The idealization of the art of measurement was, as we know, included in this, not merely as the art of measuring things but as the art of empirical causal constructions (in which deductive inferences helped, of course, as they do in every art). The theoretical attitude and the thematization of pure idealities and constructions led to pure geometry (under which we include here all pure mathematics of shapes); and later—in the reversal which has by now become understandable—applied geometry (as we remember) arose, as the practical art of measuring, guided by idealities and the constructions ideally carried out with them: i.e., an objectification of the concrete causal world of bodies within corresponding limited spheres. As soon as we bring all this to mind, the conception proposed above, which at first appeared almost eccentric, loses its strangeness for us and takes on —thanks to our earlier scientific schooling—the character of something taken for granted. What we experienced, in prescientific life, as colors, tones, warmth, and weight belonging to the things themselves and experienced causally as a body's radiation of warmth which makes adjacent bodies warm, and the like, indicates in terms of physics, of course, tone-vibrations, warmth-vibrations, i.e., pure events in the world of shapes. This universal indication is taken for granted today as unquestionable. But if we go back to Galileo, as the creator of the conception

which first made physics possible: what came to be taken for granted only through his deed could not be taken for granted by him. He took for granted only pure mathematics and the old familiar way of applying it.

If we adhere strictly to Galileo's motivation, considering the way in which it in fact laid the foundation for the new idea of physics, we must make clear to ourselves the *strangeness* of his basic conception in the situation of his time; and we must ask, accordingly, how he could hit upon this conception, namely, that everything which manifests itself as real through the specific sense-qualities must have its *mathematical index* in events belonging to the sphere of shapes—which is, of course, already thought of as idealized—and that there must arise from this the possibility of an *indirect* mathematization, in the fullest sense, i.e., it must be possible (though indirectly and through a particular inductive method) to construct *ex datis*, and thus to determine objectively, *all* events in the sphere of the plena. The whole of infinite nature, taken as a concrete universe of causality—for this was inherent in that strange conception—became [the object of] a *peculiarly applied mathematics*.

But first let us answer the question of what, in the pregiven world which was already mathematized in the old limited way, could have incited Galileo's basic conception.

d. The motivation of Galileo's conception of nature.

Now there were some occasions, rather scanty, to be sure, of manifold but disconnected experiences, within the totality of prescientific experience, which suggested something like the indirect quantifiability of certain sense-qualities and thus a certain possibility of characterizing them by means of magnitudes and units of measurement. Even the ancient Pythagoreans had been stimulated by observing the functional dependency of the pitch of a tone on the length of a string set vibrating. Many other causal relations of a similar sort were, of course, generally known. Basically, all concrete intuitively given events in the familiar surrounding world contain easily discernible dependencies of plenum-occurrences on those of the sphere of shapes. But there was generally no motive for taking an analytical attitude toward the nexus of causal dependencies. In their vague indeterminateness they could not incite interest. It was different in cases where they took on the character of a determinateness which made them susceptible to determining induction; and this

leads us back to the measurement of plena. Not everything which concomitantly and visibly changed on the side of shapes was measurable through the old, developed measuring methods. Also, it was a long way from such experiences to the universal idea and hypothesis that all specifically qualitative events function as indices for precisely corresponding constellations and occurrences of shape. But it was not so far for the men of the Renaissance, who were inclined to bold generalizations everywhere and in whom such exuberant hypotheses immediately found a receptive audience. Mathematics as a realm of genuine objective knowledge (and technology under its direction)—that was, for Galileo and even before him, the focal point of "modern" man's guiding interest in a philosophical knowledge of the world and a rational praxis. There must be measuring methods for everything encompassed by geometry, the mathematics of shapes with its a priori ideality. And the whole concrete world must turn out to be a mathematizable and objective world if we pursue those individual experiences and actually measure everything about them which, according to the presuppositions, comes under applied geometry—that is, if we work out the appropriate method of measuring. If we do that, the sphere of the specifically qualitative occurrences must *also* be mathematized *indirectly*.

In interpreting what was taken for granted by Galileo, i.e., the universal applicability of pure mathematics, the following must be noted: In every application to intuitively given nature, pure mathematics must give up its abstraction from the intuited plenum, whereas it leaves intact what is idealized in the shapes (spatial shapes, duration, motion, deformation). But in one respect this involves the performance of coidealization of the sensible plena belonging to the shapes. The extensive and intensive infinity which was substructed through the idealization of the sensible appearances, going beyond all possibilities of actual intuition—separability and divisibility *in infinitum,* and thus everything belonging to the mathematical continuum—implies a substruction of infinities for the *plenum*-qualities which themselves are *eo ipso* cosubstructed. The whole concrete world of bodies is thus charged with infinities not only of shape but also of plena. But it must also be noted once again that the "indirect mathematizability" which is essential for the genuine Galilean conception of physics is not yet given thereby.

As far as we have come, only a general idea has been attained or, more precisely, a general hypothesis: that a universal

inductivity [9] obtains in the intuitively given world, one which announces itself in everyday experiences but whose infinity is hidden.

To be sure, this inductivity was not understood by Galileo as a hypothesis. For him a physics was immediately almost as certain as the previous pure and applied mathematics. The hypothesis also immediately traced out for him [its own] path of realization (a realization whose success necessarily has the sense, in our eyes, of a *verification of the hypothesis*—this by no means obvious hypothesis related to the [previously] inaccessible factual structure of the concrete world).[10] What mattered for him first, then, was the attainment of farther reaching and ever more perfectible *methods* in order actually to develop, beyond those which had thus far in fact been developed, all the methods of measuring that were prefigured as ideal possibilities in the ideality of pure mathematics—to measure, for example, speeds and accelerations. But the pure mathematics of shapes itself required a richer development as constructive quantification—which later on led to analytic geometry. The task now was to grasp systematically, by means of these aids, the universal causality—or, as we may say, the peculiar universal inductivity—of the world of experience which was presupposed in the hypothesis. It is to be noted, [then,] that along with the new, concrete, and thus two-sided idealization of the world, which was involved in Galileo's hypothesis, the obviousness of a universal, exact causality was also given—a universal causality which is not, of course, first arrived at by induction through the demonstration of individual causalities but which precedes and guides all induction of particular causalities—this being true even of the concretely general, intuitable causality which makes up the concretely intuitable form of the world as opposed to particular, individual causalities experienceable in the surrounding world of life [*Lebensumwelt*].

This universal idealized causality encompasses all factual shapes and plena in their idealized infinity. Obviously, if the measurements made in the sphere of shapes are to bring about truly objective determinations, occurrences on the side of the plena must also be dealt with methodically. All the fully concrete

9. *eine universale Induktivität,* i.e., that all types of occurrence in the world are such as to be susceptible to induction.

10. "Our eyes," referring to us who are engaged in this historical reflection. Once we have removed our own prejudices, we see this as a strange hypothesis rather than simply taking it for granted.

things and occurrences—or rather the ways in which factual plena and shapes stand in causal relation—must be included in the method. The application of mathematics to plena of shape given in reality makes, because of the concreteness involved, causal presuppositions which must be brought to determinateness. How one should actually proceed here, how one should regulate methodically the work to be accomplished completely within the intuitively given world; how the factually accessible bodily data, in a world charged through hypothetical idealization with as yet unknown infinities, are to be brought to causal determination in *both* aspects;[11] how the hidden infinities in these data are to be progressively disclosed according to methods of measuring; how, through growing approximations in the sphere of shapes, more and more perfect indices of the qualitative plena of the idealized bodies become apparent; how the bodies themselves, as concrete, become determinable through approximations in respect to all their ideally possible occurrences: all this was a matter of *discovery* in physics. In other words, it was a matter for the passionate *praxis of inquiry* and not a matter for prior systematic reflection upon what is possible in principle, upon the essential presuppositions of a mathematical objectification which is supposed to be able to determine the concretely real within the network of universal concrete causality.

Discovery is really a mixture of instinct and method. One must, of course, ask whether such a mixture is in the strict sense philosophy or science—whether it can be knowledge of the world in the ultimate sense, the only sense that could serve us as a [genuine] understanding of the world and ourselves. As a discoverer, Galileo went directly to the task of realizing his idea, of developing methods for measuring the nearest data of common experience; and actual experience demonstrated (through a method which was of course not radically clarified) what his hypothetical anticipation in each case demanded; he actually found causal interrelations which could be mathematically expressed in "formulae."

The actual process of measuring, applied to the intuited data of experience, results, to be sure, only in empirical, inexact magnitudes and their quantities. But the art of measuring is, in itself, at the same time the art of pushing the exactness of measuring further and further in the direction of growing

11. I.e., the aspect of shape and the aspect of plenum.

perfection. It is an art not [only] in the sense of a finished method for completing something; it is at the same time a method for improving [this very] method, again and again, through the invention of ever newer technical means, e.g., instruments. Through the relatedness of the world, as field of application, to pure mathematics, this "again and again" acquires the mathematical sense of the *in infinitum*, and thus every measurement acquires the sense of an approximation to an unattainable but ideally identical pole, namely, one of the definite mathematical idealities or, rather, one of the numerical constructions belonging to them.

From the beginning, the whole method has a *general* sense, even though one always has to do with what is individual and factual. From the very beginning, for example, one is not concerned with the free fall of *this* body; the individual fact is rather an *example*, embedded from the start in the concrete totality of types belonging to intuitively given nature, in its empirically familiar invariance; and this is naturally carried over into the Galilean attitude of idealizing and mathematizing. The indirect mathematization of the world, which proceeds as a methodical objectification of the intuitively given world, gives rise to general numerical formulae which, once they are formed, can serve by way of application to accomplish the factual objectification of the particular cases to be subsumed under them. The formulae obviously express general causal interrelations, "laws of nature," laws of real dependencies in the form of the "functional" dependencies of numbers. Thus their true meaning does not lie in the pure interrelations between numbers (as if they were formulae in the purely arithmetical sense); it lies in what the Galilean idea of a universal physics, with its (as we have seen) highly complicated meaning-content, gave as a task to scientific humanity and in what the process of its fulfillment through successful physics results in—a process of developing particular methods, and mathematical formulae and "theories" shaped by them.

e. The verificational character of natural science's fundamental hypothesis.

According to our remark [above, pp. 38–39]—which of course goes beyond the problem of merely clarifying Galileo's motivation and the resulting idea and task of physics—the Galilean idea is a *hypothesis*, and a very remarkable one at that; and

the actual natural science throughout the centuries of its verification is a correspondingly remarkable sort of verification. It is remarkable because the hypothesis, in spite of the verification, continues to be and is always a hypothesis; its verification (the only kind conceivable for it) is an endless course of verifications. It is the peculiar essence of natural science, it is a priori its way of being, to be unendingly hypothetical and unendingly verified. Here verification is not, as it is in all practical life, merely susceptible to possible error, occasionally requiring corrections. There is in every phase of the development of natural science a perfectly correct method and theory from which "error" is thought to be eliminated. Newton, the ideal of exact natural scientists, says *"hypotheses non fingo,"* and implied in this is the idea that he does not miscalculate and make errors of method. In the total idea of an exact science, just as in all the individual concepts, propositions, and methods which express an "exactness" (i.e., an ideality)—and in the total idea of physics as well as the idea of pure mathematics—is embedded the *in infinitum,* the permanent form of that peculiar inductivity which first brought geometry into the historical world. In the unending progression of correct theories, individual theories characterized as "the natural science of a particular time," we have a progression of hypotheses which are in every respect hypotheses *and* verifications. In the progression there is growing perfection, and for all of natural science taken as a totality this means that it comes more and more to itself, to its "ultimate" true being, that it gives us a better and better "representation" [*"Vorstellung"*] of what "true nature" is. But true nature does not lie in the infinite in the same way that a pure straight line does; even as an infinitely distant "pole" it is an infinity of theories and is thinkable only as verification; thus it is related to an infinite historical process of approximation. This may well be a topic for philosophical thinking, but it points to questions which cannot yet be grasped here and do not belong to the sphere of questions we must now deal with. For our concern is to achieve complete clarity on the idea and task of a physics which in its Galilean form originally determined modern philosophy, [to understand it] as it appeared in Galileo's own motivation, and to understand what flowed into this motivation from what was traditionally taken for granted and thus remained an unclarified presupposition of meaning, as well as what was later added as seemingly obvious, but which changed its actual meaning.

In this connection it is not necessary to go more concretely into the first beginnings of the enactment of Galileo's physics and of the development of its method.

f. The problem of the sense of natural-scientific "formulae."

But one thing more is important for our clarification. The *decisive accomplishment* which, in accord with the total sense of natural-scientific method, makes determined, systematically ordered predictions immediately possible, going beyond the sphere of immediately experiencing intuitions and the possible experiential knowledge of the prescientific life-world, is the establishment of the actual correlation among the mathematical idealities which are hypothetically substructed in advance in undetermined generality but still have to be demonstrated in their determined form. If one still has a vivid awareness of this correlation in its original meaning, then a mere thematic focus of attention on this meaning is sufficient in order to grasp the ascending orders of *intuitions* (now conceived as approximations) indicated by the functionally coordinated quantities (or, more briefly, by the formulae); or rather one can, following these indications, bring the ascending orders of intuitions vividly to mind. The same is true of the coordination itself, which is expressed in functional forms; and thus one can outline the empirical regularities of the practical life-world which are to be expected. In other words, if one has the formulae, one already possesses, in advance, the practically desired prediction of what is to be expected with empirical certainty in the intuitively given world of concretely actual life, in which mathematics is merely a special [form of] praxis. Mathematization, then, with its realized formulae, is the achievement which is decisive for life.

Through these considerations we see that, from the very first conceiving and carrying-out of the method, the passionate interest of the natural scientist was concentrated on this decisive, fundamental aspect of the above-mentioned total accomplishment, i.e., on the *formulae,* and on the technical [12] method ("natural-scientific method," "method of the true knowledge of nature") of acquiring them and grounding them logically and compellingly for all. And it is also understandable that some

12. *kunstmässig,* i.e., having the character of a technique.

were misled into taking these formulae and their formula-meaning for the true being of nature itself.

This "formula-meaning" requires a more detailed clarification, now, in respect to the superficialization of meaning [13] which unavoidably accompanies the technical development and practice of method. Measurements give rise to numbers on a scale, and, in general propositions about functional dependencies of measured quantities, they result not in determined numbers but in numbers in general, stated in general propositions which express laws of functional dependencies. Here we must take into account the enormous effect—in some respects a blessing, in others portentous—of the algebraic terms and ways of thinking that have been widespread in the modern period since Vieta (thus since even before Galileo's time). Initially this means an immense extension of the possibilities of the arithmetic thinking that was handed down in old, primitive forms. It becomes free, systematic, a priori thinking, completely liberated from all intuited actuality, about numbers, numerical relations, numerical laws. This thinking is soon applied in all its extensions—in geometry, in the whole pure mathematics of spatiotemporal shapes—and the latter are thoroughly formalized algebraically for methodical purposes. Thus an "arithmetization of geometry" develops, an arithmetization of the whole realm of pure shapes (ideal straight lines, circles, triangles, motions, relations of position, etc.). They are conceived in their ideal exactness as measurable; the units of measurement, themselves ideal, simply have the meaning of spatiotemporal magnitudes.

This arithmetization of geometry leads almost automatically, in a certain way, to the emptying of its meaning. The actually spatiotemporal idealities, as they are presented firsthand [*originär*] in geometrical thinking under the common rubric of "pure intuitions," are transformed, so to speak, into pure numerical configurations, into algebraic structures. In algebraic calculation, one lets the geometric signification recede into the background as a matter of course, indeed drops it altogether; one calculates, remembering only at the end that the numbers signify magnitudes. Of course one does not calculate "mechanically," as in ordinary numerical calculation; one thinks, one

13. *Sinnesveräusserlichung,* literally, "externalization of meaning," but with the sense of rendering it superficial, separating it from its origin.

invents, one may make great discoveries—but they have acquired, unnoticed, a displaced, "symbolic" meaning. Later this becomes a fully conscious methodical displacement, a methodical transition from geometry, for example, to pure *analysis,* treated as a science in its own right; and the results achieved in this science can be applied to geometry. We must go into this briefly in more detail.

This process of method-transformation, carried out instinctively, unreflectively in the praxis of theorizing, begins in the Galilean age and leads, in an incessant forward movement, to the highest stage of, and at the same time a surmounting of, "arithmetization"; it leads to a completely universal "formalization." This happens precisely through an improvement and a broadening of the algebraic theory of numbers and magnitudes into a universal and thus purely formal "analysis," "theory of manifolds," "logistic"—words to be understood sometimes in a narrower, sometimes a broader, sense, since until now, unfortunately, there has been no unambiguous characterization of what in fact, and in a way practically understandable in mathematical work, a coherent mathematical field is. Leibniz, though far ahead of his time, first caught sight of the universal, self-enclosed idea of a highest form of algebraic thinking, a *mathesis universalis,* as he called it, and recognized it as a task for the future. Only in our time has it even come close to a systematic development. In its full and complete sense it is nothing other than a formal logic carried out universally (or rather to be carried out *in infinitum* in its own essential totality), a science of the forms of meaning of the "something-in-general" which can be constructed in pure thought and in empty, formal generality. On this basis it is a science of the "manifolds" which, according to formal elementary laws of the noncontradiction of these constructions, can be built up systematically as in themselves free of contradiction. At the highest level it is a science of the universe of the "manifolds" as such which can be conceived in this way. "Manifolds" are thus in themselves compossible totalities of objects in general, which are thought of as distinct only in empty, formal generality and are conceived of as defined by determinate modalities of the something-in-general. Among these totalities the so-called "definite" manifolds are distinctive. Their definition through a "complete axiomatic system" gives a special sort of totality in all deductive determinations to the formal substrate-objects contained in them. With this sort of

totality, one can say, the formal-logical idea of a "world-in-general" is constructed. The "theory of manifolds" in the special sense is the universal science of the *definite* manifolds.*

g. The emptying of the meaning of mathematical natural science through "technization." [14]

This most extreme extension of the already formal but limited algebraic arithmetic has immediate applications, in its a priori fashion, within all "concretely material" [*konkret sachhaltige*] pure mathematics, the mathematics of "pure intuitions," and can thus be applied to mathematized nature; but it also has applications to itself, to previous algebraic arithmetic, and, again by extension, to all its own formal manifolds; in this way it is related back to itself. Like arithmetic itself, in technically developing its methodology it is drawn into a process of transformation, through which it becomes a sort of *technique;* that is, it becomes a mere art of achieving, through a calculating technique according to technical rules, results the genuine sense of whose truth can be attained only by concretely intuitive thinking actually directed at the subject matter itself. But now [only] those modes of thought, those types of clarity which are indispensable for a technique as such, are in action. One operates with letters and with signs for connections and relations (+, ×, =, etc.), according to *rules of the game* for arranging them together in a way essentially not different, in fact, from a game of cards or chess. Here the *original* thinking that genuinely gives meaning to this technical process and truth to the correct results (even the "formal truth" peculiar to the formal *mathesis universalis*) is excluded; in this manner it is also excluded in the formal theory of manifolds itself, as in the previous algebraic theory of number and magnitude and in all the other applications of what has been obtained by a technique, without recourse to the genuine scientific meaning; this includes also the application to geometry, the pure mathematics of spatiotemporal shapes.

* For a more exact exposition of the concept of the definite manifold see *Ideen zu einer reinen Phänomenologie und phänomenologischen Philosophie* (1913), pp. 135 ff. [i.e., § 72]. On the idea of the *mathesis universalis* see *Logische Untersuchungen,* Vol. I (1900; rev. ed., 1913) [§§ 60, 69, 70], and, above all, *Formale und transzendentale Logik* (Halle: Niemeyer, 1930) [§ 23].

14. *Technisierung,* i.e., the process of becoming a technique.

Actually the process whereby material mathematics is put into formal-logical form, where expanded formal logic is made self-sufficient as pure analysis or theory of manifolds, is perfectly *legitimate,* indeed necessary; the same is true of the technization which from time to time completely loses itself in merely technical thinking. But all this can and must be a method which is understood and practiced in a fully conscious way. It can be this, however, only if care is taken to avoid dangerous shifts of meaning by keeping always immediately in mind the original bestowal of meaning [*Sinngebung*] upon the method, through which it has the sense of achieving knowledge about the *world.* Even more, it must be freed of the character of an *unquestioned tradition* which, from the first invention of the new idea and method, allowed elements of obscurity to flow into its meaning.

Naturally, as we have shown, the *formulae*—those obtained and those to be obtained—count most for the predominant interest of the discovering scientist of nature. The further physics has gone in the actual mathematization of the intuited, pregiven nature of our surrounding world, the more mathematical-scientific propositions it has at its disposal, the further the instrument destined for it, the *mathesis universalis,* has been developed: the greater is the range of its possible deductive conclusions concerning new facts of quantified nature and thus the range of indicated corresponding verifications to be made. The latter devolve upon the experimental physicist, as does the whole work of ascending from the intuitively given surrounding world, and the experiments and measurements performed in it, to the ideal poles. Mathematical physicists, on the other hand, settled in the arithmetized sphere of space-time, or at the same time in the formalized *mathesis universalis,* treat the mathematical-physical formulae brought to them as special pure structures of the formal *mathesis,* naturally keeping invariant the constants which appear in them as elements of functional laws of factual nature. Taking into account all the "natural laws already proved or in operation as working hypotheses," and on the basis of the whole available formal system of laws belonging to this *mathesis,* they draw the logical consequences whose results are to be taken over by the experimenters. But they also accomplish the formation of the available logical possibilities for new hypotheses, which of course must be compatible with the totality of those accepted as valid at the time. In this way, they see to the preparation of those forms of hypotheses which now are the only ones admissible, as hypothetical possibilities for the interpretation of causal regular-

ities to be empirically discovered through observation and experiment in terms of the ideal poles pertaining to them, i.e., in terms of exact laws. But experimental physicists, too, are constantly oriented in their work toward ideal poles, toward numerical magnitudes and general formulae. Thus in *all* natural-scientific inquiry these are at the center of interest. All the discoveries of the old as well as the new physics are discoveries in the formula-world which is coordinated, so to speak, with nature.

The formula-meaning of this world lies in idealities, while the whole toilsome work of achieving them takes on the character of a mere pathway to the goal. And here one must take into consideration the influence of the above-characterized technization of formal-mathematical thinking: the transformation of its experiencing, discovering way of thinking, which forms, perhaps with great genius, constructive theories, into a way of thinking with transformed concepts, "symbolic" concepts. In this process purely geometrical thinking is also depleted, as is its application to factual nature in natural-scientific thinking. In addition, a technization takes over all other methods belonging to natural science. It is not only that these methods are later "mechanized." To the essence of all method belongs the tendency to superficialize itself in accord with technization. Thus natural science undergoes a many-sided transformation and covering-over of its meaning. The whole cooperative interplay between experimental and mathematical physics, the enormous intellectual work constantly accomplished here, takes place within a transformed horizon of meaning. One is, of course, to some degree conscious of the difference between τέχνη and science. But the reflection back upon the actual meaning which was to be obtained for nature through the technical method stops too soon. It no longer reaches far enough even to lead back to the position of the idea of mathematizing nature sketched out in Galileo's creative meditation, to what was wanted from this mathematization by Galileo and his successors and what gave meaning to their endeavors to carry it out.

h. The life-world as the forgotten meaning-fundament of natural science.

But now we must note something of the highest importance that occurred even as early as Galileo: the surreptitious substitution of the mathematically substructed world of idealities for the

only real world, the one that is actually given through perception, that is ever experienced and experienceable—our everyday life-world. This substitution was promptly passed on to his successors, the physicists of all the succeeding centuries.

Galileo was himself an heir in respect to pure geometry. The inherited geometry, the inherited manner of "intuitive" conceptualizing, proving, constructing, was no longer original geometry: in this sort of "intuitiveness" it was already empty of meaning. Even ancient geometry was, in its way, τέχνη, removed from the sources of truly immediate intuition and originally intuitive thinking, sources from which the so-called geometrical intuition, i.e., that which operates with idealities, has at first derived its meaning. The geometry of idealities was preceded by the practical art of surveying, which knew nothing of idealities. Yet such a pregeometrical achievement was a meaning-fundament for geometry, a fundament for the great invention of idealization; the latter encompassed the invention of the ideal world of geometry, or rather the methodology of the objectifying determination of idealities through the constructions which create "mathematical existence." It was a fateful omission that Galileo did not inquire back into the original meaning-giving achievement which, as idealization practiced on the original ground of all theoretical and practical life—the immediately intuited world (and here especially the empirically intuited world of bodies)—resulted in the geometrical ideal constructions. He did not reflect closely on all this: on how the free, imaginative variation of this world and its shapes results only in possible empirically intuitable shapes and not in exact shapes; on what sort of motivation and what new achievement was required for genuinely geometric idealization. For in the case of inherited geometrical method, these functions were no longer being *vitally* practiced; much less were they reflectively brought to theoretical consciousness as methods which realize the meaning of exactness from the inside. Thus it could appear that geometry, with its own immediately evident a priori "intuition" and the thinking which operates with it, produces a self-sufficient, absolute truth which, as such—"obviously"—could be applied without further ado. That this obviousness was an illusion —as we have pointed out above in general terms, thinking for ourselves in the course of our exposition of Galileo's thoughts—that even the meaning of the application of geometry has complicated sources: this remained hidden for Galileo and the ensuing period. Immediately with Galileo, then, begins the sur-

reptitious substitution of idealized nature for prescientifically intuited nature.

Thus all the occasional (even "philosophical") reflections which go from technical [scientific] work back to its true meaning always stop at idealized nature; they do not carry out the reflection radically, going back to the ultimate purpose which the new science, together with the geometry which is inseparable from it, growing out of prescientific life and its surrounding world, was from the beginning supposed to serve: a purpose which necessarily lay *in* this prescientific life and was related to its life-world. Man (including the natural scientist), living in this world, could put all his practical and theoretical questions only to *it*—could refer in his theories only to it, in its open, endless horizons of things unknown. All knowledge of laws could be knowledge only of predictions, grasped as lawful, about occurrences of actual or possible experiential phenomena, predictions which are indicated when experience is broadened through observations and experiments penetrating systematically into unknown horizons, and which are verified in the manner of inductions. To be sure, everyday induction grew into induction according to scientific method, but that changes nothing of the essential meaning of the pregiven world as the horizon of all meaningful induction. It is this world that we find to be the world of all known and unknown realities. To it, the world of actually experiencing intuition, belongs the form of space-time together with all the bodily [*körperlich*] shapes incorporated in it; it is in this world that we ourselves live, in accord with our bodily [*leiblich*],[15] personal way of being. But here we find nothing of geometrical idealities, no geometrical space or mathematical time with all their shapes.

This is an important remark, even though it is so trivial. Yet this triviality has been buried precisely by exact science, indeed since the days of ancient geometry, through that substitution of a methodically idealized achievement for what is given immediately as actuality presupposed in all idealization, given by a [type of] verification which is, in its own way, unsurpassable. This actually intuited, actually experienced and experienceable world,

15. *Körper* means a body in the geometric or physical sense; *Leib* refers to the body of a person or animal. Where possible, I have translated *Leib* as "living body" (*Leib* is related to *Leben*); *Körper* is translated as "body" or sometimes "physical body." In cases where adjectival or adverbial forms are used, as here, it is sometimes necessary to insert the German words or refer to them in a footnote.

in which practically our whole life takes place, remains unchanged as what it is, in its own essential structure and its own concrete causal style, whatever we may do with or without techniques. Thus it is also not changed by the fact that we invent a particular technique, the geometrical and Galilean technique which is called physics. What do we actually accomplish through this technique? Nothing but *prediction* extended to infinity. All life rests upon prediction or, as we can say, upon induction. In the most primitive way, even the ontic certainty[16] of any straightforward experience is inductive. Things "seen" are always more than what we "really and actually" see of them. Seeing, perceiving, is essentially having-something-itself [*Selbsthaben*] and at the same time having-something-in-advance [*Vor-haben*], meaning-something-in-advance [*Vor-meinen*]. All praxis, with its projects [*Vorhaben*], involves inductions; it is just that ordinary inductive knowledge (predictions), even if expressly formulated and "verified," is "artless" compared to the artful "methodical" inductions which can be carried to infinity through the method of Galilean physics with its great productivity.

In geometrical and natural-scientific mathematization, in the open infinity of possible experiences, we measure the life-world —the world constantly given to us as actual in our concrete world-life—for a well-fitting *garb of ideas*, that of the so-called objectively scientific truths. That is, through a method which (as we hope) can be really carried out in every particular and constantly verified, we first construct numerical indices for the actual and possible sensible plena of the concretely intuited shapes of the life-world, and in this way we obtain possibilities of predicting concrete occurrences in the intuitively given life-world, occurrences which are not yet or no longer actually given. And this kind of prediction infinitely surpasses the accomplishment of everyday prediction.

Mathematics and mathematical science, as a garb of ideas, or the garb of symbols of the symbolic mathematical theories, encompasses everything which, for scientists and the educated generally, *represents* the life-world, *dresses it up* as "objectively actual and true" nature. It is through the garb of ideas that we take for *true being* what is actually a *method*—a method which is designed for the purpose of progressively improving, *in infinitum*, through "scientific" predictions, those rough predictions

16. *Seinsgewissheit*, i.e., certainty of being.

which are the only ones originally possible within the sphere of what is actually experienced and experienceable in the life-world. It is because of the disguise of ideas that the true meaning of the method, the formulae, the "theories," remained unintelligible and, in the naïve formation of the method, was *never* understood.

Thus no one was ever made conscious of the radical problem of *how* this sort of naïveté actually became possible and is still possible as a living historical fact; how a method which is actually directed toward a goal, the systematic solution of an endless scientific task, and which continually achieves undoubted results, could ever grow up and be able to function usefully through the centuries when no one possessed a real understanding of the actual meaning and the internal necessity of such accomplishments. What was lacking, and what is still lacking, is the actual self-evidence through which he who knows and accomplishes can give himself an account, not only of what he does that is new and what he works with, but also of the implications of meaning which are closed off through sedimentation or traditionalization, i.e., of the constant presuppositions of his [own] constructions, concepts, propositions, theories. Are science and its method not like a machine, reliable in accomplishing obviously very useful things, a machine everyone can learn to operate correctly without in the least understanding the inner possibility and necessity of this sort of accomplishment? But was geometry, was science, capable of being designed in advance, like a machine, without [17] an understanding which was, in a similar sense, complete—scientific? Does [18] this not lead to a *regressus in infinitum*?

Finally, does this problem not link up with the problem of the instincts in the usual sense? Is it not the problem of *hidden reason*, which knows itself as reason only when it has become manifest?

Galileo, the discoverer—or, in order to do justice to his precursors, the consummating discoverer—of physics, or physical nature, is at once a discovering and a concealing genius [*entdeckender und verdeckender Genius*]. He discovers mathematical nature, the methodical idea, he blazes the trail for the infinite number of physical discoveries and discoverers. By contrast to the universal causality of the intuitively given world (as

17. Reading *ohne ein* for *aus einem*.
18. Reading *führt* for *führte*.

its invariant form), he discovers what has since been called simply the law of causality, the "a priori form" of the "true" (idealized and mathematized) world, the "law of exact lawfulness" according to which every occurrence in "nature"—idealized nature—must come under exact laws. All this is discovery-concealment, and to the present day we accept it as straightforward truth. In principle nothing is changed by the supposedly philosophically revolutionary critique of the "classical law of causality" made by recent atomic physics. For in spite of all that is new, what is essential in principle, it seems to me, remains: namely, nature, which is in itself mathematical; it is given in formulae, and it can be interpreted only in terms of the formulae.

I am of course quite serious in placing and continuing to place Galileo at the top of the list of the greatest discoverers of modern times. Naturally I also admire quite seriously the great discoverers of classical and postclassical physics and their intellectual accomplishment, which, far from being merely mechanical, was in fact astounding in the highest sense. This accomplishment is not at all disparaged by the above elucidation of it as τέχνη or by the critique in terms of principle, which shows that the true meaning of these theories—the meaning which is genuine in terms of their origins—remained and had to remain hidden from the physicists, including the great and the greatest. It is not a question of a meaning which has been slipped in through metaphysical mystification or speculation; it is, rather, with the most compelling self-evidence, the true, the only real meaning of these theories, as opposed to the meaning of being a *method*, which has its own comprehensibility in operating with the formulae and their practical application, technique.

How what we have said up to now is still one-sided, and what horizons of problems, leading into new dimensions, have not been dealt with adequately—horizons which can be opened up only through a reflection on this life-world and man as its subject—can be shown only when we are much further advanced in the elucidation of the historical development according to its innermost moving forces.

i. Portentous misunderstandings resulting from lack of clarity about the meaning of mathematization.

With Galileo's mathematizing reinterpretation of nature, false consequences established themselves even beyond the

realm of nature which were so intimately connected with this reinterpretation that they could dominate all further developments of views about the world up to the present day. I mean Galileo's famous doctrine of the merely subjective character of the specific sense-qualities,[19] which soon afterward was consistently formulated by Hobbes as the doctrine of the subjectivity of all concrete phenomena of sensibly intuitive nature and world in general. The phenomena are only in the subjects; they are there only as causal results of events taking place in true nature, which events exist only with mathematical properties. If the intuited world of our life is merely subjective, then all the truths of pre- and extrascientific life which have to do with its factual being are deprived of value. They have meaning only insofar as they, while themselves false, vaguely indicate an in-itself which lies behind this world of possible experience and is transcendent in respect to it.

In connection with this we arrive at a further consequence of the new formation of meaning, a self-interpretation of the physicists which grows out of this new formation of meaning as "obvious" and which was dominant until recently:

Nature is, in its "true being-in-itself," mathematical. The *pure* mathematics of space-time procures knowledge, with apodictic self-evidence, of a set of laws of this "in-itself" which are unconditionally, universally valid. This knowledge is immediate in the case of the axiomatic elementary laws of the a priori constructions and comes to be through infinite mediations in the case of the other laws. In respect to the space-time form of nature we possess the "innate" faculty (as it is later called) of knowing with definiteness true being-in-itself as mathematically ideal being (before all actual experience). Thus implicitly the space-time form is itself innate in us.

It is otherwise with the more concrete universal lawfulness of nature, although it, too, is mathematical through and through. It is inductively accessible a posteriori through factual experiential data. In a supposedly fully intelligible way, the a priori mathematics of spatiotemporal shapes is sharply distinguished from natural science which, though it applies pure mathematics, is inductive. Or, one can also say: the purely

19. This doctrine is perhaps best expressed in Galileo's *Il Saggiatore* (*The Assayer*). See *Discoveries and Opinions of Galileo*, trans. Stillman Drake (Garden City: Doubleday Anchor Original, 1957), pp. 274 ff.

mathematic relationship of ground and consequent is sharply distinguished from that of real ground and real consequent, i.e., that of natural causality.

And yet an uneasy feeling of obscurity gradually asserts itself concerning the relation between the mathematics of nature and the mathematics of spatiotemporal form, which, after all, belongs to the former, between the latter "innate" and the former "non-innate" mathematics. Compared to the absolute knowledge we ascribe to God the creator, one says to oneself, our knowledge in pure mathematics has only one lack, i.e., that, while it is always absolutely self-evident, it requires a systematic process in order to bring to realization as knowing, i.e., as explicit mathematics, all the shapes that "exist" in the spatiotemporal form. In respect to what exists concretely in nature, by contrast, we have no a priori self-evidence at all. The whole mathematics of nature, beyond the spatiotemporal form, we must arrive at inductively through facts of experience. But is nature in itself not thoroughly mathematical? Must it not also be thought of as a coherent mathematical system? Must it not be capable of being represented in a coherent mathematics of nature, precisely the one that natural science is always merely seeking, as encompassed by a system of laws which is "axiomatic" in respect of form, the axioms of which are always only hypotheses and thus never really attainable? Why is it, actually, that they are not? Why is it that we have no prospect of discovering nature's own axiomatic system as one whose axioms are apodictically self-evident? Is it because the appropriate innate faculty is lacking in us in a factual sense?

In the superficialized, more or less already technized meaning-pattern of physics and its methods, the difference in question was "completely clear": it is the difference between "pure" (a priori) and "applied" mathematics, between "mathematical existence" (in the sense of pure mathematics) and the existence of the mathematically formed real (i.e., that of which mathematical shape is a component in the sense of a real property). And yet even such an outstanding genius as Leibniz struggled for a long time with the problem of grasping the correct meaning of the two kinds of existence—i.e., universally the existence of the spatiotemporal form as purely geometrical and the existence of universal mathematical nature with its factual, real form—and of understanding the correct relation of each to the other.

The significance of these obscurities for the Kantian problem of synthetic judgments a priori and for his division between the

synthetic judgments of pure mathematics and those of natural science will concern us in detail later [see below, § 25].

The obscurity was strengthened and transformed still later with the development and constant methodical application of pure formal mathematics. "Space" and the purely *formally* defined "Euclidean manifold" were confused; the *true axiom* (i.e., in the old, customary sense of the term), as an ideal norm with unconditional validity, grasped with self-evidence in pure geometric thought or in arithmetical, purely logical thought, was confused with the *inauthentic* [*uneigentliches*] "axiom"—a word which in the theory of manifolds signifies not judgments ("propositions") but forms of propositions as components of the definition of a "manifold" to be constructed formally without internal contradiction.

k. Fundamental significance of the problem of the origin of mathematical natural science.[20]

Like all the obscurities exhibited earlier, [the preceding] follow from the transformation of a formation of meaning which was originally vital, or rather of the originally vital consciousness of the task which gives rise to the methods, each with its special sense. The developed method, the progressive fulfillment of the task, is, as method, an art (τέχνη) which is handed down; but its true meaning is not necessarily handed down with it. And it is precisely for this reason that a theoretical task and achievement like that of a natural science (or any science of the world)—which can master the infinity of its subject matter only through infinities of method[21] and can master the latter infinities only by means of a technical thought and activity which are empty of meaning—can only be and remain meaningful in a true and original sense *if* the scientist has developed in himself the ability to *inquire back* into the *original meaning* of all his meaning-structures and methods, i.e., into the *historical meaning of their primal establishment,* and especially into the meaning of all the *inherited meanings* taken over unnoticed in this primal establishment, as well as those taken over later on.

But the mathematician, the natural scientist, at best a highly brilliant technician of the method—to which he owes the discoveries which are his only aim—is normally not at all able to carry out such reflections. In his actual sphere of inquiry and discovery he does not know at all that everything these reflections must clarify is even in *need* of clarification, and this for the sake of that interest which is decisive for a philosophy or a science, i.e., the interest in true knowledge of the *world itself, nature itself.* And this is precisely what has been lost through a science which is given as a tradition and which has become a τέχνη, insofar as this interest played a determining role at all in its primal establishment. Every attempt to lead the scientist to such reflections, if it comes from a nonmathematical, nonscientific circle of scholars, is rejected as "metaphysical." The professional who has dedicated his life to these sciences must, after all—it seems so obvious to him—know best what he is attempting and accomplishing in his work. The philosophical needs ("philosophicomathematical," "philosophicoscientific" needs), aroused even in these scholars by historical motives to be elucidated later, are satisfied by themselves in a way that is sufficient for them—but of course in such a way that the whole dimension which must be inquired into is not seen at all and thus not at all dealt with.

20. There is no section "j." In German one does not distinguish between "i" and "j" in an enumeration of this sort.

21. I.e., the infinite pursuit of its method.

l. Characterization of the method of our exposition.

In conclusion let us say a word about the *method* we have followed in the very intricate considerations of this section, in the service of our over-all aim. The historical reflections we embarked upon, in order to arrive at the self-understanding which is so necessary in our philosophical situation, demanded clarity concerning the *origin of the modern spirit* and, together with that—because of the significance, which cannot be overestimated, of mathematics and mathematical natural science—clarity concerning the origin of these sciences. That is to say: clarity concerning the original motivation and movement of thought which led to the conceiving of their idea of nature, and from there to the movement of its realization in the actual development of natural science itself. With Galileo the idea in question appears for the first time, so to speak, as full-blown; thus I have linked all our considerations to his name, in a certain sense simplifying and idealizing the matter; a more exact historical analysis would have to take account of how much of his thought he owed to his "predecessors." (I shall continue, incidentally, and for good reasons, in a similar fashion.) In respect to the situation as he found it and to the way in which it had to

motivate him and did motivate him according to his known pronouncements, much can be established immediately, so that we understand the beginning of the whole bestowal of meaning [*Sinngebung*] upon natural science. But in this very process we come upon the shifts and concealments of meaning of later and most recent times. For we ourselves, who are carrying out these reflections (and, as I may assume, my readers), stand under the *spell* of these times. Being caught up in them, we at first have no inkling of these shifts of meaning—we who all think we know so well what mathematics and natural science "are" and do. For who today has not learned this in school? But the first elucidation of the original meaning of the new natural science and of its novel methodical style makes felt something of the later shifts in meaning. And clearly they influence, or at least make more difficult, the analysis of the motivation [of science].

Thus we find ourselves in a sort of circle. The understanding of the beginnings is to be gained fully only by starting with science as given in its present-day form, looking back at its development. But in the absence of an understanding of the *beginnings* the development is mute as a *development of meaning.* Thus we have no other choice than to proceed forward and backward in a zigzag pattern; the one must help the other in an interplay. Relative clarification on one side brings some elucidation on the other, which in turn casts light back on the former. In this sort of historical consideration and historical critique, then, which begins with Galileo (and immediately afterward with Descartes) and must follow the temporal order, we nevertheless have constantly to make *historical leaps* which are thus not digressions but necessities. They are necessities if we take upon ourselves, as we have said, the task of self-reflection which grows out of the "breakdown" situation of our time, with its "breakdown of science" itself. Of first importance for this task, however, is the reflection on the original meaning of the new sciences, above all that of the exact science of nature; for the latter was and still is, through all its shifts of meaning and misplaced self-interpretations, of decisive significance (in a manner to be pursued further) for the becoming and being of the modern positive sciences, of modern philosophy, and indeed of the spirit of modern European humanity in general.

The following also belongs to the method: readers, especially those in the natural sciences, may have become irritated by the fact—it may appear to them almost as dilettantism—that no use has been made of the natural-scientific way of speaking. It has been consciously avoided. In the kind of thinking which everywhere tries to bring "original intuition" to the fore—that is, the pre- and extrascientific life-world, which contains within itself all actual life, including the scientific life of thought, and nourishes it as the source of all technical constructions of meaning—in this kind of thinking one of the greatest difficulties is that one must choose the naïve way of speaking of [everyday] life, but must also use it in a way which is appropriate for rendering evident what is shown.

It will gradually become clearer, and finally be completely clear, that the proper return to the naïveté of life—but in a reflection which rises above this naïveté—is the only possible way to overcome the philosophical naïveté which lies in the [supposedly] "scientific" character of traditional objectivistic philosophy. This will open the gates to the new dimension we have repeatedly referred to in advance.

We must add here that, properly understood, all our expositions are supposed to aid understanding only from the relative [perspective of our] position and that our expression of doubts, given in the criticisms [of Galileo, etc.] (doubts which we, living in the present, now carrying out our reflections, do not conceal), has the methodical function of preparing ideas and methods which will gradually take shape in us as results of our reflection and will serve to liberate us.[22] All reflection undertaken for "existential" reasons is naturally *critical.* But we shall not fail to bring to a reflective form of knowledge, later on, the basic meaning of the course of our reflections and our particular kind of critique.

22. This is a rough guess at a passage which is so obscure that I suspect something is missing (cf. Translator's Introduction, p. xviii). The sense, borne out by subsequent sentences, seems to be: In the historical but also critical reflections of this section, it is not yet clear (at least to the reader) *from what point of view* we are criticizing Galileo, Descartes, *et al.*, or where it will all lead. This point of view or attitude will gradually emerge as the phenomenological attitude which takes the form (in this case a historical-critical form) of liberating us from our prejudices.