The Social Foundations of the Mechanistic Philosophy and Manufacture*

Henryk Grossmann

Borkenau's Theory

The following is not meant to be a résumé of the contents of Borkenau's book *The Transition from the Feudal to the Bourgeois World-Picture*. Rather, these are but a few economic-historical and sociological reflections on some problems connected with the book's main subject, leaving aside problems involving philosophy and the history of ideas

Borkenau wants to show that the metamorphosis of the image of nature in the course of historical development "can only be understood from the changes in the image of the world in general" (p. 15). These again do not only depend on the experiences derived from the process of production, but also on the "general categories" which, by virtue of their being organizing concepts, hold the world-picture together. All experience is as such subject to change through categories which are themselves changing in the course of history: "which experience is being sought and accepted,

[161]

[162]

* The concept 'manufacture' is taken from Marx, *Capital*, Vol. I, Chap. 14 (chap. 12 in the fourth German edition). Since this concept is not familiar in current English usage, a brief quotation from that chapter may prove helpful in understanding Grossmann's views. The term refers to production characterized by division of labor in which the labor process is not yet simplified enough that a mechanism can replace the skill of the craftsman.

"That co-operation which is based on division of labour, assumes its typical form in manufacture, and is the prevalent characteristic form of the capitalist process of production throughout the manufacturing period properly so called. That period, roughly speaking, extends from the middle of the sixteenth to the last third of the eighteenth century . . . For a proper understanding of the division of labour in manufacture, it is essential that the following points be firmly grasped. First, the decomposition of a process of production into its various successive steps coincides, here, strictly with the resolution of a handicraft into its successive manual operations. Whether complex or simple, each operation has to be done by hand, retains the character of a handicraft, and is therefore dependent on the strength, skill, quickness, and sureness, of the individual workman in handling his tools. The handicraft continues to be the basis. This narrow technical basis excludes a really scientific analysis of any definite process of industrial production, since it is still a condition that each detail process gone through by the product must be capable of being done by hand and of forming, in its way, a separate handicraft" (Karl Marx, *Capital*, Vol. 1, transl. S. Moore and E. Aveling, edited by F. Engels (1887), Moscow: Progress Publishers, 1965, pp. 338–339; see also pp. 342–348) [G.F./P.M.].

G. Freudenthal, P. McLaughlin (eds.), *The Social and Economic Roots of the Scientific Revolution,* Boston Studies in the Philosophy of Science 278,
DOI 10.1007/978-1-4020-9604-4_3,

whatever appears to be evident, empirical or nonsensical – all this depends on the dominant categories." The book undertakes the task of demonstrating this historical change in the basic categories in relation to the natural sciences and "to render comprehensible their connection with social life" (p. 15). Borkenau wants to present the process of the reification of consciousness, as described in the introductory part of the book (pp. 15–96). He leads us from the flowering of scholasticism via the late Renaissance and Francis Bacon to the threshold of Cartesian philosophy – the principal topic of the book. Dealing with the beginning of this development, which started out with Thomas Aquinas, Borkenau explicitly states the priority of the social sphere. The natural law is guided by the "natural," i.e. class-determined, order of society with its hierarchical structure, and the world is understood analogously as a harmonious ordering of its parts in its ultimate relation to God. Since all nature exists for society and the latter is and should be a harmoniously arranged cosmos of fixed structures, "the" scholasticism's conception of natural law is static: "The Thomist system excludes modern dynamics and all of modern natural science which is based thereon" (p. 34).

With the erosion of feudalism due to the advent of the monetary system and of capitalism, the optimistic-harmonious view of the universe in Thomist doctrine is replaced by the pessimistic doctrine of the separation and antagonism between [non-]rational affects and the natural law. There follows a gradual transformation of the concept of natural law and the reversal of the order of precedence between natural and human law. During the Renaissance, human fate was regarded as accidental, at the mercy of unpredictable external forces. Yet, even here in this wicked world, God's influence becomes visible in the contemplation of harmoniously ordered nature. Nature, which in classic scholasticism ranked lowest in the divine plan of the world, attains a higher rank, and human society should be understood – and legitimized – only by the cognition of nature. The reversal of the hierarchy is complete.

Contrary to scholasticism, the Renaissance took upon itself the task of concretely exploring nature. But the Renaissance was not interested in the cognition of nature as such – the cognition of the causal connection between the parts of nature by means of quantitative measuring methods – but in the "interpretation of the concrete world as a whole, as a system of harmonic measures" (p. 65). The mathematical proportion of the whole universe was to be shown in the seemingly chaotic flow of nature; only from this viewpoint are all parts of nature important and is the concrete
[163] exploration of nature significant.

This attitude of the Renaissance to the exploration of nature is understandable. Within the monetary and commercial capitalism of the Renaissance period, there still was lacking any attempt at elaborating quantitative methods for the exploration of nature. Therefore the philosophy of that period remained qualitative. Only with the development of industrial capitalism and its first expression – *manufacture* – did the quantitative methods evolve; "only the application of capitalist methods in the production process enabled an observation of nature by quantitative methods" (p. 54). Since manufacture, which already arose in the sixteenth century, only developed in the seventeenth century, it is understandable that the formation of the

modern world-picture, based upon exact quantitative methods, only became possible at the beginning of the seventeenth century. The culmination of the "process of reification" of consciousness was reached in Descartes; for him it is an established fact that everything that happens in human life (apart from thinking) is of a purely external contingency which, however, is governed by laws which conform to reason. With this "the bell is ringing in the birth of the modern concept of natural law" (p. 358) and simultaneously of the mechanistic world view.

The mechanistic world view prevailed because of the thorough revolution of social relations which took place at the turn of the sixteenth to the seventeenth century. Italy had been affected by it only temporarily; therefore the mechanistic exploration "was soon suffocated there by the blows of the Counter-Reformation" (p. 14). In France, Holland and England the development was different. "In all these three countries it is at that great turning point that the industrial bourgeoisie and its related class of the gentry first appeared on the stage as an independent power and soon occupied the center of the stage. . .. This historic change immediately preceded the emergence of the mechanistic world-picture; it brought it about" (p. 14). Yet Borkenau did not describe this "revolution of social relations," which was decisive for the emergence of the mechanistic world-picture, for any of the countries with which he was dealing. Neither did he demonstrate why Italy had been "only temporarily affected" by this revolution. Rather, we have to deduce from incidental remarks, scattered throughout his book, how Borkenau perceives this situation which is so decisive for his research.

The specific carrier of the Renaissance world view is the monetary and commercial capital, viz. in the first instance the "booty-capitalism," (p. 215) the "adventuresome capitalism" (pp. 155, 157) which – in contrast to the "solid" manufacturing capital (p. 155) of the later period – remained exclusively in the sphere of circulation (p. 89) and stood apart from the capitalistic labor process and thus from its rational shaping (p. 155); this view of a class remote from the labor process could only be a harmoniously balanced ideology, an estheticism which despised the life of the masses. Only when the monetary capital entered the sphere of production, which – despite the repeated endeavors in this direction during the sixteenth century – did [164]
not have "the first decisive success" before the beginning of the seventeenth century, did the "first period of capitalistic industry, the period of manufacture" arise (pp. 89, 90). This also implied an important revolution in the history of science as well as in the history of philosophy. For the monetary capital, remote from the labor process, could not create rational techniques; the latter was "adequate to capitalism alone and was realized . . . for the first time during the period of manufacture" (p. 90).

The representatives of these new manufacturing techniques are not the "religiously indifferent capitalists," but the "upward-struggling Calvinist little people." The rational techniques of manufacture "emerged from the efforts toward the rationalization of handicraft" (p. 90), whereas the monetary capitalists are lacking "any motivation to rationalize the techniques systematically" (p. 90). Borkenau declares, though, that "during the Renaissance innumerable inventions had been made by practitioners, some of them of the highest significance; but incidentally and without

the possibility of systematical perfection" (pp. 88, 89). But things had been different in the case of manufacturing techniques: "The simple basic forms of modern techniques," which "became the foundations of the mechanistic world-picture ... developed quite apart from the inventions of the Renaissance" (p. 90).

The essence of these new techniques, which were so important for the new world-picture was, "as is well known," nothing but an extreme division of labor, retaining at the same time all the craftsmanlike essentials of the production process (p. 2). Through division of labor, the skilled worker in manufacture was replaced by unskilled laborers whose work consisted of "the execution of a quite simple movement" (p. 7). Thus there was no longer any need for specialized training, work lost its quality and "became mere quantity." This meant that qualified work was replaced by "general human" or "abstract work," which constitutes the basic concept of modern mechanics. Thus it is evident that manufacture constitutes a necessary condition for the development of the basic concepts of modern Galilean mechanics, "in that for the first time it created abstract work and abstract matter" (p. 13).

Galilean mechanics or "one related to it" was, however, a condition of the mechanistic world picture, since this new philosophy was nothing but the demonstration "that all processes in nature can be explained in a mathematical-mechanistic way" (p. 10), that all natural phenomena can be reduced to meaningless changes of matter, i.e. to impact and motion (p. 12). This interlocking chain of deductions provides evidence that the mechanistic world-picture is only "an extrapolation from the manufacturing processes to the cosmos as a whole" (p. 12). The mechanistic world-picture prevailed simultaneously with modern mechanics and modern philosophy (p. 10): "The rejection of qualitative philosophy, the creation of the mechanistic world-picture is a radical change that started around 1615 and had its culmination in Descartes' *Discours* (1637), Galileo's *Discorsi* (1638), and Hobbes's *Elements*
[165] (1640)" (p. 13).

The Reality of Historical Development

The historian has methodological doubts from the very beginning: Does history really take so rectilinear a course as Borkenau would have it? Do the single stages of the process really follow each other in such a sequence that one can speak of *the* world-picture of Scholasticism, of *the* Renaissance and of modern times as clearly distinct concepts? And are there never any regressions – often lasting for centuries – which also should be taken into account and explained? Yet doubts arise not only with regard to the succession in time but also to the proximity in space: do not different world-pictures coexist in every period, e.g. in the Scholastic, hence rendering the scholar's work even more complicated; does he not also have to explain this particular coexistence? Are these world-pictures not equally differentiated as the social circumstances of the times? And furthermore: Should it not be assumed that the various disciplines develop at a quite uneven pace; that in northern Italy,

e.g., astronomy, mathematics, and mechanics attained a higher stage of development than anatomy and other disciplines? It appears to us that the real task is the tracing of the concrete connections between the various areas of material social life and the individual disciplines.

We might have expected that Borkenau, adducing characteristic examples from the history of the sciences and their particular disciplines, would demonstrate and directly explain their prevailing basic categories and their metamorphoses by studying the historical material to be analyzed. In order to fulfill the task outlined in the title of the book, to demonstrate the "transition from the feudal to the bourgeois world-picture," it would have been necessary to describe, in the separate spheres of positive knowledge of nature, those social and intellectual processes through which the feudal world-picture was upset and the germ of the modern world picture was developed simultaneously. But Borkenau got stuck in generalities: the empty formula of the eroding influence of the upcoming monetary and commercial capitalism upon the harmonious stratified hierarchical feudal order is supposed to explain phenomena which can only be elucidated by a closer study of the networks of facts of material life! Borkenau feels correctly that, with such a formula as the methodological instrument of analysis, the task cannot be fulfilled, and he actually narrows [166]
this task with the aid of a syllogism: the concept of natural law is *the* fundamental category of our image of nature. Instead of presenting the change of categories in the history of sciences, he gives the history of the development of the *concept* of natural law, i.e. the "history of the *word*" (p. 19).

The examination of Borkenau's construction as to its content of reality appears to us even more necessary since in itself it constitutes a revolution in the previously prevailing conceptions. A few of the most important points will be enumerated here:

1. The assumption seems to suggest itself that mechanistic philosophy and scientific mechanics derived their basic mechanical concepts from the observation of mechanisms, of *machines*. Borkenau however deduces the rise of mechanical conceptions not from the machines but from the division of human labor in the crafts.

2. The beginning of modern natural sciences, viz. of a complex of knowledge having at its disposal both exact methods of investigation and the formulation of fundamental laws governing a certain sector of nature, has been placed, usually, in the second half of the fifteenth century, but the *beginnings* of exact research date even farther back. Borkenau negates more than 150 years of the history of science with its "increasingly speedy" progress, and postpones the birth of modern science to the turn of the sixteenth to the seventeenth century.

3. According to Borkenau the elaboration of exact scientific methods, which some scholars already ascribe to the Arabs of the Middle Ages, viz. at least to the twelfth and thirteenth centuries, arises between the sixteenth and seventeenth centuries together with the dissemination of the division of labor in manufacture. Here he even negates three to four centuries of development. Before considering Borkenau's further deviations from the previous state of knowledge, we have to delve more deeply into this question of the beginnings of scientific mechanics.

Presenting here the beginnings and development of scientific mechanics since the end of the fifteenth century would lead us too far. Suffice it to mention the name

of Leonardo da Vinci. Today, after the publication of the most important heritage of Leonardo's manuscripts from the library of the Institut de France (1881–1901), of the *Codice Trivulziano* (1891) and *Codice Atlantico* from the Abrosiana of Milan
[167] (1894), of the *Windsor manuscripts* (1901), of the *Codice sul volo degli uccelli* (1893) – so important to theoretical mechanics – and especially of the mechanical manuscripts of the Kensington Museum in London (1901),[1] and after the pioneering research by P. Duhem into Leonardo,[2] determining the time of Galileo and Descartes as the beginnings of scientific mechanics would mean ignoring at least fifty years of scientific research. "Nowhere," says Borkenau, "does the Renaissance seek knowledge for mere knowledge's sake" (p. 73). It was only interested in the symbolism of the circle with God as its center of attraction, whereas scientific research was but a by-product of this attitude. Only where the circular form was applicable, as in astronomy, did science progress as far as the formulation of precise laws; beyond astronomy, therefore, the attempt at framing the phenomena in mathematically exact laws proved unavailing. The contribution of the Renaissance to our contemporary knowledge of nature was "pure natural history; an accumulation of an immense, often valuable, mass of material, an empirical acceptance" (p. 72), and "an entirely unmathematical method of observation" (p. 80). There followed in the second half of the sixteenth century an upward turn in the sciences which described nature; the use of experiments was demanded but not systematically carried out (p. 80).

One need only lay one's hand on Leonardo da Vinci's manuscripts, only consult any general presentation of Leonardo's scientific achievements (e.g. G. Séailles' book)[3] in order to become convinced that every sentence in the above description of "the" Renaissance is quite incredible. It is an established fact that Leonardo in his research used exact quantitative methods, that he stressed the general applicability of mathematics. Libri, the learned historian of the mathematical sciences in Italy, reports: "Léonard étudiait la mécanique et la physique avec le secours de l'algèbre et de la géometrie . . . et appliqua cette science à la mécanique, à la perspective et à la theorie des ombres."[4] It is also certain that Leonardo not only always demanded
[168] the systematic use of experiments but also actually carried them out in various fields of science – see the book on the flight of birds.[5] There is no doubt nowadays that

---

[1] Leonardo da Vinci, *Problèmes de géométrie et d'hydraulique. Machines hydrauliques. Application du principe de la vis d'Archimède. Pompes, machines d'épuisement et de dragage*, Paris, 1901, Vols. I–III.

[2] P. Duhem, *Les origines de la statique*, Paris, 1905/6, Vols. I/II; *Études sur Léonard de Vinci*, Paris, 1906, Vols. I/II.

[3] *Léonard de Vinci, l'artiste et le savant*, Paris, 1906.

[4] *Histoire des sciences mathématiques en Italie*, Paris, 1840, Vol. III, p. 46. Leonardo writes: "Qu'il ne me lise pas celui qui n'est pas mathématicien, car je le suis toujours dans mes principes." (Peladan, *Léonard de Vinci, Textes choisis*, Paris, 1907, p. 34), and "La mechanica e il paradiso delle science matematiche perche con quella si viene al frutto matematico" (Duhem, *Les origines de la statique*, Vol. I, p. 15).

[5] Leonardo writes: "When dealing with scientific problems I first make some experiments, because I intend to pose the question according to experience, and then to prove why the bodies are compelled to act in the manner demonstrated. This is the method according to which one should

Leonardo not only knew the contents of the most important basic laws of mechanics, hydrostatics, hydrodynamics, optics, aerodynamics, and several other sciences, and precisely formulated these laws, but that he also already laid the foundations of a comprehensive mechanistic world-picture.[6]

Leonardo knew the basic principle of mechanics, the law of inertia, the impossibility of the perpetuum mobile, and he fought opposing views, even though until now the discovery of the principle of the impossibility of the perpetuum mobile was ascribed to Simon Stevin (1605).[7] Leonardo recognized "la loi d'équilibre de la balance ou du levier."[8] With regard to the parallelogram of forces, he provides an equivalent, mathematically precisely formulated solution: "le moment d'une résultante de deux forces est égal à la somme des moments des composants."[9]

According to Borkenau (who refers to Duhem) the "beginning of the calculations of the center of gravity" was in the mid-seventeenth century (p. 35). Duhem really shows that Leonardo had already made these calculations.[10] And before him M. Cantor, in his "Vorlesungen über die Geschichte der Mathematik," had stated that Leonardo correctly determined the center of gravity of a pyramid with a triangular base.[11] [169]

"Cent ans avant Stevin et avant Galilée Léonard établit . . . la chute d'un corps qui suit la pente . . . d'un plan incliné."[12] Leonardo provides an exact calculation of the speed of the fall on an inclined plane. "There is no doubt," says Hermann Grothe as early as 1874, "that by the end of the fifteenth century Leonardo had already clearly and distinctly formulated many laws of mechanics, and these bestow on

---

proceed in all explorations of the phenomena of nature." (Cf. August Heller, *Geschichte der Physik von Aristoteles bis auf die neueste Zeit*, Stuttgart, 1882, Vol. I, p. 237. Kurt Lasswitz, *Geschichte der Atomistik*, Hamburg 1890, Vol. II, p. 12.) "This clear insight," adds Lasswitz, "into the essence of the experimental-mathematical method of natural sciences determines da Vinci's procedure and success."

6 "Cent ans avant Galilée," says G. Séailles (op. cit. p. 220), "Léonard a posé les vrais principes de la mécanique; cent cinquante ans avant Descartes il a pressenti en elle l'idéal de la science. Il semble qu'il lui ait dû l'idée même de sa méthode. Observer les phénomènes, les reproduire artificiellement, découvrir leurs rapports, appliquer à ces rapports la mesure, enfermer ainsi la loi dans une formule mathématique qui lui donne la certitude déductive d'un principe que confirment ses conséquences, c'est la méthode même de Léonard et celle de la mécanique."

7 E. Mach, *Populär-wissenschaftliche Vorlesungen*, Leipzig, 1903, p. 169. [E. Mach, *Popular Scientific Lectures*, transl. by Th. J. McCormack, La Salle: The Open Court, 1943, p. 140f.]

8 P. Duhem, *Les origines de la statique*, Vol. I, p. 19.

9 Op. cit., Vol. I, p. 32. Cf. Vol. II. pp. 347f.

10 Op. cit., Vol. II, p. 111.

11 Leipzig, 1899, Vol. II, pp. 302, 570. Séailles says: "Commandin (1565) et Maurolycus (1685) se disputaient jusqu'ici l'honneur de ces découvertes" (op. cit., p. 225). The calculations of Maurolycus, though executed in 1548, were only published in 1685. (Cf. Libri, *Histoire des sciences mathématiques*, Vol. III, p. 115.)

12 Séailles, op. cit., p. 229. Similarly Eug. Dühring, *Kritische Geschichte der Principien der allgemeinen Mechanik*, 3rd ed., Leipzig, 1887, pp. 12–17.

Leonardo . . . at least equal importance for mechanics as was ascribed to Stevinus – and moreover the precedence."[13]

Leonardo's pioneering work in the field of comparative anatomy is based on the realization that the functions of the animal body and the motion of its limbs are governed by the laws of mechanics. "The whole world, including living things, is subject to the laws of mechanics; the earth is a machine, and so is man. He regards the eye as a camera obscura, . . . he determines the crossing point of the reflected rays."[14]

In aerodynamics he provides a mechanical theory of air pressure. "Plus étonnantes sont les expériences sur le frottement et les lois qu'il sut en déduire . . . Ainsi, deux siècles avant Amonton (1699), trois siècles avant Coulomb (1781), de Vinci avait imaginé leurs expériences et en avait fixé à peu près les mêmes conclusions."[15] In hydrodynamics and hydrostatics, Leonardo discovers the basic mechanic laws of liquids. "Il faut rectifier sur ce point l'histoire de la science positive." Leonardo "a l'idée nette de la composition moléculaire de l'eau . . .; un siècle et demi avant Pascal, il observe les conditions d'équilibre de liquides placés dans des vases communicants."[16] In hydrodynamics: "plus de cent ans avant le traité de Castelli (*Della misura dell'aqua corrente*, 1638), Leonardo cherche la quantité d'eau qui
[170] peut s'écouler par une ouverture pratiquée à la paroi d'un canal" . . . "Il calcule la vitesse de l'écoulement de l'eau . . . Il donne la théorie des tourbillons, il en produit d'artificiels pour les mieux observer."[17] "La mise au jour des manuscrits de Léonard de Vinci recule les origines de la science moderne de plus d'un siècle . . . Conscience de la vraie méthode . . . union féconde de l'expérience et des mathématiques, voilà ce que nous montrent les carnets du grand artiste. Pratiquée avec génie, la nouvelle logique le conduit à plusieurs des grandes découvertes attribuées a Maurolycus, Commandin, Cardan, Porta, Stevin, Galilée, Castelli."[18]

And now the essential point: according to Borkenau, the concept of mechanical work has its origins at the beginning of the seventeenth century only, in connection with the division of industrial labor and with highly skilled work being replaced by "general human" work. In fact, the concept of mechanical work was already well known to Leonardo by the end of the fifteenth century and he developed it from observing the effect of machines which replace human performance. In comparing the work of machines with the human work it replaces, both types of

---

[13] *Leonardo da Vinci als Ingenieur und Philosoph*, Berlin, 1874, p. 21; cf. p. 92. Similarly M. Herzfeld, *Leonardo da Vinci*, Leipzig, 1904, CXIII. The influence of Italian science is demonstrable in other areas of Stevin's work as well: he introduced into Holland the Italian bookkeeping system whose beginnings in Florence go back to the book by Luca Paccioli (1494), Leonardo's friend. (Cf. E. L. Jäger, *Luca Paccioli und Simon Stevin*, Stuttgart, 1876.)

[14] M. Herzfeld, op. cit., CXXII, CXV.

[15] Séailles, op. cit., p. 231.

[16] Op. cit., pp. 232–34. Leonardo writes: "Le superficie di tutti i liquidi immobili, li quali infra loro sieno congiunti, sempre sieno d'equale altezza," independent of the *width* and *shape* of the vessels, and he shows that the height of the columns of liquid is inversely proportional to their *weight* (density). (Cf. A. Heller, *Geschichte der Physik*, Vol. I, p. 242.)

[17] Séailles, op. cit., pp. 235/236.

[18] Op. cit., pp. 369/370.

work are reduced to a common denominator, to the concept of mechanical work. Thus Leonardo calculates the work of a water wheel which activates a machine.[19] From the knowledge of the basic laws of mechanics he already calculates the amount of work to be performed by machines while building them, and in the case of the rolling mill for iron rods which he constructs he calculates both the load and the force (work) to be applied to pull the iron along under the rollers. As theoretical basis for this calculation he uses his study "Elementi machinali" (which has evidently been lost), to which he often refers.[20] A similar case is that of a spinning jenny which he invented around 1490.[21] And there is more. Leonardo does not confine himself to such calculations, he even constructs an apparatus for this purpose: "Pour calculer l'effet des machines il inventa un dynamomètre; il détermina le maximum [171] de l'action des animaux en combinant leur poids avec la force musculaire."[22]

It would be superfluous to add further examples. Is Borkenau perhaps of the opinion that Leonardo da Vinci's achievements need not be taken into account because his writings were not published, and therefore had no influence on the emergence of scientific mechanics? Did Venturi not believe, when he rediscovered Leonardo's manuscripts in 1797, that, because they were unkown, mankind had been compelled to make his discoveries a second time? But would not such an argument be irrelevant, since the primary problem lies in the questions of why and how could Leonardo da Vinci already lay the foundations of scientific mechanics in the end of the fifteenth century?

Besides, P. Duhem has established – and therein in particular lies the importance and originality of his research – that Leonardo's mechanics did not remain as unknown as hitherto presumed; that, e.g., Galileo frequently quotes Girolamo Cardano, who himself was undoubtedly influenced by Leonardo;[23] that a long list of writers, conscious or unconscious plagiarists, knew Leonardo's mechanics and made use of its results throughout the sixteenth century; and that, through their very intermediary, his influence had a mighty effect on the works of Stevin, Kepler, Descartes, Roberval, Galileo, Mersenne, Pascal, Fabri, Christian Huygens and others. These intermediaries, such as Cardano, Tartaglia, Benedetti, or bold plagiarists like Bernardino Baldi, rendered an important service to mankind in rescuing Leonardo's ideas and inventions from oblivion and introducing them into the wide mainstream of science.[24]

---

[19] Duhem, *Les origines de la statique*, Vol. I, p. 21.

[20] H. Grothe, *Leonardo da Vinci als Ingenieur*, op. cit., p. 77. Cf. furthermore August Heller, op. cit., p. 242.

[21] H. Grothe, op. cit., p. 82. Leonardo calculates, e.g., the force (work) required for hammering in nails and bolts, regarding them as wedges. A. Heller, op. cit., p. 242.

[22] G. Libri, *Histoire des sciences mathématiques*, Vol. III, p. 42. Cf. there also appendix VII, p. 214: "Della forza dell'uomo."

[23] Duhem, *Les origines de la statique*, Vol. I, pp. 40, 44.

[24] Op. cit., Vol. 1, pp. 35, 147; *Études sur Léonardo da Vinci*, Vol. I, pp. 108, 127. Olschki (*Galilei und seine Zeit*, Halle, 1928) however says that pre-Galilean mechanics had quite a different character (he did not show wherein this difference lies) and that, therefore, the predating of the origins of scientific mechanics is due to the "malice" of Galileo's "detractors." But this is not a matter of

The fact that modern mechanics already originated with Leonardo da Vinci at the end of the fifteenth century has been recognized for these past fifty years by a
[172] majority of leading scholars; for example, K. Lasswitz wrote in 1890: "Thus the new mechanics, and modern scientific thinking generally, begins with the admirable genius of Leonardo da Vinci who was so incredibly far ahead of his time."[25] The task lies, though, in rendering the "incredible" "credible," i.e. not conceiving of the phenomenon of Leonardo da Vinci as an "individual phenomenon beyond the context of historical development" (Lasswitz), but rendering it comprehensible from the social development of his epoch.

However – and here we come to our decisive conclusion – if Borkenau nevertheless does not want to recognize the significance of Leonardo's mechanics, if he rejects the views of a Venturi, Libri, Grothe, Duhem, G. Séailles, and many others who see in Leonardo the originator of modern mechanics already at the end of the fifteenth century, then such rejection must be substantiated. By failing to do so, he conceals the whole problem! In his book, wherein he deals with so many secondary figures of the Renaissance, the name of Leonardo da Vinci is not even mentioned.

4. Just as revolutionary as his view of the chronological beginning and substantial origin of modern science is Borkenau's opinion on the processes in social and economic history, which were conditional for the development of modern science and of the mechanistic world-picture. Even if the capitalist methods of production only became general in the sixteenth century, and one can only speak of the "capitalist era" at that time, the beginnings of the capitalist method of production (and these are of prime importance in elucidating the rise of the bourgeois world-picture) date much farther back. In contrast to Marx's view, that in Italy "we meet the first beginnings of capitalist production as early as the fourteenth or fifteenth century, sporadically, in certain towns of the Mediterranean,"[26] Borkenau says that not before the turn of the seventeenth century did the introduction of monetary capital into the sphere of production "have its first decisive success." Only at that time, therefore, did the "first period of capitalist industry, the period of manufacture" begin. Here, Borkenau skips three hundred years of capitalist development in Western Europe.

5. Wherever capitalist production is taking place, the abolition of serfdom and of the stratified-feudal order has been long since achieved through monetary capital.
[173] Since capitalist production exists in Italy in the fourteenth century, the dissolution of the stratified-feudal structure through the mercantile and monetary capital must have taken place much earlier, viz. during the twelfth and thirteenth centuries – as could be read (until now) in every history book of Italian economics. Let us only mention the development of monetary and commercial capital in the proud Italian republics of the twelfth and thirteenth centuries, and the protracted trade

---

"detracting" from Galileo, Descartes, Pascal, or Stevin, but of understanding an historical epoch as a whole.

[25] K. Lasswitz, *Geschichte der Atomistik*, Vol. II, p. 12.

[26] *Das Kapital*, 3rd ed., Vol. I, pp. 739, 740. [*Marx-Engels-Werke*, Vol. 23, pp. 743, 744; *Capital*, Vol. I, pp. 715–716.]

wars between Amalfi and Pisa, between Pisa and Genoa, and between Genoa and Venice.[27] Due to the greatly intensified circulation of money and goods in thirteenth-century Italy, the quantity of silver specie in circulation no longer sufficed, so that in 1252 Florence was compelled to start minting gold coins (hence the name "Florin"). J. Burckhardt describes how, as early as the twelfth century, the Italian nobility lived in the towns together with the burghers and, having become quite bourgeois, turned to commerce.[28] There are licensed banks in Genoa, since the thirteenth century, with a highly developed system of deposits and clearing concentration.[29] When industrial capitalism began to develop in northern Italy, feudalism had long since completely disintegrated due to the invasion of monetary and banking capital. These historical research findings are also disregarded by Borkenau. According to him, capitalist production methods were nonexistent in Italy prior to the beginning of the seventeenth century; the dissolution of the stratified-feudal order through the incursions of monetary and merchant capital into Italy had not taken place in the twelfth and thirteenth, but only in the sixteenth century, and then the mental attitude of the Renaissance, the character of its scientific research, and its philosophy, are explained by the destructive influence of the inflow of monetary capital.

6. Past research into the history of economics presented the view that the industrial-capitalist development of Italy, which started in the fourteenth century and which developed in a steeply ascending line until the middle of the fifteenth century, suffered a heavy setback after the discovery of America and the blockade of the East European trade routes by the Turks: As a consequence of the shift in the axis of international trade from the Mediterranean to the Atlantic Ocean, Italy [174] entered a period of regression of capitalism – this process of deterioration explains the specific characteristics of the mental attitudes of the late Renaissance.

According to Borkenau's book, this conception was evidently unfounded. That shift in the axis of world trade plays no role in his attempt to interpret the Renaissance; he does not even mention it. In this he is quite consistent. Having asserted that Renaissance Italy had only advanced as far as monetary capitalism, and that productive capitalism never existed there, he cannot discern any setback in the development of industrial capitalism. He clearly finds it superfluous to adduce the phenomenon of the revolution in the world market to the end of the fifteenth century, in order to explain the material and intellectual situation of the Renaissance.

7. The conception of the genesis of capitalist production in the other West European countries is just as new as that of Italy's development. This applies firstly to the question pertaining to the initial plant structure in capitalist production. Borkenau adopts Sombart's erroneous interpretation of Marxist theory, according to which Marx had designated manufacture as the first stage of capitalist plant structure,[30] and he even places the thesis that "manufacture is the first period of capitalist industry" at

---

[27] Cf. H. Grossmann, *Das Akkumulations- und Zusammenbruchsgesetz*, Leipzig, 1929, p. 48.
[28] *Die Cultur der Renaissance*, Leipzig, 1899, Vol. II, p. 81.
[29] H. Sieveking, *Genueser Finanzwesen*, Freiburg i.B., 1899, Vol. II, p. 47.
[30] W. Sombart, *Der moderne Kapitalismus*, 2nd ed., 1917, Vol. II/2, p. 731.

the center of his conception and its substantiation! Here again he pays no heed to the 100–150 years of capitalist development which preceded the period of manufacture, namely the period of decentralized putting-out system.

8. Not quite as new as the conceptions just outlined – but perhaps even more interesting – is Borkenau's theory of the genesis of capitalism from the material aspect. Following the publication of *Das Kapital*, theoretical controversy arose about this genesis, in which W. Sombart, M. Weber, H. Sieveking, J. Strieder, G. von Below, Heynen, A. Doren, H. Pirenne, R. Davidsohn, and many others participated either directly or indirectly. One basic question was the following: According to *Das Kapital* the bearers of the emerging capitalism did not originate from among the artisans, and such provenance would have been impossible. This impossibility relates to (a) capital necessary to operate a capitalist enterprise, (b) the new technical processes, (c) the precognition of complicated elements of profitability (cheap sources of raw materials in distant markets, the currency and legal conditions of foreign marketing outlets, costs of transportation, customs, etc.), (d) to the technical and monetary organizational problems of a large enterprise, and finally (e) to the class origin of wage laborers.

[175]

The competition which threatens local handicraft comes with the rise of world commerce and international trade fairs in the thirteenth century. In order to neutralize this and prevent any social differentiation within the community or the guild, the rules of the medieval guilds try to block the master's ascent to capitalist status through regulations governing the number of tools he may use, the number of journeymen (*Gesellen*) he may employ, etc. Thus the accumulation of larger, freely disposable amounts of capital within the guild is rendered impossible. At the same time and for the same motives, any technical innovation is discouraged, the established technique becomes rigid routine, and production is adapted to the local market from which the competition is being excluded. The narrow horizon of the production of the local guilds prevented them from surveying distant markets of raw materials; the artisan obtained his raw materials second- or third-hand from the wholesale merchant. Likewise the artisans had no knowledge of foreign outlets for exports, of conditions governing foreign currencies and of customs duties. But above all, the guilds' artisans were lacking all organizational prerequisites for the creation of large-scale undertakings, as well as the ability to rationally calculate a production process extending over longer periods. How could the impoverished artisans, in their process of decay, who respected the spirit of traditionalism and routine, and rejected every innovation, have acted as historical signposts and have opened new horizons? Even in the best of circumstances the accumulation of capital within the framework of local manufacturing production was too slow and did not answer the new commercial requirements of the world market. It was also incapable of creating a new class of industrial entrepreneurs.[31]

The new capitalistic plant structures gradually emerged "outside the control of the ancient urban system and its constitution of guilds" – be it in the rural areas

[31] Marx, op. cit., I, p. 776. [*Marx-Engels-Werke*, Vol. 23, pp. 777f; *Capital*, Vol. I, p. 750.]

or in the trading ports by the sea where, for specific reasons, the structure of the guilds became relaxed. Yet the bearer of this new revolutionary development was [176] naturally not the artisan who belonged to a guild but the large-scale merchant, i.e. the trading and usury capital. The first big capital funds in circulation accumulated through banking and usury, before they could be used in the sphere of production. "Usury centralizes money wealth where the means of production are dispersed."[32] The large-scale merchant possessed larger capital means, knowledge of sources of raw material supplies and of buyers' markets for finished merchandise in which he traded. He was accustomed to doing business on credit – in short, he had all the prerequisites necessary for the new plant structures. The latter was not created all at once, rather it developed gradually in the course of a lengthy historical process. The large-scale merchant bought finished products from the artisans who originally had been working directly for the consumer, and thus, as he cut them off from their sales outlets, made them dependent on him. As he was advanced money and soon also supplied with raw materials for processing, the craftsman became even more dependent; and finally, despite his formal autonomy, he sank to the status of a wage laborer, while the production process, manual technique, did not change. In this manner the large-scale merchant provided work for numerous artisans who worked separately in their own homes with their own tools, formally independent but in fact totally dependent on him. Thus originated the putting-out system, the first capitalistic, albeit decentralized, large-scale enterprise. In view of the relatively small amount of capital funds accumulated, this form of enterprise was the most appropriate and rational, since the entrepreneur saved capital expenditure for factory buildings, lighting, heating, taxes, etc. We encounter the first beginnings of capitalistic production in this form of putting-out systems in fourteenth-century Italy and even as early as in thirteenth-century Flanders.

The next stage in the process of subordinating production to capital was that the large-scale merchant, hitherto only the organizer of other peoples' production, proceeded to take over the production under his own management. But this change was also gradual and extended over long periods. At first the merchant takes over single stages in manufacture, e.g. dyeing and dressing, while the other processes (for instance from spinning to weaving) continue in the usual way. The centralization of [177] the workers in closed factories, manufacture, is only the last stage of this lengthy historical development and itself constitutes the beginning of a new evolution of manufacture which takes place gradually – of a new process to which we shall later revert (see no. 10 below).

This is not the place for delving into this theory's details. Numerous historians have brilliantly demonstrated its validity using the historical material.[33] Especially

---

[32] Op. cit., Vol. III/2, p. 136. [*Marx-Engels-Werke*, Vol. 25, p. 610; *Capital*, Vol. III, p. 596.]

[33] H. Sieveking, "Die kapitalistische Entwicklung in den italienischen Städten des Mittelalters," in: *Vierteljahrsschrift für Sozial- und Wirtschaftsgeschichte*, Vol. VIII, 1909, pp. 73, 80. Cf. also Adolf Schaube's criticism of Sombart on the basis of English historical material: Die Wollausfuhr Englands vom Jahre 1273, in *Vierteljahrsschrift für Sozial- und Wirtschaftsgeschichte*, Vol. VII, 1908. Heynen, *Zur Entwicklungsgeschichte des Kapitalismus in Venedig*, 1905, pp. 121ff. Broglio

with regard to Italy, Doren has proved with the aid of an abundance of factual material the correctness of Marx's conception.[34] The same proof has been supplied, just as convincingly and also on the basis of ample source material, by H. Pirenne[35] for thirteenth-century Flanders and the Netherlands, by W. Cunningham, W. J. Ashley and G. Brodnitz[36] for fifteenth- and sixteenth-century England, and by Baasch[37] for sixteenth-century Holland. Other authors have shown via exhaustive historical research that in fifteenth- and sixteenth-century France the erosion of the artisans, their narrow horizon and their adherence to routine were too strong for new plant structures and techniques to emerge from their midst – and that in France, just as in England, it was the monetary and commercial capital which pioneered capitalist production – the putting-out system.[38] One can say that this theory of the historical genesis of capitalism has become the predominant one; it has already been introduced into textbooks of general economic history, such as those by H. Sée and J. Kulischer.[39]

Such a genesis of capitalism does not, however, fit into Borkenau's "structural"
[178] scheme of development. He regards mechanics as the immediate prerequisite for the rise of the mechanistic philosophy in the first half of the seventeenth century, and the beginning of the analysis of the labor process into its constituent phases and of quantitative working methods as the immediate prerequisite for mechanics. According to him, the beginnings of capitalism are here and not in the thirteenth and fourteenth centuries. The large-scale merchant as the bearer of capitalist development does not fit very well into this scheme. Borkenau does not have capitalism emerge from monetary and commercial capital, but from the guild's craftsmen and through the rationalization of the methods of artisanship by analysis of the labor process – and he shifts its beginning in one leap across centuries into chronological proximity with the mechanistic philosophy, in the late sixteenth century! "It is," expounds Borkenau, "one of the most important insights resulting from all of Max Weber's research, that the main body (*Grundstock*) of manufacturing entrepreneurs, the first to introduce systematically capitalist methods into the production process, does not originate from the moneyed and trading bourgeois classes but from the ascending craftsmen" (p. 155). "The new manufacturing technique is not employed by religiously indifferent capitalists but by Calvinist, ambitious little men . . .." It is

---

D'Ajano, *Die Venetianer Seidenindustrie bis zum Ausgang des Mittelalters*, Stuttgart, 1893. R. Davidsohn, *Forschungen zur Geschichte von Florenz*, Vol. IV, Berlin, 1922, pp. 268ff.

[34] A. Doren, *Studien aus der Florentiner Wirtschaftsgeschichte*, Vol. I, Stuttgart, 1909, p. 23.

[35] Henri Pirenne, *Les anciennes démocraties des Pays-Bas*, Paris, 1910.

[36] W. Cunningham, *The Growth of English Industry and Commerce*, London, 1890, Vol. I. W. J. Ashley, *Englische Wirtschaftsgeschichte*, Vol. II: *Vom 14. bis zum 16. Jahrhundert*, Leipzig, 1896. G. Brodnitz, *Englische Wirtschaftsgeschichte*, Jena, 1918.

[37] Baasch, *Holländische Wirtschaftsgeschichte*, Jena, 1927, pp. 86, 156.

[38] E. Levasseur, *Histoire des classes ouvrières et de l'industrie en France avant 1780*, Paris, 1901, Vol. II: "Au XVIIe siècle les corporations opposaient un obstacle presque insurmontable à la création de la grande industrie et même de procédés nouveaux dans l'industrie" (p. 174). "La grande industrie ne pouvait pas naître dans le sein de la corporation" (pp. 271, 154). Similarly Henri Hauser, *Les débuts du capitalisme*, Paris, 1927, pp. 22ff.

[39] Henri Sée, *Les origines du capitalisme moderne*, Paris, 1930, pp. 13, 15. J. Kulischer, *Allgemeine Wirtschaftsgeschichte*, Munich, 1929, Vol. II, p. 110.

generated "by the efforts toward rationalization of craftsmanship" (p. 90). Manufacturing capitalism has *everywhere* "been recruited from the higher strata of artisans and from aristocrats who had turned bourgeois" (p. 157).

Borkenau does not notice that Max Weber's views on the origin of capitalism, to which he refers, were criticized and superseded in the discussion mentioned, and he is not aware that Weber himself had become unsure and doubtful of his theory.[40] Elsewhere Borkenau refers to Boissonade with regard to French manufacture.[41] [179]

Apart from these, of all historians of economy only J. Kulischer is mentioned once. Boissonade is the source of Borkenau's information! An "exemplary treatment of material," through which all other works on the origin of French capitalism are supposed to have become "obsolete"! The seminal works of Fagniez, E. Levasseur, Germain Martin, E. Tarlé, J. Godart, Henri Hauser, Henri Sée et al., each of whom provides deeper insight than Boissonade into the essence of the historical processes, are supposed to be obsolete!

Actually, Boissonade's book does not at all constitute a revolution in French historiography of economy. In 1899 Boissonade presented the first results of his research, providing archival documentation on 582 manufactures. In 1901 E. Levasseur already treated the findings of Boissonade's research with critical irony.[42] Since that time, in almost thirty years of untiring research in archives, Boissonade has considerably enlarged the number of known manufactures. But our knowledge about the origin of capitalism was not advanced through this investigation but rather became even more obscure. Due to its methodological insufficiency and ignorance of capitalistic forms of enterprise, his work was already outdated on publication (1927) and fell short of the results of earlier findings of French research.[43] Thus e.g. J. Kulischer blames Boissonade for having overlooked the putting-out system as the first capitalist form of undertaking and having mistaken it for artisanship! Here Tarlé's criticism had a clarifying effect. "Sée too stresses in a

---

[40] "In the occident the early capitalist putting-out system did not always, and not even usually, develop from within craftsmanship, but it originated very often beside the artisans . . ." (M. Weber, *Wirtschaftsgeschichte*, Munich, 1923, p. 145). [Max Weber, *General Economic History*, transl. by Frank H. Knight, Illinois: Free Press, 1950 (1927), p. 158.] "To sum up, one should always be aware that the factory did not originate from the workshop nor at its expense, but initially emerged alongside it (Weber identifies the factory with manufacture and criticizes the distinction made between these two concepts by the 'early science, also Karl Marx,' op. cit., p. 149. – H. G. [op. cit., p. 162f.]). Above all, it seized upon new forms of production and new products, e.g. cotton, chinaware, gold brocade or surrogates – none of which were manufactured by the craftsmen organized in guilds" (op. cit., p. 157 [English: p. 173]).

[41] "On the entire development of manufacture and of commerce protected by the state from Louis XI to Louis XIII, we now obtain very comprehensive information from P. Boissonade, *Le socialisme d'état*, Paris, 1927. It is theoretically insufficient and inadequate for the history of the relations of production, yet it is exemplary in its treatment of the material for the history of the productive forces. Since its recent publication, and despite the imperfections, all other works on the genesis of French capitalism have become obsolete" (p. 173).

[42] E. Levasseur, *Histoire des classes ouvrières* . . ., op. cit., Vol. II, p. 239.

[43] Boissonade's confusion of concepts is evident already in the title of the book, which calls the mercantile policies of the French governments in the sixteenth and seventeenth centuries "Le Socialisme d'État."

number of his writings that in France, just as in England, the industrial capital was preceded by the commercial capital, which tried to dominate the production of the small craftsmen."[44]

9. In view of the central role assigned in Borkenau's thinking to the origins of capitalism, we have tried to clarify the question as to the time of its first appearance, the monetary and commercial capital as its bearers, and finally the putting-out
[180] system as its first form of enterprise. Now it would be thinkable that capitalism, though not when it first appeared, but at some later stage of its development, viz. in the transitional phase from the decentralized putting-out system to the centralized manufacturing plant, did develop in the manner claimed by Borkenau. However, even if understood this way, this theory of the genesis of capitalism proves untenable.

In view of the problem's importance we would like to cite some proof for this statement. It can be ascertained from the sources that the overwhelming majority of the first manufacturing entrepreneurs in seventeenth-century France were monied people, capitalists, merchants, speculators, high officials, in short, anything but "little men with high aspirations."

Some typical examples from the whole period between Henry IV and Louis XIV will show who were the carriers of manufacturing. In Troyes, under the reign of Henry IV, the manufacture for satin and damask is founded by J. Schier, a wealthy merchant. (Marjépol, in Lavisse, Vol. VI/2, p. 78.) Thomas Robin, "maître de requêts" of Queen Marguerite, founds the "manufactures royales des Toiles fines et des Toiles de coton" in Rouen and Nantes (1604–1609). (Boissonade, loc. cit., p. 255.) The merchants J. Wolf and Lambert founded in 1606 the "manufacture des toiles fines de Hollande" at St. Sévère near Rouen. (Levasseur, op. cit., Vol. II, p. 171.) The first big manufacture "des industries des lainages" of the firm of Cadeau, arising at Sedan under state sponsorship, was founded by three Parisian merchants. (Boissonade, loc. cit., p. 254.) The manufacture of wallpaper was started under Colbert, and a factory was erected at Beauvais by Hinard, a Parisian merchant, while the first mirror factory was built in 1663 in Orleans by Denoyer, "receveur de tailles."[45]

These are not solitary selected examples. As was always the case with undertakings sponsored "from above," there soon appeared speculators and adventurers wishing to exploit this chance. E. Levasseur states about the time of Henry IV: "Pierre Sainctot, de Paris, membre de la Commission du Commerce; Claude Parfait, sellier, riche marchand de Troyes, étaient des capitalistes. Dans ces affaires d'argent, il se glissaient déjà des spéculateurs suspects, comme Moisset de Montauban . . . et des habiles, comme Nicolas Le Camus qui, arrivé à Paris avec 24 livres, passa pour avoir laissé à sa mort une fortune de 9 millions." (Further examples, Levasseur, op. cit., Vol. 1, p. 175; Vol. 11, pp. 200, 258. Lavisse, op. cit., Vol. VII/1, p. 220.)

Colbert, the actual initiator of the manufacturing system, surrounded himself with a team of agents who – always traveling throughout the country in the factories'

---

[44] J. Kulischer, op. cit., Vol. II, p. 110.

[45] E. Levasseur, Vol. II, p. 258. Lavisse, Vol. VII/1, p. 220.

interest and being partners in Colbert's foundations – represented a mixture of fortune hunters, speculators, and apostles of the new capitalist creed. "Pour fonder des manufactures, Colbert employa un certain nombre d'agents pris dans le commerce ou dans la banque, qui furent en quelque sorte les missi dominici de la réforme." [181]
The principal agent was Bellinzone, an Italian naturalized under Mazarin. He was appointed "inspecteur général des manufactures" with a salary of L. 4000 and was imprisoned for "malversation" at Vincennes after Colbert's death. Another agent, the banker Jabach, appointed director of the wallpaper manufacture of Aubusson, participated as a capitalist in a series of undertakings. The team included the merchant Camuzet of Paris, founder of innumerable manufactories for silk stockings, and finally the two brothers Poquelin, Parisian merchants, who had offices in Genoa and Venice and likewise participated in a number of manufactories, e.g. the mirror plant in the Faubourg St. Antoine. (Levasseur, op. cit., Vol. II, p. 238.)

Sagnac emphasizes that in Colbert's times the foundation of manufactories mainly took the form of capitalist joint-stock and similar companies, so that their original basis was not the "extreme effort" of the little man, but the participation of capital. "Sociétés en nom personnel, sociétés en commandite, sociétés anonymes surtout, recueillent des capitaux des marchands, des magistrats et des nobles euxmêmes, s'efforçant de draîner vers les grandes affaires une partie de la richesse, d'habitude employée en achat de rentes sur l'Hôtel de Ville ou d'offices royaux."[46]

The form of the joint-stock company or limited partnership enabled the merchants and magistrates to invest capital without having to leave their offices to personally look after the business. "Colbert pressait ... les gens riches qui étaient sous sa main, bourgeois et marchands de Paris, de Lyon, de Rouen, de Troyes, courtisans, magistrats, banquiers, officiers de finances et traitants d'apporter leur contingent" to the capitalists of the newly emerging joint-stock companies.[47]

Not only the capitals, the stock owners, and other suppliers of money came from the circles of commerce, finance and the magistrates – but also the managers, i.e. the practical directors, were usually taken from the estate of traders. "C'est parmi les marchands," says Sée, "que se recrutent ordinairement les directeurs de manufactures ... Ces marchands-manufacturiers n'appartiennent plus en aucune façon à la classe de maîtres des métiers; ils échappent à l'organisation corporative."[48] For Jacques Savary, the famous author of *Le parfait négociant* (1673) and [182]
Colbert's counsellor in all legislative matters of manufacturing organization, it is a matter of course that the big merchants are those who establish manufactories. Thus he provides instructions for "Négociants qui voudroient établir des manufactures."[49]

---

[46] In Lavisse, op. cit., Vol. VIII/1, p. 230.
[47] Levasseur, Vol. II, p. 241; cf. Lavisse, Vol. VII/1, p. 222.
[48] *Esquisse d'une histoire économique de France*, Paris, 1929, pp. 300/301. This statement by Sée is in agreement with Levasseur's, op. cit., Vol. II, p. 402.
[49] Jacques Savary, *Le parfait négociant*, Vol. II, Chaps. 6 and 7, quoted from the fifth edition, Lyon, 1700.

We see that Borkenau's historical conception that capitalism in general and manufacture in particular "were not created by monetary capitalists, but by upward-striving little men" does not correspond to historical reality. It is a theory which presents the origins of capitalism, i.e. of the original accumulation, as an "idyll" according to which the "work," the "unlimited effort" (p. 176) serve to create the "solid" manufacturing capital (p. 155), and the "ascent to the capitalist class through strict rationalization of work" (p. 157) is achieved.

10. In the above we have shown how Borkenau simply disregards the development of capitalism in the premanufacturing period. Now we will examine manufacture and its division of labor.

In his opinion, manufacture's span of life extended from "the beginning of the sixteenth century" (p. 13) until the last third of the eighteenth century, i.e. over a period of almost 300 years. It is clear to anybody who has studied history that manufacture cannot have remained unchanged over such a long period. Borkenau does not take this into account. The problem of the "period of manufacture" is for him a simple and unambiguous matter. He speaks of "the manufacturing bourgeoisie" (pp. 13, 162) and of "manufacturing mentality" (p. 404), as if these were always concerned with absolutely fixed and unequivocal categories. "As is well known, the manufacturing technique consists of nothing but an extremely developed division of labor, while entirely retaining the foundations of the production process in craftsmanship" (p. 2). Manufacture abolishes the qualification for work, it replaces the skilled artisan with the unskilled laborer whose work consists of "the performance
[183] of a perfectly simple manipulation which is accomplished with precision and which "should be feasible even to a child, even to an imbecile" (p. 7). Thereby all special training becomes superfluous, manufacturing work loses all particular quality and "becomes pure quantity." Thus at the turn of the seventeenth century, manufacturing has replaced qualified work by "general human" or "abstract" work, therefore developing that concept which is the basis of modern mechanics. Thus the emergence of scientific mechanics in the beginning of the seventeenth century presupposes the prior development of manufacturing.

This presentation of the character of manufactorial work at the turn of the sixteenth and seventeenth centuries is sheer fantasy. It contains an inner logical contradiction. The term "craftsmanship" already implies a skilled type of work for which one is qualified. Work that can be performed by unskilled laborers, by anybody – also by children and imbeciles – for which no training is required, ceases to be "craftsmanship." Borkenau's generalized conception of manufacture is evidently based on the description in the first chapter of *Wealth of Nations*, illustrated by the far-reaching division of labor and dissection of the work process into simple manipulations of the production of metal pins. He transfers the situation and conceptions described by A. Smith which apply to the conditions of the second half of the eighteenth century to those prevailing in the sixteenth century, without giving a thought to the question as to whether the "manufacture" of the sixteenth century can be identified with that of the eighteenth century.

Borkenau has overlooked the various stages of development in manufacturing. Manufacturing has undergone various successive phases of development in its over

two hundred years of existence. The characteristics are clearly identifiable. (1) In the beginning, manufacturing appears in the form of simple cooperation between workers in a spacious workshop, without any trace of division of labor. Although laborers assembled in a workshop is a precondition for the subsequent division of labor, at first – during the extensive period of cooperative manufacture – this division of labor does not yet exist. At the end of the sixteenth and at the beginning of the seventeenth centuries there hardly existed any division of labor in the most advanced manufacture, the Dutch one; even less existed in the relatively backward French one. Cooperative manufacturing was followed by the (2) heterogeneous and (3) serial manufacture; these are not only two different basic modes but also two consecutive phases in the development of manufacturing history. Finally there arises [184]
the fourth and last phase, the "combination of manufactures" which, although not universally accepted, did exist as a tendency: the combination of different manufactories into an "overall manufacture." The highest stage of technical development is represented by the "organic" manufacture which subdivides the work process into the simplest, repetitive manipulations performed with virtuosity, where the end product of one worker is the starting point for his successor's labour. This "organic" phase represents the "finished form," the "perfected form" of the development of manufacture.[50]

It is a blatant anachronism to apply the division of labor in "organic" manufacture of the eighteenth century to the "cooperative" and "heterogeneous" manufacture of the end of the sixteenth and the start of the seventeenth century. In the second half of the seventeenth century, in England, William Petty only knows the "heterogeneous" manufacture, i.e. a plant structure in which several independent artisans work in one workshop under the same capitalist, and nevertheless fashion their products entirely by the traditional method, without division of labor into simple manipulations, where the final product, e.g. a clock or a carriage, results from "simple, mechanical assembly of separate partial products." Almost until the end of the seventeenth century, the division of labor into simple manipulations is out of the question, as is the replacement of skilled workers by unskilled ones, children, and imbeciles. The manufacture is based upon specialized and highly qualified craftsmanship; once specialized, the participants' separate tasks in the total complex are frozen, and a hierarchy of qualified partial specialists is formed.

Beside the hierarchical pyramid of differently trained and specialized workers there appears a new "class of so-called unskilled laborers," for, within specialized work, there are also "certain simple operations of which everybody is capable." In the latter class, which is an exception within the general specialization, "the cost of apprenticeship vanishes"; the lack of specialization is thus also turned into a [185]
specialty within the hierarchical specialization of manufacture.[51]

---

[50] Cf. Marx, *Kapital*, op. cit., Vol. I, pp. 342–348. [*Marx-Engels-Werke*, Vol. 23, pp. 362–371; *Capital*, Vol. I, pp. 342–350.]

[51] Op. cit., Vol. I, p. 351. [*Marx-Engels-Werke*, Vol. 23, p. 370; *Capital*, Vol. I, p. 350.]

Because of the qualified character of the work, manufacture was dependent on the workers, as they could not easily be replaced. This is also the reason for the struggle and efforts of governments to attract foreign workers (e.g. Colbert's demand for glassblowers from Venice, for tinplate workers from Germany, etc.), whereas on the other hand the emigration of specialized workers was forbidden and was threatened by heavy prison sentences.

Nothing is more characteristic of manufacturing work's qualified character than the conditions in the first mirror factory, established in 1663. Italian workers, brought from Murano in Venice at great expense, difficulty, and danger through the intermediacy of the French ambassador, earned 3–4 ducats daily. They were to train a certain number of French workers annually, yet they strictly preserved their professional secrets, so that the manufactories with their precious equipment "dépendaient absolument du caprice des étrangers." Once, when one of those Italian workers "celui qui gouverne les glaces sur les grandes pelles" had broken his leg, the manufacture had to be closed for ten days, but the workers had to be paid and the fires in the big furnaces maintained, because the other workers "ne savent faire sa fonction et n'ont pas même voulu y essayer, disant que c'est la plus difficile et qu'il faut l'avoir appris dès l'âge de 12 ans" (G. Martin, *La grande industrie sous le règne de Louis XIV*, Paris, 1899, pp. 77, 78).

Nowhere is the arbitrariness of Borkenau's construction better illustrated than in this question. With the progress of the division of labor, each partial procedure did not become simpler nor did qualified work become superfluous and replaceable by unskilled work. Parallel with the development of the division of labor one can observe a strengthening of the role played by qualified work rather than a weakening thereof. At the end of the fifteenth century – earlier in some countries and later in others – parallel with the development of the division of labor, a process of diversification of production began. Formerly only few and simple types of cloth were produced in England, so that one and the same clothmaker could master the spinning, weaving, and dyeing; at the end of the fifteenth century new types of cloth appeared: ordinary and fine cloth, straights and kerseys, were now made; the statute
[186] of 1484 contains half a dozen varieties in addition to the aforementioned ones. With the diversification of products came greater demands on the skills of the artisans, weavers, dyers, etc. – a development which would accelerate in the future.[52] The weaver had to learn to weave ten to fifteen different kinds of cloth, the ribbonmaker had to produce twenty or thirty kinds of ribbon, etc. We see a similar diversification in Holland. By the end of the sixteenth century, new branches of production, new raw materials, new techniques appear, and all these innovations demand higher qualifications; in Leyden, e.g., begins the weaving of fustian (1586), of serge (1597), and of "draps changeants."[53]

---

[52] W. Cunningham, *The Growth of English Industry*, German translation, Halle, 1912, Vol. I, p. 508.

[53] Baasch, *Holländische Wirtschaftsgeschichte*, Jena, 1927, p. 84.

New dyes, such as cochenille and later indigo, caused a revolution in the technique of dyeing. The smallest error could spoil large quantities of material. In Haarlem, in addition to delicate tablecloths, there were the famous "Bontjes" (linen mixed with cotton). In Amsterdam there was the production of ribbons and of velvet, in Rotterdam there was plush and "Bombasin." The same development occurred in France. With the rise of the wealthy bourgeoisie in the sixteenth century, luxury became more widespread (up to the fifteenth century this was limited to the nobility and the clergy), while cheaper, "lighter" luxury materials such as satin de Bruges, crêpe de soie, serges, étamines, caddis, etc. now came into demand.

11. We have seen how, according to Borkenau, "rational technology" was impossible during the period of "predatory capitalism" and how it only arose with the "solid" manufacturing capitalism, because the industrial bourgeois which developed from artisanship "needed a rational structuring of operations" (p. 9). Manufacture, thus rationalized, therefore represented a superior plant structure which soon replaced the previous forms of production. "The displacement of handicrafts by manufacture, though it had its beginnings already in the sixteenth century, nevertheless became general only in the seventeenth century, and introduced sophisticated manufacturing techniques" (p. 2). Alongside with this fundamental view, we find elsewhere another remark which evidently contradicts the former. There we learn with regard to the first half of the seventeenth century that in France "the emerging manufacturing bourgeoisie ... had to rely on government support in every respect" and that "without the direct protection of the government it could not [187]
exist at all" (p. 171). And this despite the "rational technique" and despite the great "sophistication" of that technique!

The "displacement of the handicrafts" by manufacture, which according to Borkenau has "become even more general," is a pure illusion. Let us take the example of France to examine the character of manufacture and the truth of Borkenau's statement. In general the handicrafts were not replaced by manufacture; in the seventeenth and even in the eighteenth century the workshop remained the predominant plant structure; even though there existed undertakings which in everyday and administrative language were called "manufactures," there was no manufacture in the sense of A. Smith up to the end of the seventeenth century, i.e. as a basis of far-reaching division of labor; the capitalist forms of undertakings, as far as there were such forms, were almost exclusively represented by the system of home industry.[54]

When after the civil war the state under Henry IV (1589–1610), the "créateur" and "père" of the mercantile economic policy, began to sponsor the manufacturing system, it endeavored to keep in the country the money which was payable abroad for luxury articles. Therefore "manufactures" of luxury goods – silk and

---

[54] Thus e.g. J. Kulischer says about the French silk industry in the seventeenth century: "... The flourishing silk, velvet and brocade industry of Lyon (including also the use of gold and silver threads for braids, lace, fringes, bows, etc.) was exclusively a home industry; there were no manufactures. About half of all French silk goods were produced in Lyon" (J. Kulischer, *Allgemeine Wirtschaftsgeschichte*, Vol. II, p. 171).

wallpaper plants, the manufacture of tapestries, crystal, and mirrors – were founded in the country. Since the luxury industry was never a field for division of labor and employment of unskilled workers, but always used highly qualified, artistically and technically trained craftsmen, these were imported at great expense and with difficulty from abroad: from Milan, Venice, and even from the Levant, and this despite the fact that France itself suffered from severe general unemployment (in Paris in 1595 there were more than 14,000 unemployed, in Amiens in 1587 almost 6,000, in Troyes in 1585 nearly 3,000). In these establishments "rational techniques"
[188] were out of the question. The system of official support and premiums was bound to encourage uneconomical, speculative undertakings, even when conditions for normal profitability did not exist. Despite the monopolies and financial subsidies granted by the king, these manufactories could not hold out. "La plupart de ces créations avaient succombé de son vivant ou après sa mort."[55]

In the next half-century there was no improvement, but a deterioration in the industrial development sphere. After Henry IV's death (1610), the king's creations went bankrupt under Maria di Medici's rule. Fresh creations were, of course, out of the question. Until Richelieu became minister, there followed "quatorze années de mauvaise administration et de désordre qui arrêtèrent de nouveau le progrès de la nation," – in short, it was a "période de stérilité."[56]

The eighteen years of Richelieu's ministry (1624–1642) were a period of general decline and exhaustion in the country "peu favorable à l'industrie."[57] Richelieu was too strongly occupied with higher politics, with the struggle against the Habsburgs, to devote his attention to industry. His most important creation is the Imprimerie Royale (1640); not even Borkenau would wish to claim that this was a special area for manufactured analysis of the labor process. Then came the time of Mazarin and the Fronde. Before Louis XIV came of age, France again went through a period of civil war. "La Fronde (1648–1652) . . . porta un grand préjudice aux affaires industrielles et commerciales."[58] It was "the time of France's total ruin. How then could one find industries?"[59]

And Levasseur's judgment is not different: "Quand Louis XIV prit la direction de l'État . . . l'industrie et le commerce paraissaient languissants." "Le nom de Mazarin . . . en réalité ne mérite pas une place dans l'histoire économique."[60]

Our analysis has shown that the "période semi-séculaire de 1610–1660 a été plus agitée par les troubles à l'intérieur et par la guerre avec l'étranger. La classe industrielle souffrit."[61] This half century which, according to Borkenau, was the
[189] period in which modern mechanics emerged, was not a period of technical progress

---

[55] E. Levasseur, op. cit., Vol. II, p. 176; cf. p. 170.
[56] E. Levasseur, op. cit., p. 187.
[57] Op. cit., p. 188.
[58] Op. cit., p. 199.
[59] C. Hugo, "Die Industrie im 16. und 17. Jahrhundert," in: *Der Sozialismus in Frankreich*. Stuttgart, 1895, p. 814.
[60] Op. cit., p. 201.
[61] Op. cit, p. 410.

but one of general economic decay and of sterility in industrial development in particular, in which there could be no question of "sophistication of techniques" and progressive division of labor. The decay was so complete that Colbert had to start the reconstruction of industries anew. Thus he himself wrote about his efforts for the establishment of manufactures: "La grande manufacture étant chose presque nouvelle, hasardeuse. . ."[62]

In France, even under Colbert and up to the end of the seventeenth century, there existed no manufactures in A. Smith's sense with extensive division of labor. Most of the manufactures established with government subsidies and privileges operated too expensively and therefore found few customers – which exposes the techniques they were based on! For instance, in Berri as well as in some other provinces "les marchants aimaient mieux acheter comme par le passé, aux petits fabricants qu'à la manufacture," since the small artisans were cheaper. How, then, might the "rational" division of labor of these manufactures have looked?[63]

In addition, due to Colbert's strict official regulation of industry (Règlements généraux of 1666 and the subsequent special regulations for individual sectors of industry), all technical procedures were precisely prescribed by law, which impeded all technical progress! All the historians, such as Mosnier, Sée, G. Martin, Sagnac, Levasseur, and Kulischer, agree on this point. Thus H. Sée says about the control: "Elle a pour effet de maintenir l'industrie dans l'immobilité, d'empêcher toute innovation."[64]

Despite the generous government subsidization, the "manufactures" went broke in France. This was not as a consequence of external coincidence; their ruin was the necessary result of the internal shortcomings of the Colbertian system of protection. They were an artificial product of the royal administration; they could thrive under [190]
the wings of royal protection and not by virtue of a rationalization of production processes. Rationalization as well as division of labor in particular are a necessity for the entrepreneur, imposed on him by the struggle of competition: a reaction to the difficulties of marketing. Through technological progress and division of labor, production should become cheaper, and through the drop in prices an advantage should be gained over the competitors. But the "manufacture," privileged by the state institutions, need not be afraid of competition, for it relies on royal subsidies, import restrictions, and monopolistic privileges. Instead of developing and becoming efficient in the competitive struggle, it loses its fighting strength in the unhealthy atmosphere of monopolistic protectionism. Borkenau himself admits that the emerging

---

62 Lavisse, op. cit., Vol. VII/1, p. 221.

63 Levasseur, op. cit., Vol. II, p. 274; Mosnier, op. cit., p. 127.

64 H. Sée, *Esquisse d'une histoire*, p. 295. Cf. Mosnier, op. cit., p. 140; Sagnac, op. cit., p. 210; Levasseur, op. cit., Vol. II, pp. 339, 341; J. Kulischer, op. cit., Vol. II, p. 107. For Borkenau's construction, which speaks of the "displacement of handicraft by manufacture, the assessment of the decline of manufacture by both contemporary writers (Vauban, Boisguillebert, Fénelon) and by present historians is a fatal fact. According to him, the decline of manufacture was only a decline in quotation marks, a result of intentional blows directed by the monarchy against capitalism! (p. 263).

French bourgeoisie "was in every respect dependent on government support," and that "without direct governmental protection it could not exist" (p. 171).

12. However, the manufactural work was by no means made redundant by unskilled labor -on the contrary, it always remained quality work. Also and especially for this reason, its effects on scientific mechanics were and had to be different from those stated by Borkenau! The highly sophisticated nature of the manufactural work makes it impossible for it to give impetus to the development of that "general human" and "abstract" kind of work which is the basis of scientific mechanics. On the contrary, manufactural work was fundamentally unsuitable for this. The most important characteristic of every mechanical labor is its homogeneity; the work done is always identical qualitatively and is only different quantitatively, and these differences can be exactly measured. (Descartes, in the preface to his *Traité de la Mécanique* (1637) presupposes such homogeneity of performance as a condition for measurability.)

It is just this characteristic of homogeneity which every labor of man or animal is lacking. The manufactural worker's performance is not "general human," i.e. qualitatively always uniform, but is dependent on the worker's strength and skill, and therefore individually different, subjective – therefore not *homogeneous*, not *uniform*. In the long run man performs uniform movements only very imperfectly.

This individual, subjective character of human labor precludes, according to
[191] Marx, "truly scientific analysis," viz. exact quantitative methods are not applicable to it. Borkenau makes an effort to formally agree with Marx's standpoint (p. 2), but then to prove the contrary, namely that manufactural work had excluded qualification thereby becoming "general human" work; it had thus founded the basis for exact scientific analysis, for exact quantitative methods in mechanics!

If the far-reaching division of labor sufficed for the development of a "general human" labor, then scientific mechanics would have already emerged in the fourteenth century. Borkenau says repeatedly that the manufactural technique of the seventeenth century consists of a "division of labor to the utmost degree," yet in this matter, which is of decisive importance for his conception, he does not adduce a single example, not even a source. If one compares the division of labor in England and France of the sixteenth and seventeenth centuries with that practised in Italy during the fourteenth century, one will see that the former had a rather miserable appearance, whereas e.g. in the silk industry of Lucca and Venice a total of sixteen separate processes of labor are mentioned, including winding, twining, boiling (*cocitori*), dyeing, rolling bobbins (*incannaresse*), warping, weaving, etc.[65]

Because of human labor's aforementioned subjective, heterogeneous character it could not serve – divided or undivided – as the basis of scientific analysis; therefore

---

[65] Broglio d'Ajano, *Die Venetianische Seidenindustrie*, pp. 21/23. In the Florentine cloth industry at the beginning of the fifteenth century, one distinguished between the following processes: sorting, washing, beating, combing, scraping and carding of wool, weaving, dyeing, shearing, weaving, degreasing, fulling, roughing, stretching, smoothing, pressing, rolling, etc. of cloth – altogether up to thirty different partial processes: Doren, *Studien*, op. cit., Vol. I, p. 43.

the impetus to theoretical mechanics was not given by human labor but by the material means of labor, the machine, i.e. only to the extent that this narrow subjective barrier of human labor was overcome! In the manufacture "the process was previously made suitable to the worker"; thus "the organization of the social labor process is purely subjective." "This subjective principle of division of labor no longer exists in production by machinery. Here, the process as a whole is examined objectively" and therefore open to scientific analysis, to quantitative methods. "The implements of labor, in the form of machinery, necessitate the substitution of natural forces for human force, and the conscious application of science, instead of rule of thumb."[66]

Thus we arrive at the decisive point: In the course of their development since the middle of the fifteenth century, the mechanistic thinking and the progress of [192] scientific mechanics show no trace of a closer relationship to manufactural division of labor, but are always and everywhere closely related to the use of machines! It is typical that Borkenau suppresses all traces of the use of machines over a period of some three hundred years, thereby deterring the reader from thinking that modern scientific mechanics have anything to do with machines! Thus, for instance, he speaks of "the technique of the artisan, which is almost exclusive to the period of manufacture" (p. 8).[67] Thus he does not mention Descartes' *Traité de la Mécanique* of 1637, although he discusses all his other works.

As a matter of fact, manufacture has never been a form of production in which artisanship "is almost exclusive." From the very beginning, machines were used in manufacture – and even before – and for two purposes:

(1) As motor mechanisms, where human labor was replaced e.g. by water power, as in mills and other water-driven machines. This in particular was the strongest incentive for going deeper into theoretical mechanics. Namely, when attempts were made to achieve an increased performance (e.g. driving two milling processes or two stamps by means of one water wheel), the overstrained mechanism of transmission became incompatible with the insufficient water power, which led to research into the laws of friction.
(2) As working machines – wherever there was a matter of crude, undivided, largescale processes requiring the application of brute force: crushing ore in metallurgy, so-called stamping mills in pits and mines, grinding rags in paper mills, etc.

Water power was instrumental in one of the greatest upheavals of technology, the revolutionizing of the iron and mining industries. Since Roman times, iron was obtained from ore in the smithies' primitive furnaces in the woods. Farmers usually [193] did this as a sideline. The invention of casting iron and the transition to blast furnaces

---

66 Marx, *Kapital*, op. cit., Vol. 1, pp. 383, 390. [*Marx-Engels-Werke*, Vol. 23, pp. 401 and 407; *Capital*, Vol, III, pp. 380, 386.]

67 Thus he already contradicts himself on the following page, where he says that the seventeenth century was a century of water, while the nineteenth was a century of fire. But it could become a "century of water" only through the natural force of water applied as the driving power for machines which replaced artisan's labor.

and to the indirect production of crude iron came with the beginning of the fifteenth century. The technical starting point of this upheaval was the use of water as driving force in the production of iron, viz. the water-powered hammers in smelting and in moving the bellows when melting and forging. This technical upheaval, itself connected with the upheaval in the technology of warfare and the greater need for iron, soon led to a social upheaval, to the relocation of the iron industry from the heights of the mountains and woods to the river valleys. There, the numerous small furnaces were replaced by large-scale enterprises with mass production: impressive blast furnaces with foundry buildings, water wheels, bellows, stamping works, and heavy water hammers operated on a capitalistic basis with wage labor and rational bookkeeping.

Furthermore, water power caused the upheaval in the mining industry from the second half of the fifteenth century. The use of water as another mechanism for powerful pumping works and conveyor systems enabled the first really deep excavations, the building of deep mines and shafts. In general the exploitation of the natural forces (water in the mines, machines for crashing ore, etc.) enabled the application of concentrated power which transcended human power, thus rendering mankind independent of the latter and placing it before new tasks. This was the beginning of the technological age.[68]

[194] It is evident that man, in all these technological upheavals, acquired new, important material for observing and contemplating the actions of forces. In the machines, in the turning of the water wheels of a mill or of an iron mine, in the movement of the arms of a bellows, in the lifting of the stamps of an iron works, we see the simplest mechanical operations, those simple quantitative relations between the homogeneous power of water-driven machines and their output, viz. those relations from which modern mechanics derived its basic concepts. Leonardo da Vinci's mechanical conceptions and views are only the result and reflection of the experiences and the machine technology of his time, when one new technical invention follows the other or the previous inventions are improved and rationalized.[69]

---

[68] The technical revolution in mining brought about a thorough social upheaval. With the extension of mining, the need for more capital to finance the building of shafts, ventilation, ore-lifting, and water storage systems caused a *thorough change in ownership and concentration of capital*: on German soil and in adjacent regions, in the middle of the fifteenth century the small medieval (communal) enterprises became dependent on a few financially powerful putting-out capitalists, usually wholesale ore dealers (as e.g. the Fuggers in Augsburg), who granted them advances, took possession of their shareholdings (Kuxe), while the original members of the miners' union, deprived of their ownership, were reduced to wage laborers. In this manner *industrial capitalism in the German, Tyrolean, and Hungarian mining industry became a major power long before the Reformation*. The financial support of the Fuggers was not only instrumental in 1519 in the election of Charles V as emperor; this big power, as we know from Ranke, was even capable of thwarting the strengthening of the central government within the empire, so as to safeguard the interests of its own price monopoly and unrestricted profits.

[69] Since the middle of the fifteenth century a technical literature emerges. The oldest printed publication on technical matters, with numerous descriptions of machines, is the book of Valturio Roberto of Rimini, written about 1460 and printed at Verona in 1472. Vanuccio Biringuccio of Siena, the originator of modern metallurgy, mathematician, engineer, and practical director of

Here in the case of machines we see the tendency toward the replacement of qualified work by unskilled labor at an early stage – which Borkenau ascribes to the division of labor in manufacture. Yet for Borkenau the mechanical aspect of manufacture does not exist; he does not even mention it. Even though during the period of manufacture the work of machines was quantitatively less important than the work of human beings, it was most significant for theoretical mechanics. Marx has demonstrated that the sporadic use of machines in the seventeenth century was extremely important and inspired the great mathematicians of the time to initiate modern mechanics. Research in economic history has since revealed much new material; chronologically the use of machines began much earlier and their sophistication and frequency was greater than was assumed only sixty years ago. But Borkenau wants the basic concepts of theoretical mechanics to be derived from the manufactural division of labor, which is why the history of machines and their use must be obliterated from the horizon.

13. According to Borkenau, the manufacturing period at the turn of the sixteenth and seventeenth centuries *put capitalist accounting into practice*, thereby [195]
also enabling the observation of nature according to quantitative methods. It must be stated against this: capitalistic calculation has nothing to do with any work processes. As Max Weber correctly remarked, it is a formal procedure of comparing the monetary value of expenses (costs) with income (prices) for the sake of maximal profitability. Once it had developed in the sphere of trade, capitalist calculation could easily be extended to the sphere of production. Exact accounting, like the general partiality for exact methods of measuring in diverse areas of knowledge, was first developed in Italy during the thirteenth and fourteenth centuries.[70] This development culminated in the first scientific system of double-entry bookkeeping in Fra Luca Paccioli's book (1494), in which Paccioli theoretically formulated a practice in use for a hundred years, viz. since the second half of the fourteenth century (Sombart, loc. cit., p. 312). The oldest well-kept Italian account books originated in the fourteenth and fifteenth centuries. In Italy, the period's leading capitalist country, says Sombart, "the general spirit of rationalization and mechanization was most advanced" (loc. cit., p. 325). Double-entry bookkeeping "organizes the phenomena in an intricate system which one can call the first cosmos based on the principle of mechanical thinking . . .. It is the consistent application of the basic idea of quantification which entails the endeavor to conceive all phenomena merely as quantities,

---

mines and iron works, describes in his *Pirotechnia* (1540) the mechanical system for the better exploitation of water power, which he invented and introduced in northern Italian iron works: a large bucket-wheel, which set in motion a number of bellows and could serve four fires at the same time, for which otherwise four water wheels had been needed. – Georg Agricola shows in book VIII of his work *De re metallica*, written around 1550 (Basel 1556), the construction of the crushing machines which were already used in Germany in the fifteenth century for the crushing of iron ore. The water wheel moves at first one, and later three or four crushing stamps, which entailed a considerable *rationalization* of the work and a saving in manpower. (Cf. Ludwig Beck, *Geschichte des Eisens*, Braunschweig, 1893, Vol. II, p. 87.)

[70] W. Sombart, "Die Entstehung der kapitalistischen Unternehmung," *Archiv für Sozialwissenschaft*, Vol. 41, 1915, pp. 311, 325.

an idea which brought to light all the wonders of the cognition of nature." In short, the "double-entry bookkeeping, developed in the fourteenth century, originated from the same spirit as the systems of Galileo and Newton" (loc. cit., p. 318). Here again, Borkenau has eliminated from history two hundred years of capitalist methods of calculation.

The Substantiation of Borkenau's Conception

Until now we have outlined Borkenau's conception and have confronted it with
[196] reality; now the question arises of how he substantiates his conception. To him there are only two ways of considering historical facts: the descriptive presentation, which he scorns, and the emphasis on "structural" moments, i.e. their arrangement into a structured scheme. We have seen how he neglected the historical development of natural sciences and presented the historical change in the concept of natural laws in its place. We see the same disdain for facts in his principal conception of the connection between mechanistic philosophy and manufactural division of labor. Here, too, a proof is replaced by an assertion. Borkenau himself comments on his thesis: "if this conception is valid, then the actual scientific research of the time had to be done at [sic!] the manufactural production process itself" (p. 6). This can only mean that scientific research had to frame its basic concepts according to the manufactural division of labor which presented the material for scientific analysis. Now Borkenau himself establishes that three different technical procedures existed side by side during the period of manufacturing: (1) the traditional artisanship, (2) the division of labor in manufacture, and finally (3) "the factory which was emancipated to a large extent from artisanship," i.e. if we express this phrase more clearly – mechanical production by machines. And Borkenau finds: "It is striking that the science of the period allows itself to be led exclusively by the methods of manufacture" (p. 4). In the face of this "striking exclusiveness" it ought not be difficult to adduce the necessary evidence. Yet no such evidence is produced.

Borkenau tries to illustrate his thesis by the example of physiology: "At the very beginning of the seventeenth century, physiology obtains its scientific foundation through Harvey's discovery of blood circulation which he explains with the analogy of a pump mechanism" (p. 5). One asks with surprise: what does a pump mechanism have to do with the manufacturing methods based on division of labor? After all, the pump is a machine. Thus, instead of demonstrating the connection of mechanically conceived physiology with the division of labor in manufacture, Borkenau demonstrates its orientation towards machines. Elsewhere he says with regard to the seventeenth century that the "manufacturing period" was simultaneously "the century of water" (p. 9), that is, a century which built machines driven by water. But what have water-driven machines to do with the division of labor in manufacture? Finally, on a third occasion he asserts that this connection is "evident in Simon Stevin, the field engineer of Moritz of Nassau," the founder of modern mechanics in Holland (p. 6). And again we ask in wonder: what does the practice of field
[197] engineers have to do with the method of division of labor in manufacture? These are

the only examples given for the historical proof of the alleged connection. Galileo's mechanics and those of his time are said to be nothing but the scientific treatment of the process of manufacturing production. "According to the latest state of research, this thesis can now be critically confirmed by the recourse to the sources, which was until recently impossible" (p. 6). Yet Borkenau does without this attestation from sources. To console us he says that this can be found in another author's book. Olschki, he says, "in his excellent research on Galileo and his time," has proven that what is innovative in Galileo's quest is the rejection of theoretical tradition and the reference to the active technicians' practice.[71] The same interconnection with practice, Borkenau says, was also "self-evident" for Simon Stevin, the field engineer (p. 6). But we can only repeat our question: what does the connection with the praxis of technicians have to do with the scientific treatment of the division of labor in the manufactural process of production? After all, we know that three different procedures existed side by side in the practice of the manufacturing period. The "connection with the praxis" does not yet indicate with which praxis the connection was established – the artisan's, the manufacturer's or the praxis with machines. Thus Borkenau thinks with regard to Francis Bacon that it was "precisely Bacon's close ties with the most highly developed (i.e. mechanical, H. G.) forms of industrial praxis" which impeded his access to those basic forms of technique which became the foundations of the mechanistic world view (p. 90). Therefore, if Borkenau's thesis is to make sense at all, then proof should be provided not only of the connection with some kind of praxis but of manufacture based on division of labor. For this is the "thema probandi" of Borkenau's book. He does not provide the proof, and Olschki, whom he cites, does not either.

In addition to the historical evidence in the sources, Borkenau wants to provide a second, theoretical proof: "The new mechanistic world view's dependence on the technique of manufacture can also be easily shown from their respective contents." And now the reasoning we already know follows – by the division of work into simple manipulations, the skilled workers are replaced by unskilled ones, whereby all work is reduced to uniform, "general human," and thus quantitatively measur- [198]
able labor. Only thereby do the quantitative methods which are the foundations of mechanics become possible. We have already shown what this reasoning is worth. Where and how the argument by "content" is supported by evidence is essential here. This is already provided in the introductory remarks on p. 7 of the book, before the start of the research and before any material has been presented. In the book itself, especially in the section on Descartes, no further proof is brought; the previously developed trend of thought is simply repeated (p. 357).

---

[71] Everyone familiar with Alberti's and Leonardo da Vinci's achievements, knows that Galileo's rejection of the traditional academic science and his reference to practice is not "innovative." One hundred and fifty years before Galileo, Alberti, this "truly universal Titan" – as Burckhardt calls him – studied all possible sciences and arts; "he went into physics and mathematics and simulataneously learned all the skills of the world, asking artists, scholars, and craftsmen of all sorts, including shoemakers, about their secrets and experiences" (Jakob Burckhardt, *Die Cultur der Renaissance in Italien*, op. cit., Vol. I, p. 150).

We are told of Descartes' whole family's civic history, the professions of his father and grandfather, of his mother's father and grandfather, of the grand-uncles and other ancestors; we are given a lengthy interpretation of the dreams in the mystical crisis of Descartes' youth, from which – after all the biographers' earlier interpretations – nothing substantially different or better emerges; we find many other superfluous details – however, what is really essential for the thesis is missing, viz. positive evidence of the connection between mechanistic philosophy and division of labor in manufacture. Within the system of categories actually used, the reduction of the elements of the mechanistic world image to the division of labor in manufacture proves to be decorative, "materialistically" adorning the genesis of mechanistic philosophy, but by no means serving as a means of analysis. In the book itself this technique of division of labor in manufacture is inconsequential in the analysis of individual thinkers' actual ideas or of concrete intellectual trends.

Only when one bears this in mind does Borkenau's attitude toward a series of phenomena become comprehensible – e.g. toward the inventions of the Renaissance: there were many, and some were "of the greatest importance," but were made only accidentally, by practitioners, without a possibility for perfecting them systematically. Again, it is enough to mention Leonardo da Vinci to see this assertion's baselessness. All his inventions – and there were dozens of them – emerge from the theoretical cognition of the relevant subject matters. Leonardo himself writes:
[199] "The practice must always be based upon good theory."[72] "Science is the captain, practice the soldiers."[73] The research on air and air pressure laws led him to construct the parachute, invent the pluviometer (which measures the humidity in the air), the pendulum of the anemometer (which measures the wind force) and to his systematic, long-lasting endeavors to construct a flying machine.[74] The discovery of the most important laws of mechanics, of the law of the lever, of the inclined plane, the screw, etc., all of which he traces back to the pulley, leads him to the construction of various pulleys and combinations of pulleys, winches and various lifting machines. The discovery of the laws of hydrostatics leads him to the idea of the artesian well, for which he also constructs the suitable drilling equipment.

For Borkenau the inventions of the Renaissance are purely "accidental." Had he really applied the thesis of the connection between mechanics and division of labor, he would soon have encountered factual connections which would have induced him to revise his thesis. He would immediately have grasped the connection of Renaissance inventions with the situation prevailing in Italian industry. But he did not pay any attention to the Italian economy's development at that time. He made do with the empty formula of the incipient monetary capitalism as a general explanation.

Due to lack of space it is impossible to describe in greater detail Italy's state of affairs in those days. Let us only recall that, as a consequence of the shift of the international trade axis from the Mediterranean to the Atlantic coast of Europe,

---

72 M. Herzfeld, *Leonardo da Vinci*, op. cit., p. xvii.

73 G. Séailles, *Leonardo da Vinci, l'artiste et le savant*, Paris, 1906, p. 353.

74 Op. cit., p. 231. Cf. F. M. Feldhaus, *Die Technik*, Leipzig 1914, and idem, *Leonardo da Vinci, der Techniker und Erfinder*, Jena, 1913.

Italian capitalism – which had been flourishing for almost two hundred years – experienced a sudden recession. This was aggravated by the wage increases caused by the best manpower's move from the cities to the country – into gardening. In order to compete with the world markets, efforts were made to reduce production costs. Hence the trend toward replacing expensive human labor with cheap natural power – water power – a context which clearly emerges from Leonardo's[75] writings.[76] Do we here encounter the problem of capitalist "rationalization"? By no means, according [200]
to Borkenau; for him it is an established fact that rational technique can only "be put into practice for the first time during the manufacturing period," that it only "develops from the endeavors to rationalize crafts," and that its bearers could not be the religiously indifferent Renaissance men, but only the "Calvinist ambitious little men" (p. 90).

Not only the general connections between industrial development of Italy and the invention of industrial machinery become clear with an economic analysis. One can go further and recognize that certain inventions are determined by the social situation of a particular stratum. Since the late fifteenth century, Venice, the maritime power, had been using, on its war galleys propelled by rowing slaves, mitrailleuses of a special structure consisting of twenty barrels arranged in two circles, with the ten interior barrels longer than the ten outer ones. During normal service on the galleys the whip was enough to impose obedience; in face of the enemy in battle the situation was different. In this connection we learn about the purpose of the mitrailleuses: "elles servaient à tenir les rameurs en respect pendant l'action, quand le fouet des surveillants n'y suffisait pas." The salvo from the shorter barrels was intended for the more closely placed slaves, that from the longer barrels for the more distant side of the ship.[77]

The Sources of Descartes' Mechanistic Conception According to His Texts

Since in Descartes there is no reference to division of crafts labor, the question arises: what do his texts reveal regarding the sources of his mechanistic inspiration? In all his principal works we find numerous explicit references to machines. These are not just occasional remarks but are the foundations of his mechanistic conception. His concept of the world and its parts being a mechanism is demonstrated in decisive passages of his argumentation with the example of machines. None of these numerous passages, which are at the core of the Cartesian arguments, is [201]
ever mentioned by Borkenau! And there is even more. He also negates the practical importance that Descartes attributes to the machines as a way of reducing human

---

[75] Grothe, op. cit., p. 10.

[76] G. Cardano, in his book *De subtilitate* (1550) stresses the most important advantages of the use of machines: (1) the savings in manpower, (2) the possibility of employing unskilled, and therefore cheaper, workers, (3) less waste of material, thereby making production even cheaper, (4) general advantages of hygiene, thus saving cleaning expenses.

[77] E. Hardy, *Les Français en Italie* de *1494 à 1559*, Paris, 1880, p. 37.

labor, in short, as productive forces. "By the way, there is no doubt that, in regard to the practical usefulness of knowledge, he was much less interested in the development of productive forces than in medicine. His mechanical inventions were limited to appliances for polishing lenses" (p. 274). Indeed, Descartes was a physician and not an engineer. His interest in the development of productive power was not based upon the utilization of his own inventions but on his conviction that science can be generally useful for practical tasks of life. Although "there is no doubt" that Descartes was less interested in the practical applicability of knowledge and in the development of productive power – a statement not substantiated by a single word – there is evidence to the contrary. It is precisely the development of productive forces, the practical usefulness of knowledge for dominance over nature and alleviation of human toil and labor which Descartes – in contrast to the speculative philosophy of earlier times – posits as the main tasks of science. In this respect he does not differ in any way from Bacon.

In the first part of the "Discours" of 1637 he already says, ". . . que les mathématiques ont des inventions trés subtiles, et qui peuvent . . . faciliter tous les arts et diminuer le travail des hommes."[78] And he pursues that same thought even more consistently at the close of the "Discours": "Les notions générales touchant la physique" – which Descartes acquired – "diffèrent des principes dont on s'est servi jusqu'à présent" . . . "car elles m'ont fait voir qu'il est possible de parvenir à des connoissances qui soient fort utiles à la vie, et qu'au lieu de cette philosophie spéculative qu'on enseigne dans les écoles on en peut trouver une pratique par laquelle, connoissant la force et les actions du feu, de l'eau, de l'air, des astres, des cieux, et de tous les autres corps qui nous environnent, aussi distinctement que nous connaissons les divers métiers de nos artisans, nous les pourrions employer en même façon à tous les usages auxquels ils sont propres, et ainsi nous rendre comme maître et possesseurs de la nature." To leave no doubt as to how this domination of nature should be achieved through increased knowledge of nature, he adds that
[202] this is desirable "pour l'invention d'une infinité d'artifices (i.e. artificial machines, H. G.) qui feroient qu'on jouiroit sans aucune peine des fruits de la terre et de toutes les commodités qui s'y trouvent."[79]

Here – in Descartes' own words – the source which provided the initiative for working out the mechanical concept of work is in the machines, and not connected with the division of labor in manufacture, as Borkenau claims. The practical aim of easing human labor through the work of machinery presupposes the comparison

---

[78] *Oeuvres*, Adam and Tannery, eds., Paris, 1897, Vol. VI, p. 6.

[79] This practical function of Descartes' philosophy is so evident that J. H. von Kirchmann could write sixty years ago: "Here the same tendency is evident in Descartes as in Bacon. Both were so enthusiastic about the new discoveries that they emphasized above all the need for inventions of methods and machines that were to prove beneficial in practical life" (*R. Descartes' philosophische Werke*, Berlin, 1870, part I, p. 70). Ten years after the "Discours," at the end of his preface to the "Principes," Descartes stresses the importance of science for improving the quality of practical life and shows "combien il est important de continuer en la recherche dc ces vérités et jusques . . . à quelle perfection de vie, à quelle félicité elles peuvent conduire" (*Oeuvres*, Vol. IX, p. 20).

between both types of work, their reduction to general mechanical concepts of work and the quantification of the work done. Only thus can it be ascertained whether the machine really does reduce human labor.

For Descartes, *mechanics is first of all a theory of machines*, whose principles are subsequently extended to physics and to the whole universe. Thus in his work one finds lifting machines, which were used for centuries in architecture and in loading ships' cargoes, mentioned as the first group of mechanisms. In the "Traité de la Mécanique" which he develops in his letter to Constantin Huygens (5 October 1637), using the examples of the *poulie* (pulley), the *plan incliné* (inclined plane), the *coin* (wedge), the *tour* (winch), the *vis* (screw) and the *levier* (lever) – the simplest elements to which every machine can be reduced – he gives the "explication des machines et engins par l'aide desquels on peut avec une petite force lever un fardeau fort pesant."[80] In his letter to Mersenne (13 July 1638) Descartes develops the same thoughts; he deduces the principles of mechanics from the contemplation of machines and at the same time, like Leonardo da Vinci 140 years before him, reduces all machines to the inclined plane, as their basic form.[81] Descartes gives us the theory of the pulley (*mouffle* or *poulie*), the *plan incliné*, and the *levier* one after the other. The latter, he says, is nothing but "un plan circulairement incliné." Likewise, "le coin et la vis ne sont que des [203]
plans inclinés, et les roues dont on compose diverses machines ne sont que des leviers multipliés, et enfin la balance n'est rien qu'un levier qui est soutenu par le milieu."

The relations between machines and the principles of mechanics are just as clear and close in Descartes as the relations between machines and his mechanistic philosophy. A short synopsis of his major works will confirm this.

In his early work, the "Cogitationes Privatae" (December 1618), he is already interested in the mechanical motions of the machine, and he describes a statue with pieces of iron in its arms and legs.[82] Immediately afterwards he mentions the artificial mechanical dove of Archytas of Tarent: "Columba Architae molas vento versatiles inter alias habebit, ut motum rectum deflectat."

This is not the place for a close investigation of Descartes' experiences with artillery. Suffice it to say that he was entirely familiar with cannons, which after all are machines, with the specifics of the motions they produce, with the trajectory and speed of the projectiles, and with all the factors on which the performance of this machine, namely the trajectory and speed, depends;[83] visible and important

---

[80] *Oeuvres*, op. cit., Vol. I, p. 435.

[81] Clerselier, *Lettres de Descartes*, Paris, 1657, Vol. I, letter LXXIII. Cf. *Oeuvres*, op. cit., Vol. II, pp. 236–223

[82] *Oeuvres*, op. cit., Vol. X, p. 231.

[83] In the Jesuit college at La Flèche, Descartes received an education which included, among other subjects, instruction in "l'art des fortifications et l'emploi des machines"; this education was "orientée vers la pratique militaire et orientée à former . . . un officier d'artillerie ou du génie" (P. Mouy, *Le Développement de la physique cartésienne*, Paris, 1934, p. 2).

traces of this remained in his thinking. In the second essay, "De la Refraction"[84] of the "Dioptrique" (1637), which was published simultaneously with the "Discours," he tries to explore the laws of optical reflection by establishing first an analogy between the unknown connections of optical phenomena and the laws of ballistics with which he is familiar. He compares the ray of light and the laws of its refraction with the trajectory of an artillery missile and its laws. A cannon ball, shot into a river at a certain angle, will not penetrate the water surface but will be refracted [reflected] at the same angle to the other side, as if it had hit a solid object. "Ce qu'on
[204] a quelquefois expérimenté avec regret, lorsque, faisant tirer pour plaisir des pièces d'artillerie vers le fond d'une rivière, on a blessé ceux qui étaient de l'autre coté sur le rivage."[85] Descartes' great discovery, the law of refraction, is also determined by his experiences with artillery pieces!

As a former artillery officer he also obviously knew all other factors determining the trajectory and speed of the missile (such as the length and elevation of the barrel, the amount and chemical composition of the gunpowder), which are elaborated at length in the *Principes de la Philosophie* (1647).[86]

Elsewhere in the "Principes" he mentions the cannons which are based on the principle of compressed air: "ce qui a servi de fondement à l'invention de diverses machines, dont ... des petits canons, qui n'étant chargés que d'air, poussent des balles ou des flèches presque aussi fort ... que s'ils étaient chargés de poudre."[87]

But aside from the wide area of lifting machines and machines for military use, mention is also made of other machines which were equally important for the development of mechanics: the clock and the motor mechanism in industry, the "machines mouvantes." These represented the real origin for Descartes' mechanistic conception.

Borkenau quotes the following sentence from the fifth part of the "Discours": "les règles des mécaniques, qui sont les mêmes que celles de la nature" and states: Descartes "demonstrates it there with the famous example of blood circulation, mainly adopted from Harvey" and derives the very laws of nature from mechanics (p. 356). But how did Descartes arrive at his mechanics? Borkenau reiterates the well-known conception: Up to Descartes, scientific mechanics were impossible, because "the world was a sum total of static systems" and therefore the manner of observation had to be a qualitative one. Only when the social world is set in motion, a movement which dissolves all traditional stratified orders, does "the qualitative mode of observation fall away, and what replaces it must be at the same time quantitative, mathematical and dynamic" (p. 357). This quantitative mode of observation is once again connected with the division of labor in manufacture, since
[205] "in manufacturing work, the quantified performance, the computable movement belongs with the quantified material" (loc. cit).

---

[84] *Oeuvres*, op. cit., Vol. VI, p. 93.
[85] *Oeuvres*, op. cit., Vol. VI, p. 99.
[86] *Oeuvres*, op. cit., Vol. IX, p. 262.
[87] *Oeuvres*, op. cit., Vol. IX, p. 227.

The arbitrariness of such an assertion shows itself precisely in the quotation from the "Discours" – if only one reads it till the end! Only in the fifth part, and referring to the description of the heart's and blood's movements, does Descartes say: "que ce mouvement que je viens d'expliquer suit aussi nécessairement de la seule disposition des organes . . . qu'on peut connaître par expérience, que fait celui d'une horloge, de la force, de la situation et de la figure de ces contrepoids et de ses roues."[88] There is no allusion to the division of labor in manufacture, but there is a comparison with a machine, with the clock; the movements of the heart and blood are just as much conditioned by the disposition of the bodily organs as the movement of a clock is conditioned by the disposition of its weights and wheels! After the description of the blood circulation, in which Descartes says that the rules of mechanics are the rules of nature – which in this context can only mean that the movements in nature take place according to the same principle as the mechanical movements of a clock – he presents the problem of the automatics of the movements of single organs of the body, e.g. of the muscles, and believes that these, by virtue of their disposition, "se puissent mouvoir sans que la volonté les conduise."[89] How does he illustrate the possibility of such automatic movement of muscles, to make it understandable to his contemporary reader? Not by the division of labor in manufacture, but by motor mechanisms! The possibility of automatic body movements, says Descartes, will not surprise anybody, "qui sachant combien de divers automates ou machines mouvantes l'industrie des hommes peut faire, sans y employer que fort peu de pièces." Every animal body, because it is more complex, and consists of a large number of components, is more perfect, compared to these machines and we can consider the body "comme une machine qui, ayant été faite des mains de Dieu, est incomparablement mieux ordonée et a en soi des mouvements plus admirables qu'aucune de celles qui peuvent être inventées par les hommes."[90] Thus the human body's functions are of the same kind as mechanical movements, yet machines, as compared with man, show a limitation by which they can be clearly distinguished. In order to demonstrate this, Descartes uses the fiction of a perfect man-machine which is capable of moving and uttering words. Even if this is of the best possible [206]
external likeness, such a machine will be different from man in principle, since it can only speak a few exactly prescribed sentences and execute only certain movements, whereas man can react in varied ways to all possible situations by means of his reason, because "la raison est un instrument universel."[91] In this way, the simplest man differs from the highest animal or the best machine. For animals possess no reason; even if they execute certain functions better than man, they are only acting mechanically: "C'est la nature qui agit en eux selon la disposition de leurs organes: ainsi qu'on voit qu'un horloge, qui n'est composé que de roues et de ressorts, peut compter les heures et mesurer le temps, plus justement que nous avec toute

---

88 *Oeuvres*, op. cit., Vol. VI, p. 50.
89 *Oeuvres*, op. cit. Vol. VI, p. 55.
90 *Oeuvres*, op. cit., Vol. VI, p. 56.
91 *Oeuvres*, op. cit., Vol. VI, p. 57.

notre prudence."[92] In the third meditation of the "Méditations" (1641), the famous proof of God's existence is based on the reality of the idea of God, and in answer to Caterus' "first objections" (1647): the essential argumentation is based on the example of machines. Just as the idea of the machine is based upon its builder's knowledge of mechanics, thus the idea of God must originate from God.[93]

This conception is even more strongly expressed in the seventeenth century by Descartes' successors, whose education was based on his teachings and who all use the example of the clock.

Like Descartes, Robert Boyle (1626–1691) regards the human organism "tamquam machinam, e partibus certis sibi adunitis consistentem." In his endeavor to reconcile religion with science within a unified world picture, the watchmaker's relation to the clock (which he illustrates with the Cathedral of Strasbourg's famous clock) serves as the model for the teleological conception of nature on a mechanical
[207] basis.[94] It is not different with Newton (1642–1727). His God appears as a watchmaker who – according to an ironical remark of Leibniz (1715)[95] – needs to rewind the clock of the world from time to time. Voltaire – a Newtonian – still writes in a letter dated 26 August 1768: "Les athées n'ont jamais répondu a cette difficulté qu'une horloge prouve un horloger."

Descartes, in his last work *Les passions de l'âme* (1649) again reverts to the comparison with the clock in order to make the difference between a living and an inanimate body comprehensible: "Le corps d'un homme vivant diffère autant de celui d'un homme mort que fait une montre, ou autre automate (c'est-à-dire, autre machine qui se meut de soi-même), lorsqu'elle est montée, et qu'elle a en soi le principe corporel des mouvements pour lesquels elle est instituée, avec tout ce qui est requis pour son action, et la même montre ou autre machine, lorsque'elle est rompue et que le principe de son mouvement cesse d'agir."[96]

An even more important role than that of the clock is played by various other types of motor mechanisms, "machines mouvantes," in particular water-driven machines, which were then originally invented for the Italian industry, and subsequently used for purposes of domestic convenience and for the embellishment of the affluent's palaces and gardens. In "Discours VIII," entitled "De l'arc-en-ciel," in his work *Les Météores* (1637), Descartes describes his experiences, which were probably gathered in Rome, with the artificial creation of rainbows whose form could be varied according to different arrangements of the holes in the fountain, in

---

92 *Oeuvres*, op. cit., Vol. VI, p. 59.

93 "Ce que j'ai éclairci dans ces responses par la comparaison d'une machine fort artificielle, dont l'idée se rencontre dans l'esprit de quelque ouvrier; car, comme l'artifice objectif de cette idée doit avoir quelque cause, a savoir la science de l'ouvrier . . . de même il est impossible que l'idée de Dieu qui est en nous, n'ait pas Dieu même pour sa cause" (Abrégé de la troisième Méditation, *Oeuvres*, op. cit., Vol. IX, p. 11. Cf. pp. 83–84).

94 *The Works of Robert Boyle*, London 1772, Vol. II, "Of the Usefulness of Natural Philosophy," p. 39.

95 *Hauptschriften zur Grundlegung der Philosophie*, E. Cassirer (ed.), Leipzig, 1903, Vol. I, pp. 120, 126 [Leibniz's first and second letter to S. Clarke].

96 *Oeuvres*, op. cit., Vol. XI, p. 331, art. 6. Cf. also arts. 7 and 16.

which he saw an experimental confirmation of his mechanical theory of refraction.[97] Finally, in his *Traité de l'Homme* (1644) he regards man as a machine, composed of various partial mechanisms which function in the same manner as clocks, water mills, carillons, organs, etc.: ". . . Je suppose que le corps n'est autre chose qu'une statue ou machine . . ."[98] He uses stereotypically the expression: "cette machine"[99] to characterize all organs, such as the tongue with the sense of taste, the nose with the sense of smell, the respiratory organs, the heart, the eyes, the stomach, etc. He wants to clarify the movements of all body parts through muscles and nerves, and [208] the latter through the "esprits animaux" in a purely mechanical way by comparing them with the driving force of water,[100] because "la seule force dont l'eau se meut en sortant de la source, est suffisante pour y mouvoir diverses machines, et même pour les y faire jouer de quelques instruments, ou prononcer quelques paroles, selon la diverse disposition des tuyaux qui la conduisent," . . . "ainsi que vous pouvez avoir vu dans les grottes et les fontaines qui sont aux jardins de nos Roys."

The nerves are compared with the "tuyaux des machines de ces fontaines," the muscles and sinews with the "divers engins et ressorts," and respiration and other natural functions with the "mouvements d'une horloge ou d'un moulin, que le cours ordinaire de l'eau peut rendre continus."[101] The heart's and arteries' functions are compared with the "Orgues de nos Églises," that is, with their bellows (*soufflets*).[102] The external world thus acts upon our senses and causes their movements in a purely mechanical way, "comme des étrangers qui, entrant dans quelques-unes des grottes de ces fontaines, causent eux-mémes sans y penser les mouvements qui s'y font en leur presence . . . selon le caprice des Ingénieurs qui les ont faites." The reasonable soul's role is comparable with the water engineer's function (*le fontenier*) who, by rearranging the machines' pipes, changes their pattern of movement.[103] At the end of the work, he says: "Je désire que vous considériez que ces fonctions suivent toutes naturellement en cette machine, de la seule disposition de ses organes, ni plus ni moins que font les mouvements d'une horloge, ou autre automate, de celle de ses contrepoids et de ses roues."[104]

Elsewhere, in order to explain Harvey's theory of blood circulation, Descartes says that the veins and arteries are like ducts through which the blood flows incessantly into the chambers of the heart "en sorte que ces deux cavités sont comme

---

[97] *Oeuvres*, op. cit., Vol. VI, pp. 343ff.
[98] *Oeuvres*, op. cit., Vol. XI, p. 120.
[99] *Oeuvres*, op. cit., Vol. XI, pp. 125, 138, 145, 148, 163, 173, etc.
[100] Op. cit., Vol. XI, p. 130.
[101] Op. cit., p. 131.
[102] Op. cit., p. 165.
[103] Op. cit., p. 131.
[104] Op. cit., p. 202.

des écluses par chacune desquelles passe tout le sang."[105] Thus the chambers of the
[209] heart are compared to sluices.[106]

Appendix: Galileo, Hobbes

What we have shown so far regarding Descartes is also demonstrable for all the other representatives of mechanistic philosophy in his time. For lack of space we must restrict ourselves to some brief references. According to Borkenau, the "basic concepts of mechanics, which Galileo and his contemporaries were the first to develop comprehensively, were nothing but the exact formulae of the relations emerging between human labor and the object of their work in manufacture's extremely divided manual production process. Mechanics, i.e. the science of the manufacturing period, is the scientific exploration of the process of manufacturing production" (p. 6). This assertion, made with certainty and acknowledging no possible doubt, arouses the suspicion that Borkenau knew very little of Galileo's mechanics. In the first chapter of Galileo's *Mechanics*, first published in French by Mersenne,[107] he shows quite clearly from where he derived his mechanical concepts. He does not base himself on the division of labor in manufacture but on the machines, and lifting machines in particular! In the first chapter "qui montre l'utilité des machines" he already mentions machines for the transportation of heavy loads, machines for bringing up water from the depths of wells, pumps for removing water from the hulls of ships, and finally water mills and other machines with wheels, which replace and reduce human and animal labor costs.[108] Having thus circumscribed the purpose of mechanics and his research's objectives, he in Chapter II provides the definition "afin d'en tirer les raisons de *tout ce qui arrive aux Machines, dont il faut expliquer les effets* . . ." "Or, puisque les Machines servent ordinairement pour *transporter les choses pesantes*, nous commençons par la définition de la pesanteur, que l'on peut aussi nommer gravité" (op. cit., p. 6). Then in Chapters VI-X he demonstrates the mechanical principle of the asymmetrical lever, the scales, the winch and the crane, the pulley, the screw and its uses for drawing up water, the syphon and the pump, those ordinary machines which during the almost two hundred years from L. B. Alberti and Leonardo da Vinci to Descartes had always been objects of contemplation for theoretical mechanics.

---

[105] Op. cit., p. 332.

[106] Finally, it should be mentioned that Descartes' disciples had the same conception of mechanics as their teacher. In the "Traité de la Mécanique," published by N. Poisson in 1668, mechanics is first a theory of machines, whose principles are subsequently extended to physics and the whole universe. "De même aussi on peut considérer le corps humain comme un automate ou machine" (P. Mouy, "Le Développement de la Physique Cartésienne," op. cit., p. 63).

[107] G. Galilei, *Les Méchaniques*, transl. from Italian by Mersenne, Paris, 1634.

[108] "La troisième utilité des machines est très grande, parce que l'on évite les grands frais et le coût en usant d'une force inanimée, ou sans raison, qui fait les mesmes choses que la force des hommes animés . . . comme il arrive lorsque l'on fait moudre les *moulins* avec l'eau des estangs, ou des fleuves, ou un cheval, qui suplée la force de 5 ou 6 hommes. . . par le moyen des *roues et des autres Machines* qui sont ébranlées par la force du cheval, et qui remplissent et transportent le vaisseau d'un lieu à l'autre, et qui le vident suivant le dessin de l'ingénieur" (op. cit., p. 5).

In our context Th. Hobbes is of special importance, since he first applied the mechanical conceptions to the social sphere, whereas previously they referred to [210]
natural phenomena only. In the foreword of his principal work[109] he already depicts the state and its citizens as a huge machine whose essence can only be grasped if one analyzes in thought the constituent elements which originate in human nature: "for as in a watch, or some such engine, the matter, figure, and motion of the wheeles, cannot well be known, except it be taken in sunder, and viewed in parts."

On the Genesis of Theoretical Mechanics

What can be proven by the survey presented in the preceding paragraph? Perhaps the fact that Borkenau disregarded several passages in Descartes, or that he evidently distorts Descartes' conception by connecting it arbitrarily with the division of labor in manufacture? Not at all. More is actually at stake: the history of the origins of a whole science, viz. modern mechanics! The machines mentioned by Descartes, which can be divided into four categories: artillery, clock, water and lifting machines, also represent the most important areas of practical mechanics, by which the basic concepts and laws of theoretical mechanics could be developed. Mechanics was only slowly created by the struggle of human ratio with the empirical material. For nearly two centuries – from the middle of the fifteenth to the beginning of the seventeenth century – all those who took part in the struggle (L. B. Alberti, Leonardo da Vinci, Nicolo Tartaglia, Girolamo Cardano – to name only the most important scholars) derived their mechanical concepts and theorems not from the division of labor in manufacture, but from the analysis and observation of machines and their performance.

Anybody who traces the history of the genesis of theoretical mechanics will immediately encounter the four aforementioned categories of machines; we will briefly look at them:

I. *Firearms*. The discovery of gunpowder and firearms – not even mentioned by Borkenau in this context – constitutes an epoch-making turning point in the history of scientific mechanics. Not only did it break the nobility's monopoly in martial skills, with warfare becoming a bourgeois affair, but also because "the skills of [211]
the engineer, founder of cannons and the gunner, acquired in a bourgeois manner, became prominent"[110] and educated bourgeois elements participated in war, impetus was provided to fruitful mass observations which served both the perfection of firearms and the development of the theory of mechanics.

Through the accumulated observations of missile trajectories, the old Aristotelian "milieu theory" of motion, which maintained that the progression of

---

[109] Th. Hobbes, *Elements*, Part III, *De Cive.* German translation by M. Frischeisen-Köhler, Leipzig, 1917, p. 72. [English quotation according to: Thomas Hobbes, *Philosophical Rudiments Concerning Government and Society* (1651); *Clarendon Edition of the Philosophical Works of Thomas Hobbes*, Vol. III, Oxford, 1983, p. 32].

[110] J. Burckhardt, *Die Kultur der Renaissance in Italien*, op. cit., Vol. I, p. 103. Cf. Max Jähns, *Handbuch einer Geschichte des Kriegswesens*, Leipzig, 1880, p. 831.

the projectile was caused by the movement of air, was totally undermined, for the air's obstructing effect was empirically recognized. With Aristotelian doctrine abolished, the road was opened for new observations and new attempts at theoretical explanations. The oldest work on artillery, the *Livre des faits d'armes* was written by Christine de Pisane around 1400. From Leonardo da Vinci[111] via Tartaglia and Girolamo Cardano an uninterrupted chain of scientific endeavors leads to the establishment of a theory of motion by the experience gathered from firearms. One only need open Nicolo Tartaglia's book *Nuova Scientia* (1537), written almost one hundred years before Galileo,[112] in order to become convinced that the laws of motion were studied above all on the example of artillery projectiles' trajectories.

Anybody familiar with the genesis of mechanics must know that the discovery of the law of free fall is closely connected with the history of firearms, with the observations on the projectiles of guns.[113] Here, as in so many other areas, the economic aspect provided the impetus for the continuation of research, while striving,
[212] through rational construction of guns, to attain the same effect with smaller calibers, to achieve better transport capacity and lower construction costs.[114]

Just as Borkenau is silent on the history of firearms as a source of theoretical mechanics, his attitude is the same vis-à-vis the other principal sources and spheres of observation: the construction of water-driven machines, the lifting mechanisms, and finally the clock mechanisms.

II. *The mechanism of clocks*. Nowadays we can hardly imagine the intellectual upheavals connected with the discovery and perfection of the mechanical clock. The close connection established among the Arabs between the construction of clocks and astronomy is well known. Scientific chronometry, i.e, the exact quantification of time, is the precondition of exact observations in all spheres of science. In thirteenth and fourteenth-century Italy the astronomers were often also watchmakers and mechanics. But in mechanics the clock is the first and most important machine, having a uniform motion produced automatically by a system of weights. At first the

---

111 Numerous texts by Leonardo, which illuminate his problematic show how theoretical mechanics tried to derive its concepts from the flight of projectiles. Just one example: "Si une bombarde avec 4 livres de poudre jette 4 livres de boulet à sa plus grande puissance, à 2 milles, de combien faut-il augmenter la charge de poudre pour qu'elle tire à 4 milles? La puissance du boulet dépend-elle de sa vitesse initiale?" (G. Séailles, op. cit., p. 353).

112 *Inventione de Nicolo Tartaglia, Brisciano, intitolate Scientia Nova*, divisa in V libri, 2nd ed., Venice, 1550.

113 Also TartagIia's other work, *Quesiti et Inventione diverse* (1546), the first volume of which is devoted to the study of the motion of cannonballs; and this, according to the testimony of P. Duhem, had a strong influence on the development of mechanics in the sixteenth century. It was, therefore, of basic significance for the history of dynamics (P. Duhem, *Les origines de la statique*, Vol. I, p. 197).

114 "On peut restreindre beaucoup de la mesure commune et faire l'artillerie de moindre poids; chose qui rend très grande facilité a la conduire et si espargne beaucoup à celui qui la fait forger" (Vanuccio Bringuccio, *La pyrotechnie ou art du feu*, X livres, 1st ed., 1540, quoted from the French edition, Paris, 1556, p. 142).

automatic motion was of even greater interest than the indication of the time.[115] The public tower clocks in the towns of Italy and Flanders were enormous gear works, combining the mechanism for the measuring of time with the bell-ringing mechanism.[116] At the threshold of the fourteenth century, two astronomers who were also mechanics, the Dondi brothers of Padova, constructed a planetarium (described in a book of this title): a complicated gear work driven by weights, which visualized the observable movements of the sun, the moon and the planets.[117]

A field of observation for scientific mechanics was thus created, which was to stimulate the investigation of the elementary laws of motion: a vertical movement [213]
of the slowly descending weight was transformed by a mechanism of wheels into a circular motion. The automation of circular motions in the planetarium had to be adapted to the speed of the individual heavenly bodies' movements, according to astronomical calculations. One single weight set in motion several wheels which had to move at various speeds in different orbits, and this necessarily led to systematic contemplation on the causes for this difference in the space-time relation. The experimental imitation of the structure of heavenly mechanics removed the latter's mystic veil and suggested the idea that the heavenly bodies' movement was governed by principles similar to those of the mechanics of the planetarium. The orreries, which were constructed as increasingly complicated mechanisms, are important for the histories of both mechanics and astronomy; their construction simultaneously reflected the actual state of practical mechanics and of astronomical knowledge – first on the basis of the Ptolemaic system and subsequently of the Copernican system.[118]

Aside from these clockworks whose purpose it was to measure time and illustrate astronomic processes, the clockwork mechanism was also employed in Italy for the production of power: in Milan, around the middle of the fourteenth century, there were mills driven by clockworks.[119]

III. *Lifting mechanisms*. Due to lack of space we will not go into the details of the lifting machines used in medieval architecture and shipping, with which considerable loads, such as church bells and blocks of marble, were raised to great heights. We only mention that in 1466 the tower Della Magione in Bologna, with its foundations, was moved a substantial distance without the slightest damage![120]

---

[115] Mathieu Planchon, *L'évolution du mécanisme de l'horlogerie depuis son origine.* Bourges, 1918, p. 4.

[116] Pierre Dubois, *Horlogerie, iconographie des instruments horaires du XVIe siècle*, Paris, 1858, p. 25.

[117] G. Libri, op. cit., Vol. II, p. 220.

[118] Here I would briefly mention two of the most prominent planetaria of the sixteenth century: the one built in Paris in 1546–1553 by the mathematician and astronomer D'Oronce Finé, and the famous astronomical clock in the cathedral of Strasbourg, built in 1571–1574 by Conrad Dasypodius, professor of mathematics at Strasbourg University. *Conradi Dasypodii, Horologii astronomici Argentorati descriptio*, Argentorati, 1580. Cf. P. Dubois, *Horlogerie*, Paris, 1858, pp. 44–48.

[119] G. Libri, op. cit., Vol. II, p. 232.

[120] G. Libri, op. cit., Vol. II, p. 217.

As Libri rightly said: the technique of building in those times had at its disposal instruments "qui pouvaient conduire à des puissants effets dynamiques."

IV. *Waterworks*. The water structures and the water mechanisms should be mentioned in brief. In twelfth-century Italy, canals were already built for irrigation, since the thirteenth century canals for shipping were built in Lombardy (e.g. the Guastalla
[214] canal in 1203). In Venice, hydraulics had also reached a high stage of development in the installations of the lagoons. Since the fifteenth century, locks were installed in rivers, to enable the passage of ships through canals of varying levels.

Water as a driving power for working machines was used in Italy in an early era. In the eleventh century (1044) a mill situated in the lagoons is already mentioned; it is driven by high and low tides and it changed direction every six hours. In the fourteenth century water is used as the driving force for industrial machinery. "Dès l'année 1341, il y avait à Bologne de grandes fileries (spinning mills) mues par la force de l'eau, et elles produisent un effet évalué à quatre mille fileuses."[121] We have already pointed out the upheavals caused by the utilization of water power in the iron works and in mining, as well as the momentous and continuous rationalization of the working process, which was thus attained already in the fifteenth century.

In Italy we see the development of theoretical mechanics parallel to the development of practical mechanics. The latter first circumscribes its terms of reference in L. B. Alberti's book on architecture, written around 1450, and tentatively posits the problems,[122] reaching its first culmination about 1500 in the works of Leonardo da Vinci.

Modernity is already foretold in Alberti's enthusiastic paean to technology: it enables us to "trencher les rochers, percer des montaignes, combler les valées, résister aux débordements de la mer et des fleuves, nettoyer les paluz ou marais, bastir des navires" (preface). Then follows a treatise on a series of important problems in statics and dynamics: practical problems of balance, building sound foundations and arches, the calculation of their load-carrying capacity and their resistance. Volume VI deals with the various methods of transporting loads and the requisite machines; finally, important problems of dynamics are raised: "De
[215] deux fardeaux pareils l'un aide l'autre. – Pratique des ouvriers. – Moyens pour le mouvement de grands fardeaux" (p. 111). In the technician's mechanical praxis the struggle begins for theoretical insight; it is important to understand the genesis of theoretical mechanics, even though it did not yet lead to exact results. This next step, likewise concerned with the same matter, the machines, was taken (as already demonstrated) by Leonardo da Vinci. He was followed by Tartaglia and a large number of sixteenth-century theoreticians. Here we shall only mention – from the aspect which is relevant to us – that besides the trajectories of artillery

---

[121] G. Libri, op. cit., Vol. II, p. 233. This Bolognese machine for spinning silk and cotton thread, with its several thousands of components, cogwheels, axles, etc., was famous and was still repeatedly described in the seventeenth century, e.g. by A. Alidosi, *Instruttione delle cose notabili di Bologna*, 1621 and by J. J. Becher, *Närrische Weisheit*, 1686.

[122] L. B. Alberti, *De re aedificatoria*, Florence 1485 (posthumous), here quoted from the French edition, Paris, 1553.

projectiles the mechanisms of clocks were also the subjects of theoretical study and became points of issue for numerous theoretical treatises. Thus, for instance, the well-known theoretician of mechanics, Maurolycus of Messina (1494–1575) wrote a "treatise on clocks."[123] In G. Cardano's work *De rerum varietate* (1557), Book IX ("De motibus"), different kinds of motion are also discussed and the general rule of acceleration changes is established; these motions are studied based on experience gathered in the art of watchmaking. In his work *De Subtilitate* (1550) Cardano sees the importance of the machines primarily in the saving and replacement of human labor. And similarly Conrad Dasypodius, professor of mathematics and builder of the astronomical clock in Strasbourg; the essential task of mechanics as realized in machines consists of saving labor: "quod maxima pondera minimis moveantur viribus et quibusnam talis motus fiat machinis."[124] As shown above, the same applies to Galileo and Descartes.

This short synopsis also shows that theoretical mechanics derived its concepts from experience with machines, and that these machines have been the subject of discussions since the mid-fifteenth century, while division of labor in manufacture is never mentioned then or in later literature. All these facts, so important for the development of practical and scientific mechanics, are not mentioned by Borkenau. His history of the birth of scientific mechanics lets a ready-made form of mechanics emanate from the heads of Stevin, Galileo and Descartes in the first decades of the seventeenth century. Thus the great mathematicians and mechanists turned into its founders and pioneers who in reality only perfected classical mechanics. [216]

Borkenau's Method and Its Metamorphoses

We now want to demonstrate that Borkenau's failure is due to his method. In contrast to the isolating way of viewing history, such as Max Weber's, who "only knows separate factors in historical events which determine the course of history" (p. 158), Borkenau acknowledges "the dialectic materialism which is based on the categories of totality and objective tendency" (p. 159). He strongly emphasizes that "two inseparably linked determinants, forces and relations of production, determine the whole ideology" (p. 118). However, in his work he neglects to explain the mechanistic world picture via the forces and relations of production at the time of its emergence; in vain we search for a description of productive forces at work – during the epoch discussed in his book – whether in France, Holland, or England. Over and above this: he completely negates the effect of productive forces on the genesis of that epoch's ideology. He replaces them in these countries with the manufacturing technique! "The mechanistic world-picture," we read in his book, "is a transposition of the manufacturing process to the cosmos as a whole . . . this transposition can have nothing to do with the development of the productive forces" (p. 127). In transferring the role of productive forces to the technique, to the manufactural technique

[123] G. Libri, op. cit., Vol. III, p. 108.
[124] Conrad Dasypodius, *Heron Mechanicus, seu de mechanicis artibus*, Argentorati 1580, p. E2r.

only, he immediately confronts us with a problem that is difficult to understand: "Mechanics, i.e. the science of the manufacturing period, is the scientific treatment of the process of manufacturing production" (p. 6); but why only of the process of manufacturing production? Is the technique of manufacture the only one existing at that time? By no means. We know that concurrently there existed three different technical methods: next to the traditionally undivided craftsmanship and manufacturing, there is "also the modern ... factory" (p. 4). Is perhaps the manufacturing technique the most advanced? It is not, for besides manufacture there existed the "most highly developed forms of industrial praxis," in navigation, in warfare, in the art of the printer (p. 90). And yet: scientific research, "more strongly based on the observational material supplied by industry," does not consider all these three techniques, not even the most highly developed one, the industrial praxis based on machines; it is based "not on the material of all processes of production, but particularly on the manufactural ones" (p. 5). Borkenau himself finds this "striking"; and [217] actually it is more than striking, especially if one considers that, according to him, the science of that period was led not only exceptionally or mainly, but exclusively by the methods of manufacture (p. 4)! The first question is: why does not Borkenau take into account the category of totality? Why should not all the productive forces be relevant here, instead of only a particular technique which was not even the most progressive one? A second question: Does that epoch's science really allow itself to be led "exclusively" by the methods of manufacture? Borkenau asserts that it does, but – as we have already discovered – does not adduce a single example in support of this thesis.

Moreover, despite the fact that Borkenau so emphatically underlines the importance of manufacturing technique, for him this is not the ultimate causal element of the mechanistic world-picture: the manufactural production also "contains ... very few incentives for the creation of this world picture" (p. 13). The point in time, in which insights into manufactural technique were transformed into the mechanistic world picture "was not decisively determined by the development of manufacture" (loc. cit.).

But if manufactural production lacks the drive to create the mechanistic world-picture, the question remains: what else does create it? "How, then, did we reach this immense generalization of the experiences of manufactural technique?" (p. 3). And further on: "This generalization would never have developed, unless simultaneously forces were active toward a conception of man as a merely mechanically functioning being" (p. 13). What sort of secret "forces" were those? We learn: "As in all periods, thus also in the period of manufacture it is the relations of production which cause the generalization of that which in technology at first exists as mere subject matter for thought" (p. 14).

Through this new methodological twist, through the decisive role now ascribed by Borkenau to the relations of production, it is not clearer by what and how the new world-picture was determined. Rather, new difficulties arise. On the one hand, the role of the relations of production is thought to consist only in [determining] the theoretical generalization of the "material for thought" provided by technique viz. in a rather receptive auxiliary function. On the other hand, however, he assures us

that the relations of production are those forces "which urged to perceive of man as a merely mechanically (why must it be mechanically? H. G.) functioning being" [218] (p. 13). Here, then, the relations of production are understood as active, independent forces which are not limited to the auxiliary role in the generalization of the "material for thought" supplied by technology, but of their own accord, press us to perceive man as a merely mechanically functioning being.

Borkenau's method is presented as a truly Protean method, secretly undergoing continual metamorphoses. At the beginning it stated that the new world-picture was determined by two inseparably linked factors – forces of production and relations of production. Then the effectiveness of the productive forces for the genesis of the mechanistic world-picture was negated and was replaced by a particular technique. Finally it emerges that this technique alone is incapable of creating that world-picture, and that it only supplied "material for thought." This was then theoretically generalized "on the part of the relations of production." But a generalized "material" for thought still remains only material and not a world-picture. Thus we conclude that it is the relations of production which create – in an unexplained way – the very mechanistic conception from the "material." The place of the originally "inseparably united" determinants was ultimately taken by the relations of production alone, while the technique of manufacture was reduced to a mere supplier of "material for thought."

Yet we still do not have that "last" element with which the world-picture is explained. It is clear: if one proceeds from the relations of production which are said to "urge" us to perceive of man as a mechanistic being, one is inescapably confronted with the question: why is it just the relations of production at the beginning of the seventeenth century, and not those of the fifteenth or sixteenth centuries which do the "urging"? Relations of production is merely an economic expression for property relations. The property relations of a period are as such static. That the relations of production of the seventeenth century urge toward the mechanistic conception of man, while those of the earlier period did not – this can only be explained by the changes which occurred in property relations. It is impossible to understand any changes in the property relations which as such are static without looking into [219] the dynamic element, the forces of production. The changes in the property relations are the results of the respective changes in the forces of production. Since Borkenau, as we have seen, has excluded the forces of production as possible explanations for the mechanistic world picture, he is lacking the dynamic factor which should explain changes in the relations of production. Consistent with his position he discards all the previously mentioned elements of explanation: forces of production, technique of manufacture, relations of production – and allows for a further change in his system of categories. Instead of the totality of relations of production, of manufacture technique or the economic structure of society as a whole, his final explanation in the analysis of the ideological trends is party warfare.

For this purpose, Borkenau adopted a special method which he wants to apply in his first three introductory chapters in an "abbreviated form," but subsequently the more strictly, the nearer he comes to his "principal theme of the genesis of mechanistic philosophy" (p. 21). He starts from the premise that a thinker can "be

considered as truly understood only if understood within the context of the struggles of which he was a party" (p. 21). He therefore believes that he gives "a full history of dogmas and their causal derivation" through "a record of all those elements of thought which are imposed on every thinker by virtue of his position in party struggles" (p. 21).

Before we examine the value of such a method, we want to discover to what extent he fulfilled his promise of "a very special analysis of the parties." The description of "all those elements of thought" which are "imposed" on a thinker "by virtue of his position in the party struggles" means a presentation of all the parties in the period concerned, their mutual relations, their contrasts or common features. Only by analyzing all parties can one obtain an insight into the totality of the historical situation in a particular period. There is no trace of such an undertaking in Borkenau's work. "The interplay of social forces which led each thinker to his system is here only adumbrated; in this book's framework, an unsatisfactory but unavoidable abbreviation" (p. 21). The fact that he does not even keep to this minimum is evident e.g. in the chapters on Thomas Aquinas (pp. 23–35), on Cusanus (pp. 40–53) and on Luther (pp. 104–107). "According to our program we refrain from analyzing . . . the
[220] question . . . regarding Thomas' special position in the struggles of his time" (p. 31). "Again, according to our program, we refrain from analyzing the historical element and Cusanus' role in the struggles of his time" (p. 42). We find the same attitude in the presentation of Luther's ideas. There is not a word on the Reformation's social background, Germany's economic situation, its economic structure and the different classes. Parties, party warfare? – no trace of these. Luther's doctrine of the abysmal depravity of human nature, and the conclusion drawn from there that men can only be restrained by force, is only an accommodation of Lutheranism to the demands of absolutism. The unavoidable question is why the Reformation remained unsuccessful in the two greatest absolute monarchies – in Spain and France. Are "the" teachings of Luther really to be regarded as something so immutable as in Borkenau, who undertook the particular task of "examining the changes in the form of thought"?

Instead of an overall picture of the situation, through which the different classes and parties' position, with the thinkers and intellectual trends belonging to them, would become intelligible, we are given a number of single, separate, incoherent, random facets which tear apart the general context. The particular social stratum to which a certain thinker (Bodin, Vanini, Descartes) belongs is isolated and taken out of context when that thinker is discussed. The prevailing economic and political situations in England are disposed of by some remarks when Hobbes's theory of the state is presented (p. 440). The following survey shows how unsystematically Borkenau deals with the grouping of the French parties: in connection with the libertines' moral teachings, the nobility's social situation is described (pp. 207–208); in connection with Luther's teachings in the chapter on "natural law," the party of the divine rights of kings in France is described (p. 106). Then, after having mentioned the moderate royalist party (p. 114) in connection with Bodin, and later touched on the Dutch situation in passing, there is a chapter on the new morals and the new theology which contains the characterization of the French noblesse de robe (pp. 172ff.) and finally there are the moral groupings of Jansenism, which emerged
[221] later on (p. 248).

This method's arbitrariness is striking and becomes evident particularly in what is omitted. The social situation of the absolute monarchy, of the state, is not mentioned. Borkenau speaks of the period of the "emergence of absolutism" (p. 100). We do not learn anything about the causes of this "emergence." In one passage we hear that "the aspiring absolute monarchy has domesticated the rebellious nobility" (p. 171), and elsewhere that "for some time absolutism tried . . . to maintain a balance between nobility and bourgeoisie," "to defend the former and to advance the latter" (p. 263) etc. Who is this absolute state? Why does it ally itself with one class and fight the other? Is it at all possible to render intelligible Luther and Calvin's reformations without explaining the state's attitude? How could the Reformation prevail against the church of the Pope? The latter had, after all, an immense secular power. "Depuis deux siècles," says Seignobos, "aucune hérésie n'avait échappé à la destruction."[125] If the Reformation was not already nipped in the bud, this was only possible because Luther in Saxony and Calvin in Geneva could organize their churches under the protection of the state.[126] Wherever the state turned against the Reformation – as in France or Spain – it could not succeed. But why do the states in Germany place themselves at the head of the Reformation, but in France and Spain at the head of its opponents? On this there is also no elucidation. Borkenau evidently believes that for the success of the Reformation Calvin's "doctrine of probation" was much more important than the state's attitude as caused by its social situation.

That which is said about the state applies to the church as well. The presentation of the social situation, the differences within the clergy, the situation of the poor clergy of the orders, the situation of the secular clergy with all its prebends and benefices – all factors of great importance for the Reformation's fate – are not mentioned. The church's social significance at that time becomes evident when one considers that in the *États Généraux* of 1614 out of a total of 464 delegates, the clergy alone numbered 140 representatives compared with only 132 representatives of the nobility; the church was the greatest landowner and disposed of the largest resources. Without knowledge of the church's social position one [222]
cannot comprehend the attitudes of: the high and low clergy, the religious parties of the Reformation and the Counter-Reformation, or the other propertied classes – the nobility and bourgeoisie and their parties. For these classes basically lived on the church's benefices which were disposed of by the court! Just as the nobility in France was turned into a court nobility, most French prelates became courtiers, who lived in Paris, far from their dioceses. The bishops' income, no matter how large, did not suffice to cover the cost of their "grand-seigneurial" life style. Therefore, they were dependent on benefices and incomes which the king controlled and thus were dependent on him. Some bishops accumulated the revenues from six large abbeys. The nobility too was dependent of the king. The abbeys were not reserved for the

---

[125] Ch. Seignobos, *Histoire sincère de la nation française*, Paris, 1933, p. 238.

[126] On the developments in Germany, Ranke says: "The new churches were founded under the protection, the immediate influence, of the reigning powers. It is only natural that thus their shaping was also determined." (*Deutsche Geschichte im Zeitalter der Reformation*, 5th ed., Leipzig, 1873, Vol. II, p. 308).

clergy, they were distributed among the nobility, to women and even to children as additional sources of income. The nobility grew accustomed to regarding the church estates as their sources of income and the church as a career, especially for younger sons. The unmarried daughters viewed ecclesiastic posts as an honorable refuge which enabled them to lead an elegant style of life. The upper strata of the bourgeoisie had similar aspirations. The king presented abbeys to Protestants, to poets such as Desportes and Brantôme for their love songs or daring stories about amorous ladies. After the civil war (1596) the majority of the abbeys were bestowed on lay members. Can one comprehend in such circumstances any party groupings and party struggles in France, when not a single word is mentioned about the church and clergy's role which so deeply influenced all aspects of life?

Borkenau uses an easy method of analysis. If he possesses factual material, e.g. regarding the Catholic Counter-Reformation in France during the second quarter of the seventeenth century, then he expounds this fraction of material concerning the church in full detail, in order to show "by which social stratum the movement was set in motion" (p. 210). The much more important material on the church's social situation as a whole is not presented, and ad hoc he makes a virtue of necessity: "The social stratification of the clergy in that period and its attitude to Jansenism have not yet been sufficiently researched. These belong in a sociological (*sic!* H. G.) history of the church, not in our study of the changes in forms of thought" (p. 265).

But he also omits any description of the peasant's situation and the proletarian elements, although in Germany for instance the peasants' revolution played an
[223] important part in the party struggles at the time of the Reformation. Ranke has shown how the parties in the fights between the churches accused one another of responsibility for the outbreak of the revolution, the Protestants pointing at the exploitation of the people by the Catholic clergy, and the Catholics accusing the Protestant preachers of demagogy.

The party struggles of the propertied classes, which were fought at the expense of the broad masses, must remain incomprehensible if these masses are not taken into account. Borkenau describes the programmatic "passionlessness" of Neo-stoicism (p. 187), a philosophy of the magistrates who want to keep aloof from the troubles of the times to preserve their equanimity. In reality, this simulated passionlessness is only a mask which cannot be recognized as such without considering the peasants' revolts in the rural areas against the background of the upper classes' political struggles and without the urban proletariat's revolts. The magistrates in particular experienced the violent outbreaks of a people driven to depression; the outbreaks were directed in the first place against the lower officialdom of the fiscal and judicial administration in the provinces. The rigorous fiscal policy pursued throughout the ministry of Richelieu was the cause of continuous uprisings of the poor: 1630 in Dijon, 1631 in the Provence and in Paris, 1632 in Lyon, 1635 in Bordeaux. Similar outbreaks occurred in smaller towns such as Agen, La Réole, Condom, Périgueux. In Montferand, the citizens beat the priest to death because he preached the duty of paying taxes. In 1636, the peasants revolted in Limousin, Poitou, Angoumois. Mobs of seven- to eight-thousand people roamed the land and manhandled the officials of the fiscal administration. In 1637, insurrections of the "frondeurs" with battles

on barricades took place in Gascony and Périgord. In 1639, there was a peasants' revolt in Normandy, led by the "discalced," in which several tax collectors with their personnel were beaten to death. Similar upheavals occurred in Caen and Rouen; these took a particularly violent form, and several tax officials were torn to pieces by wheels with nails affixed. A punitive expedition of four thousand roamed the country murderously. It occupied Rouen in 1640, dispersed the parliament in order to reinstate the king's authority, replaced it by royal commissars, and abrogated all municipal privileges; the municipality (*mairie*) was abolished, and the leaders of the revolt executed by the military. [224]

Such a situation must influence the manner of thinking of the most directly affected magistrates. This officialdom which, as Borkenau asserts, had created for itself a philosophy of "sages" through "Neo-stoicism," a program consisting of "dispassionateness" and "aloofness" from the suffering of the "outside world" (p. 187), was surely not as neutral in its attitude toward the social upheavals as Borkenau claims. Insofar as it remained neutral, this was only vis-à-vis the political fights among the propertied classes; but it stood with all its passion in the midst of the battle when not only party struggles within the propertied classes were concerned but also their common interest vis-à-vis the mass of the people. Then Neo-stoicism completely forgets its "dispassionateness," and Borkenau himself has to admit that "Neo-stoicism was imbued in all directions with the pride of a ruling class" (p. 189).

Whereas so far we have examined the "very special analysis of the parties," promised by Borkenau, from the aspect which he failed to take into account, we shall now look into his perception of those parties with which he deals and to which he ascribes a decisive role in his theoretical construction: the party of the manufacturing bourgeoisie and that of the officialdom or what he calls the "gentry." We only learn about the first that "the divine right is the political doctrine of the mercantile monopolistic bourgeoisie, or of those parts of the bureaucracy and the nobility that are connected with it" (pp. 106f). It is not explained any further, and is clearly considered self-evident why the capitalist manufacturers who, according to Borkenau, emerged from the artisans, elevated "divine right" to their doctrine of the state. Neither does he say why certain strata of the bureaucracy and the upper nobility – who as a whole represent other specific interests – should be "allied" with the monopolistic bourgeoisie, and what is the basis of the alliance: blood relationship, religious ties, or economic interests.

The "very special analysis of the parties" furthermore arrives at the conclusion that divine right, the theory of the state of the monopolistic bourgeoisie, was nothing but "the adaptation of Lutheranism" (or the Anglicanism and the French Catholicism related to it) "to the requirements of absolutism" (p. 105); this would seem reasonable if one considered that the French manufacturing bourgeoisie was "dependent on government subsidies" and "could not exist without government support" (p. 171). But it also becomes evident that "insofar as absolutism sought [225] an understanding with the bourgeoisie," "it had to renounce (!) the doctrines of the divine right" (p. 115). Borkenau does not explain why an "understanding" should be needed here, when the divine right was to be regarded as adaptation by this bourgeoisie to the requirements of absolutism; the contradiction is evident.

Absolutism, "insofar as it sought an understanding with the bourgeoisie," had to renounce its divine right, which means, according to Borkenau, dissociating itself from the monopolistic bourgeoisie.

The core of the manufacturing capitalists, whose origins were in craftsmanship, stood (according to Borkenau) in sharp contrast to the financial capitalists (p. 155). On the following page we are already told that just these manufacturers had "swept along with themselves part of the bankocracy (i.e. of the financial capitalists. H. G.) and together they led the communities" (p. 156). He does not explain how this is compatible with the "sharp contrast." There remains a contradiction; this, like many other contradictions, is the consequence of Borkenau's distortion, to benefit his construct of the historic role played by the parties. It shows up most clearly in the example of the "gentry," that stratum of officialdom from which Descartes was born.

"Descartes was the first to attempt the construction of a unified world-picture from the categories which determined the capitalist individual's life" (p. 268). – "His origins rendered him most suitable for this task. Descartes' family is like an extract from all the important strata of French bourgeoisie, whose center was the *noblesse de robe*. His father was a counsellor in the parliament of Rennes" (p. 269). – In short Descartes "belonged to the gentry" (p. 271). And what was that gentry? "Gentry is . . . the strongest, most independent, politically and intellectually most active class of absolutist France, the noblesse de robe" (p. 172). – "By virtue of its privileges it represented the class interests of the bourgeoisie vis-à-vis the monarchy (p. 174). – Taken all in all, Borkenau presents the "gentry" as the bourgeoisie's hero. At the convention of the Estates General in 1614 it had the absolute majority in the Third Estate's delegation; "there it was the official leader of the tiers état" (p. 175). Although Borkenau sees that the gentry "in its own interest" often acts in league with the nobles, he thinks "one should not be led astray" by such "tactical maneuvers" and constellations (p. 176, note). Rather, "on this gentry devolves the exclusive ideological leadership in the struggle for the new capitalistic way of life in France" (p. 172).

Was the gentry, which represented "overwhelmingly the revenue capital," espe-
[226] cially the provincial magistrates – from which Descartes was a descendant – really the leader in the strife for the implementation of bourgeois interests? We have heard before that because the Renaissance revenue capitalists were detached from the process of work, they lacked any motivation for the rationalization of the technique, and became the carrier of Renaissance aestheticism which despised the common people. Although the French gentry is also a revenue capitalist class, aloof from the working processes – it is here supposed to be almost revolutionary, exercising the ideological leadership in the struggle against the monarchy and for the interests of the bourgeoisie – the gentry and not the manufacturing bourgeoisie which is close to the work processes and which strives for rationalization!

"In the fifteenth and above all in the sixteenth century the monied classes invested their capital mainly in real estate, and now they often gave up land in favor of official position" (p. 174). "The social position of the class was ambiguous" (p. 176) in that "a formally bourgeois class, by virtue of its capital power, attains in fact a position of nobility within the bourgeoisie" (p. 172) and is therefore "a stranger in the capitalist

world." The magistrates are "almost unaffected by the need for unlimited effort with uncertain success in the capitalist competition ... The magistrates were the only ones whose economic life could take its course in feudal traditional security" (p. 176). And it was just this class, which does not, and does not want to, know anything of the "rigid rationality of the work process," this "noblesse de robe is ... the protagonist of the bourgeoisie" (loc. cit.), despite its independent wealth, despite its remoteness from work, despite the fact that it is "alien" to capitalism! This time neither independent wealth nor monetary and commercial capital are leading to an "aesthetic world view," they fulfill another task: "The propertied class that emerged from monetary and commercial capitalism had already been the principal standard bearer of courtly humanism. Now it was the bearer of ... the new philosophical development" (p. 174).

What was the role of the parliamentary bourgeoisie in historic reality? No other factor has contributed more to the weakening and demoralization of the bourgeoisie than the venality of office. Therefore, in the Estates General of 1560, not only the nobility and the clergy but also the representative of the Third Estate protested against the purchase of offices. It was abolished by the ordinances of 1560 and 1566, but was reintroduced already in 1567 – in the interest of the monarchy which was always in need of money. "A partir de cette époque, on peut suivre pas à pas le travail de décomposition qui s'opère dans les rangs du Tiers."[127] [227]

When in 1604 the purchase of offices was finally authorized by Henry IV, the moral collapse of the Third Estate and the development of the magistrate into a self-seeking class was unavoidable. Perhaps, says Normand, Henry IV had anticipated and intended these consequences of the purchase of offices, perhaps he had "prévu qu'il briserait ainsi toute opposition de la part de ses parlements et des tribunaux inférieurs."[128] In the Estates General of 1614, which Borkenau extols because the magistrates prevailed among the representatives of the Third Estate, it was evident that: "Sur 192 députés 131 étaient titulaires d'offices. La bourgeoisie laborieuse et commerçante avait été presque partout remplacée par la nouvelle noblesse de robe, ignorante ou insoucieuse des besoins du peuple."[129] The representation of a class had become the representation of a caste! This stands to reason. The purchase of offices had to have a paralysing effect on the industrial accumulation and the productive activity of industry, thus delaying the progress of the bourgeoisie, since large amounts of money were withdrawn from industry in order to be used for the unproductive purposes of the court.

During the eighteen years of Richelieu's ministry alone, more than two billion Gold Francs (in today's currency) accrued to the state treasury from the purchase of offices,[130] without taking into account enormous ancillary expenses that went into the pockets of high court officials. An immense, superfluous and idle bureaucratic

---

127 Charles Normand, *La Bourgeoisie française au XVII'ème siècle*, Paris, 1908, p. 30.
128 Normand, op. cit., p. 18.
129 Op. cit., p. 17.
130 G. D'Avenel, *Découvertes d'histoire sociale 1200–1910*, Paris, 1910, p. 26.

machinery, whose only raison d'être was the exploitation of the people: under Colbert 45,780 financial and justiciary offices were sold – according to Forbonnais' opinion 40,000 too many – whose monetary value was 417,630,842 livres (also billions according to the present currency).[131] "Economiquement, cette puissance d'attraction de l'Etat eut une influence fâcheuse …. En ouvrant ce débouché à la richesse acquise, on lui faisait une retraite au lieu de l'obliger à travailler. Les capitaux à peine formés, sortaient des affaires pour n'y plus rentrer …." "Si la France, beaucoup plus avancée que l'Angleterre au début du règne de Henri IV (1589), était fort depassée par elle au moment de la Revolution … cela pouvait tenir à la manière française de placer son argent en valeurs inproductives."[132]

But not only did the "paulette" mean the economic disintegration and weakening
[228] of the bourgeoisie; its moral and intellectual consequences were even worse. Why should the industrialist or the merchant send his son to study for many years, when the latter, through the purchase of a judiciary or financial office, could become a "Monsieur" and elevate himself from the ranks of the disdained Third Estate to the nobility? Instead of conquering rights for his whole class in the struggle against the powers-that-be, everybody with money at his disposal strove individually to avoid the struggle by purchasing rights for himself and his descendants. The result for the class as a whole was "l'insuffisance de la volonté pour la lutte."[133] Just as the buying of offices resulted in a regression in the development of the bourgeoisie, it also led to the incapsulation of the "gentry" as a caste. It goes without saying that among the magistrates there were some individuals who excelled in their education and wider political horizon. As a whole, however, due to the simony, the magistrates were venal and incapable of representing the interest of the class as a whole beyond their own narrow interests.

Thus Sée, in a retrospective view of the seventeenth century, says: "Souvent les membres des cours exercent leurs fonctions à un âge où ils ne possèdent ni l'instruction, ni la pratique nécessaires. Dans les Universités, ils ont souvent acquis à prix d'argent un diplôme qui ne prouve, en aucune façon, qui'ils aient étudié le droit …. En somme, beaucoup de parlementaires sont ignorants ou incapables."[134] The "gentry," this alleged protagonist of the Third Estate, was therefore detested by the "philosophers" of the Enlightenment, as well as by all the real protagonists of the revolution.[135] And rightly so. The parliaments opposed all, even the most useful reforms, which were in the bourgeoisie's interest, if the interests of their own

---

131 Normand, op. cit., p. 41.

132 D'Avenel, op. cit., pp. 270–277

133 Normand, op. cit., p. 43.

134 H. Sée, *La France économique et sociale au XVIIIe siècle*, Paris, 1933, p. 95.

135 Thus Diderot passes judgment on the parliaments: 'Intolérant, bigot, stupide, conservant ses usages gothiques et vandales. . ., ardent à se mêler de tout, de religion, de gouvernement, de police, de finance, d'art et de sciences, et toujours brouillant tout d'après son ignorance, son intérêt et ses préjugés'. And even more damning is Voltaire's (1774) judgment: "Il était digne de notre nation de singes de regarder nos assassins comme nos protecteurs; nous sommes des mouches qui prenons le parti des araignées." (Sée, op. cit.)

castes were affected. They opposed reductions in judicature costs, reforms in the outdated procedure of the penal law with its system of torture, and were against the unification of local common law: "Ils réprouvaient la liberté de la presse; ils condamnaient et faisaient brûler une foule d'ouvrages, comme irrespectueux des vérités religieuses ou des institutions existantes. Ils combattirent la déclaration qui accordait l'état civil aux protestants," in short, Sée speaks of the "esprit conservateur [229]
des parlementaires."[136] When they made a stand against the "lettres de cachet," they only did so because they were often affected, and they regarded them as limiting their judicial prerogatives. But "les Parlements se firent les défenseurs de tous les privilèges sociaux et se dressèrent contre toutes les réformes qui s'efforçaient de les atténuer."[137] This was what the "protagonist" of the bourgeois interests looked like!

All the contradictions described above, in which Borkenau gets entangled, are not incidental, but are the unavoidable result of his method, which takes the struggles of the parties as its point of departure for the analysis of the ideologies. It attempts to understand the architectural basic law of a building by explaining the structure of the sixth floor from the character of the fifth, disregarding the foundations and the intermediate storeys. Only the historian of today, looking back at the available historical material, and analyzing methodically the productive forces and the relations of production of the epoch, can grasp the totality of their social situation, and only from such reconstruction of the overall situation (e.g., Italy's situation after the shift of the axis of world trade from the Mediterranean to the oceanic coasts of Western Europe) can he properly understand the various parties or thinkers of that period (e.g., Machiavelli's program for the unification of Italy). In contrast, this situation is reflected only in distorted form as if in a convex mirror in the mere party struggles of contemporaries. Could Machiavelli's contemporaries realize that, when the dynamical and centralizing power of rising Italian capitalism was broken, this spelled the end of the program for Italy's unification as well? The party struggles of that time, the interests defended or opposed by the parties, do not so much express the real situation of the period as the conscious or unconscious illusions entertained by the parties regarding this situation. Therefore, if one adopts as his point of departure the party struggles as such, the ground is cut from under his feet and one forms his judgment not according to the essence of things but according to its more or less shadowy distortions. [230]

Social Origins of Mechanistic Thought [Original English Summary]

Franz Borkenau's book "The Transition from Feudal to Modern Thought" (*Der Übergang vom feudalen zum bürgerlichen Weltbild*), serves as background for Grossmann's study. The objective of this book was to trace the sociological origins [231]

[136] H. Sée, op. cit., p. 96.
[137] H. Sée, op. cit., p. 96.

of the mechanistic categories of modern thought as developed in the philosophy of Descartes and his successors. In the beginning of the 17th century, according to Borkenau, mechanistic thinking triumphed over mediaeval philosophy which emphasized qualitative, not quantitative considerations. This transition from mediaeval and feudal methods of thought to modern principles is the general theme of Borkenau's book, and is traced to the social changes of this time. According to this work, the essential economic change that marked the transition from mediaeval to modern times was the destruction of the handicraft system and the organization of labor under one roof and under one management. The roots of the change in thought are to be sought here. With the dismemberment of the handicraft system and the division of labor into relatively unskilled, uniform, and therefore comparable activities, the conception of abstract homogeneous social labor arises. The division of the labor process into simple, repeated movements permits a comparison of hours of labor. Calculation with such abstract social unities, according to Borkenau, was the source from which modern mechanistic thinking in general derived its origin.

Grossmann, although he considers Borkenau's work a valuable and important contribution, does not believe that the author has achieved his purpose. First of all, he contends that the period that Borkenau describes as the period of the triumph of modern thought over mediaeval should not be placed at the beginning of the 17th century, but in the Renaissance, and that not Descartes and Hobbes but Leonardo da Vinci was the initiator of modern thought. Leonardo's theories, evolved from a study of machines, were the source of the mechanistic categories that culminated in modern thought.

If Borkenau's conception as to the historical origin of these categories is incorrect in regard to time, Grossmann claims it follows that it is incorrect also in regard to the social sources to which it is ascribed. In the beginning, the factory system did not involve a division of labor into comparable homogeneous processes, but in general only united skilled handicraftsmen under one roof. The development of machinery, not the calculation with abstract hours of labor, is the immediate source of modern scientific mechanics. This goes back to the Renaissance and has relatively little to do with the original factory system that was finally superseded by the Industrial Revolution.

While Borkenau, in tracing the social background of the thought of the period, relies chiefly on the conflicts and strife of political parties, Grossmann regards this as one element only in the formation of the general social situation, which in its entirety and in the interaction of its elements explains the development of modern thought.