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Boris Hessen's Participation in the Second International Congress on the History of Science and Technology (1931)

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Abstract

From 29 June-3 July 1931, the Second International Congress of the History of Science and Technology took place at the Science Museum in London. It was marked by the participation of a large and representative delegation of scientists and philosophers from the Soviet Union, led by the well-known revolutionary Nicolai Bukharin. However, the contribution that stood out the most in this event was that presented by Boris Hessen, due to his instigating analysis and the set of propositions made, suggesting a reassessment of Newton's *Principia* in the light of its context and its economic (industrial) motivations and social. After highlighting the list of works presented by the Soviet delegation, we will focus on Boris Hessen's contribution, also looking at Book II of the *Principia* to try to relate some of the problems studied by Newton with their technological applications.

Keywords

History of Science Congress, Russian Science, Capitalism versus Socialism, Sociology of Science

1. Introduction

Soviet participation in the 1931 Congress in London was felt more forcefully by the contrast in which the political and ideological dispute took place between the two systems: the capitalist and the socialist. The capitalist world was still recovering from the impact of the 1929 crisis, while the Soviet Union was rapidly organizing itself under the aegis of a planned economy and the entire country was undergoing profound changes in the countryside and in the city. Evidently, the set of these social transformations was reflected in a different and even antagonistic way in the way in which their S&T systems were structured, and the performance of the Soviet delegation explored these contrasts and their reflections on scientific and philosophical thinking in both systems.

Also deserving of a special mention is the paper Boris Hessen (1893-1936) presented to the Congress entitled *The Social and Economic Roots of Newton's Principia*, as it established a landmark and a separation in the way of classifying investigations in the History of Sciences (Freudenthal & McLauglin, 2009). Thus, in a clearer way, externalists and internalists began to be placed in separate camps. The former, whose works were primarily focused on external influences, economic, social and political contexts, while the latter focused on the internal developments of research, its logical links, its structure and organization of its formal aspects.

The Congress on the History of Science and Technology of 1931 was also important for the development of Marxism in England. Two renowned British scientists, John Desmond Bernal (1901-1971) and Joseph Needham (1900-1995) participated in it and were greatly influenced by the work presented by the Soviet delegation, especially that of Boris Hessen. Both became great Marxist historians of the History of Science, achieving much prestige and international renown. Also noteworthy is the influence of Hessen, by Robert K. Merton (1910-2003), an American sociologist. Merton, in addition to confirming the influence Hessen had on his view of scientific and technological development, added the importance exercised by religion.

Finally, it is important to emphasize that in the final part of this work, we will make a brief incursion into Book II of the *Principia*, in an attempt to verify to what extent Hessen's thesis is confirmed by the problems studied by Newton (1642-1727) in his major work (Cohen, 1999).

2. Hessen's Biographical Note

Boris Mikhailovich Hessen was born on 16 August 1893, in Elisavetgrad, a small town in Ukraine, now called Kirovgrad. Of Jewish descent, his father Mikhail Borisovich served on the board of a bank in Elisavetgrad (**Figure 1**).

Hessen studied physics and natural science at the University of Edinburgh between 1913-1914. He then joined the University of Saint Petersburg, where he remained from 1914 to 1917. During the civil war that followed the 1917 Revolution, he joined the Red Army, adhering to the revolutionary process underway in Russia, participating in the Revolutionary Military Council from 1919 to 1921.

He continued his studies in physics and graduated from the Institute of Red Professors in Moscow in 1928. After working for two years at this Institute, he became professor of physics and chair of the Department of Physics at Moscow State University in 1931. In 1933 he was elected a member of the Russian Academy of Sciences.

In 1931, he participated in the Congress on the History of Science and Technology, as mentioned earlier. From 1934 to 1936 Hessen was director of the Moscow Institute of Physics, which was directed by S. I. Vavilov (1887-1943). On 22

Figure 1. Boris Hessen (1893-1936).

August 1936, Hessen was arrested by the NKVD, the Russian political police. He was secretly tried by a military court on charges of terrorism and being part of a Trotskyist-Zinovievist conspiracy. Found guilty, on 20 December of the same year he was executed by firing squad. On 21 April 1956 he was posthumously rehabilitated (WIKEPEDIA).

3. List of Papers Presented by the Soviet Delegation in London

The papers presented by the delegation of the Soviet Union to the Second International Congress on the History of Science and Technology are easily accessible on the internet in a publication called Science at the Cross Roads (1931), published by KNIGA (England) LTD, Bush House Aldwych, London, WC 2, from 1931.

- Theory and Practice from the Point of View of Dialectical Materialism

N. I. Bukharin (1888-1938), Member of the Academy of Sciences, Director of the Department of Industrial Research of the Supreme Council of Economics, Chairman of the Commission of the Academy of Sciences for the History of Knowledge.

- Physics and Technology

A. F. Ioffe, Member of the Academy of Sciences, Director of the Physico-Technical Institute of Leningrad.

- Relations between Science, Technology and Economics under Capitalism and in the Soviet Union

M. Rubinstein, Professor at the Moscow Institute of Economics; Member of the Presidium of the Communist Academy of Moscow; Member of the Presidium of the State Planning Commission (Gosplan).

- The Physical and Biological in the Process of Organic Evolution

B. Zaradovsky, Director of the Institute of Neuro-Humoral Physiology.

K. A. Timisiaseff, Director of the Biological Museum.

- Dynamic and Statistical Regularity in Physics and Biology

E. Colman, President of the Association of the Scientific Institute of Natural Sciences, Professor at the Moscow Institute of Mathematics and Mechanics; Member of the Presidium of the State Scientific Council.

- The Problem of the Origin of the World of Agronomy in the Light of the Latest Investigations

N. I. Vavilov, Member of the Academy of Sciences, President of the Lenin Academy of Agriculture.

- Faraday's Work and Modern Developments in the Application of Electric Energy

W. Th. Mitkewich, Member of the Academy of Sciences.

- Electrification as the Basis of Technical Reconstruction in the Soviet Union

M. Rubinstein.

- The Social and Economic Roots of Newton's Principia

B. Hessen, Director of the Moscow Institute of Physics, Member of the Presidium of the State Scientific Council.

- The Present Crisis in Mathematical Sciences and a General Description of its Reconstruction

E. Colman.

- Brief Communication of Unpublished Writings by Karl Marx Concerning Mathematics, Natural Sciences, Technology and Their History

E. Colman.

4. Considerations on Boris Hessen's Work

4.1. Introduction and Formulation of Problems

Boris Hessen's long study presented to the Congress of History of Science and Technology begins with the above subtitle. 60 pages long, with 5 small appendices on related subjects, and supported by an extensive bibliography and an even more extensive number of footnotes, it presents in clear, short sentences and in an almost telegraphic style, his ideas about Newton's masterpiece.

Hessen claims for himself a radically new interpretation with an innovative vision of Newton's work, through the application of dialectical materialism and Marx's (1818-1883) conception of the historical process characterized by the study of the genesis and the development of Newton's work within the context in which he lived and worked.

He then makes a brief outline of the basic premises of this method, which will guide the development of his analysis. He points out that Marx's method is presented in a more objective way, mainly in the preface to his *Critique of Political Economy and German Ideology* and summarizes in a single sentence the essence of this method: the mode of production of the conditions of material life determines social life, political and intellectual society. He also reinforces the Marxist thesis that it is not the conscience of men that determines their being, but on the contrary, it is their social being that determines their conscience. And he ends this introductory part by stating that a Marxist analysis of Newton consists in understanding his work and his worldview as the product of the period in which he lived, which is the period of the Civil War and the British Commonwealth.

4.2. Economics, Technology, and Physics in the Age of Newton

Hessen begins, at this point in the work, by describing the historical periods from medieval times to modernity, associating them, according to Marx, with the development of different forms of private property. He distinguishes them by separating them into subsidiary periods, encompassed by a broader epoch. Thus, the first period was feudalism, the second arises as a result of the disintegration of the feudal order, characterized by the emergence and development of mercantile capital and manufacture. The third period in the history of private property is identified with industrial capitalism. In this way, the emergence of the natural sciences during the 16th and 17th centuries is the result of the destructuring of the feudal economy with all its consequences.

Focusing our attention on the time when Newton was active, we will have to analyze the second period mentioned above, associated with the forms that private property took in this period. This means investigating the historical demands that arise in the face of mercantile capital, seeking to focus on essential problems and their technical solutions. He then divides these problems into three spheres, which for him are most important from a social and economic point of view: communications, industry, and war.

1) Communications: Commerce reached a high level of development in the early Middle Ages. However, terrestrial communications did not develop and did not follow this development. The isolated character of the feudal regime and its economy did not stimulate the growth of roads. On the contrary, the feudal barons and the inhabitants of these places had no interest in this development because of certain property rights. The speed of land transport in the 14th century did not exceed five to seven miles per day. The opposite occurred with river and maritime transport. Just to give you an idea, a trip from Constantinople to Venice took three times longer by land than by sea.

Physical problems raised: a) need to know the fundamental laws of buoyancy of bodies to estimate the carrying capacity of ships; methods for estimating the displacement of bodies in fluids; b) the study of ship stability problems. All this implies problems of hydrostatics and hydrodynamics; c) need to determine latitude through celestial observation, depending on the development of optical instruments and celestial charts: celestial mechanics; d) need to determine longitude, which was only achieved in 1730, after the work of Huygens (1629-1695); from an astronomical point of view, the longitude problem was solved by knowing the position of the moon and the fixed stars.

2) Industry: At the end of the Middle Ages (14th and 15th centuries), the mining industry developed on a large scale, acquiring an industrial dimension. Precious metals, gold and silver, operated the development of currency, further stimulating exchanges. The discovery of America became an enterprise geared towards the search for gold due to the high commercial demands. In turn, the war industry, driven by the discovery of firearms and the introduction of heavy artillery into the war theater, was evidently supported by the mining of iron and

copper.

In the 15th century, artillery reached a high level of development. In the 16th and 17th centuries the war industry created an enormous demand for the metallurgical industry. One of the most serious problems posed by mining was that the deeper the excavations went, the more dangerous their exploration became, creating the need for apparatus and devices for pumping water, ventilation and lifting the ore to the surface. The correct construction of a mine became a real technical problem at the time.

Physical problems raised: a) need to know and build lifting machines; b) need to develop ventilation systems, their design and manufacture; c) need to know and manufacture pumps for extracting water from mines; the studies of Torricelli, Guerike (1602-1686), and Pascal (1623-1662), reflect this need, i.e., to study the rise of liquids in tubes with the effect of atmospheric pressure; need to build blast furnaces, design buildings, build water wheels, bellows, heavy hammers, sprockets, etc.

3) War and the industry of war: Hessen recalls that in an 1857 letter from Marx to Engels (1820-1895), the former recalled that the history of war confirmed his views on the relationship between productive forces and social relations. Hessen also notes the importance of the army for economic development and that it was war-related issues that gave rise to the system based on guilds and their artisan guilds. It was also the division of labor within the various branches of industry that began to be put into practice in the army. These aspects, in a way, condense the history of the bourgeois system.

Vannoccio Biringucio (1480-1539) studied the casting process in which he introduced many improvements and innovations in the production of weapons. Hartmann studied a scale of calibers by which each section of the weapon could be measured in relation to aperture and established specific standards for the manufacture of weapons and set the stage for the establishment of theoretical principles and empirical rules of fire. From there, artillery schools began to be created, the first in France.

Galileo (1564-1642) provided the world with the theory of the parabolic trajectory of projectiles; Torricelli (1608-1647), Newton, Bernoulli (1667-1748), and Euler (1707-1783) studied the launch of projectiles through the air, calculated their resistance and deviations in this movement.

Physical problems raised: a) need to know the theory of compression and expansion of gases; b) need to study the mechanical properties of weapon metals and test their durability; c) study the trajectory of a projectile in a vacuum; this is what Galileo did with the help of the Arsenal of Venice by providing rich material for study; d) need to understand the launch of projectiles through the air, which means the study of the displacement of bodies through a resistant medium.

4.3. Examples of Technical Problems in Principia

In the first book of the *Principia*, we find a detailed exposition of the general laws of motion generated by central forces, providing at least a preliminary solution to the work carried out since Galileo. In the second book, dedicated to the movement of bodies in fluid media, many of the technical problems raised above appear. Thus, the first three sections of the second book are devoted to the problems of resistant media with various forms of resistance. In this way, resistances appear depending linearly on velocity, velocity squared (**Figure 2**) or both simultaneously.

Newton notes that linear cases are of more mathematical interest than physical ones. In the fourth section of the second book, we find the foundations of hydrostatics and the problem of buoyancy. In this same section we have the study of the compression of gases.

In the sixth section the problem of movement and resistance encountered by a pendulum in motion appears (**Figure 3**). It was notnecessary to stress the technical importance that this problem had at the time, that is, the discovery of a clock that could be shipped and thus be able to accurately calculate the longitude of ships.

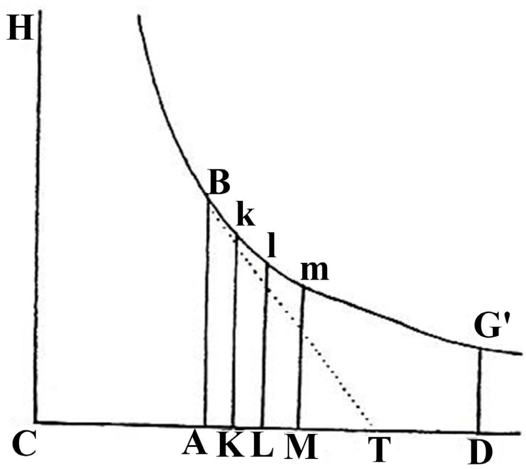

Figure 2. Body velocity versus time (*Principia* II).

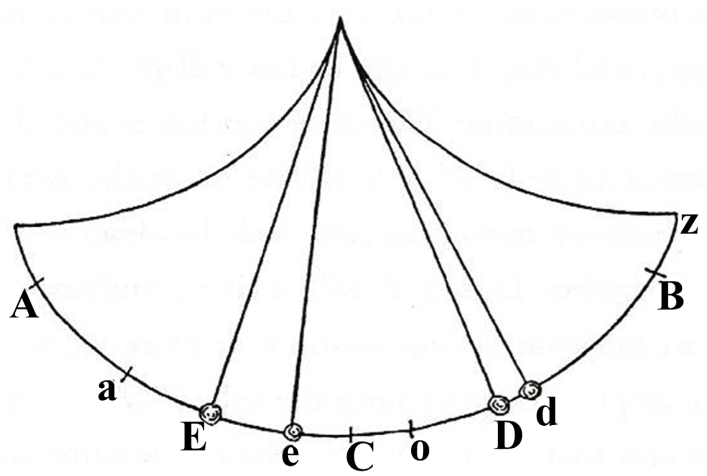

Figure 3. Pendular movement (*Principia* II).

5. Relevant Epistemological Issues

Hessen's work, despite the fact that he uses simple language, with short sentences and in a colloquial style, rests on a solid conceptual basis, linking historical analysis with epistemological questions, which we could even say is a feature of his analytical method. Among the many questions raised, evidently the most discussed and the one that has acquired the greatest notoriety, is precisely the classification or quarrel between internalist and externalist historians. From the outset, it is necessary to mention the impossibility of separating these two approaches, which makes this classification a matter of degree or measure. In other words, taking a historian of science who calls himself "internalist", however hardened he may be, he will always have to place his object of study in a certain context and at a certain time. An "externalist" historian, however radical he may be in exhaustively discussing the context to which his study refers, will never be able to minimize the fact studied itself (internal). How, then, to calibrate the doses of internalist and so many externalist elements to the problem? We believe that the nature of the problem studied will determine the right combination of these factors.

Subjects with greater abstraction, such as mathematics, physics, logic and others, require greater dedication to their internal aspects so that historians can recover their state-of-the-art and begin to analyze subsequent developments. Of course, even in these cases, depending on the conjuncture in which they were developed, a rigorous contextual analysis will be necessary. By way of example, we can mention the conception of the machine by Sadi Carnot (1796-1832) and the development of the second law of thermodynamics. A rigorous analysis of its internal development also requires a strong emphasis on the context of the Industrial Revolution under way on the European continent in the first decades of the 19th century.

A further issue studied by Hessen, and which has a general scope, is the one referring to the ways in which movement appears in nature. On page 73, he studies this interrelationship between matter and motion in Newton, stating that motion is inseparable from matter. Let us follow the reasoning he develops as follows:

In nature, we observe an endless variety of ways in which matter moves. If we consider these forms studied by physics, we will see: mechanical, thermal, electromagnetic. Mechanics studies the form of movement that consists of the simple displacement of bodies in space... Consequently, different from a mechanical view of the world, which sees natural science as a reduction of all forms of movement of matter to a single one, that of displacement mechanical, dialectical materialism adopts as the main task of natural science the study of the forms of movement of matter in their interconnections, interactions and development.

Hessen once again follows one of his teachers, this time Engels, drawing on the latter's book *Dialectics of Nature* (Engels, 1968). In the second chapter of that book, entitled: *Fundamental Forms of Movement*, we read:

Movement, in its most general sense, conceived as a form of existence, as an inherent attribute of matter, comprises all the transformations and processes that occur in the Universe, from simple changes of place to the elaboration of thought.

This association between matter and motion is very interesting as a way of analyzing physics, especially after the discovery of the principle of conservation of energy in the mid-19th century, which Engels was already aware of when writing the *Dialectics of Nature*. In the case of the mechanics of rigid bodies, their movement is done in relation to other bodies that relate to them in a common space. In the case of deformable solid mechanics, the displacements are interior to the body itself and the main objective is to study the set or field of localized movements called deformations, which are associated with the concepts of stress, mathematically represented by a tensor. In the case of the study of the heat (expansion) of a certain object, movement encompasses all particles, whether it is solid, liquid or a gaseous body. In electrodynamics and electromagnetism, movement occurs with electrical charges and in optics, movement is associated with particles of light called photons.

The analyses made above would be subjected to new considerations with the appearance of quantum mechanics at the beginning of the 20th century and with the discovery of the famous equation regarding transformation of matter into energy and vice-versa, in 1905 by Einstein (1879-1955).

The last issue raised by Hessen we would like to discuss, and which is of crucial epistemological importance, is the role of the steam engine in the Industrial Revolution in England. This question had already been studied by Marx in Capital and Hessen follows in the same way. Thus, on page 78 of his article, he states:

It was not the development of the engine and the invention of the steam engine that created the Industrial Revolution of the 18th century, but rather it was the steam engine that gained its enormous importance precisely because of the division of labor that was emerging in manufacturing and its productivity increase, which made the invention of the steam engine possible and necessary, which had been born in the mining industry, found a fertile field for its applications as a drive system.

Hessen, essentially follows the same analysis made by Marx in the first volume of Capital. There, Marx states that the steam engine was invented at the end of the 17th century, during the manufacturing period, and that it continued until the 1780s without causing any Industrial Revolution. Continuing this reasoning, Marx states:

It was, on the contrary, the creation of machine tools, which made a revolution in the steam engine necessary. Later, Marx writes: The machine from which the Industrial Revolution started has replaced the worker who handles a single tool by a mechanism that at the same time operates with a certain number of identical or similar tools, and is driven by a single motive force, whatever its form. It was this modification in the machine, which is also a modification in production and in the division of labor, as Hessen emphasizes, increasing in size and in the number of instruments (tools) that required a more powerful engine. Essentially, this is in summary Marx's analysis of the role of the steam engine in the Industrial Revolution (Marx, 1968) and of which Hessen is a follower.

6. Conclusion

The International Congress on the History of Science and Technology held in London in 1931 still continues to influence historians not only because of the propositions presented at that time, but also because it was an important milestone and a watershed for the classification of works in the History of Sciences, regardless of the merit in separating historians into internalists and externalists. Obviously, as we have seen above, this form of classification has only a relative value since it is impossible to dissociate in any scientific work the set of internal and external influences, even if historians do not refer to some of them. In general, historians of science more connected to the areas of history or sociology naturally place greater weight on external factors, while historians originating from the so-called exact sciences (Oliveira, 2020) tend to explore their internal developments, such as structure and logical organization, formal aspects of the construction of scientific knowledge, etc.

It is also important to emphasize that while Hessen focused on the social and economic context of the 17th century for a more comprehensive analysis of Newton's *Principia*, this is also valid for the entire 17th century, when the Scientific Revolution closes a virtuous circle with the greatest work of Newton. Therefore, the works of Galileo, Descartes (1596-1650), Huygens, Leibniz (Elster, 1975) and others can be subjected to the same method of analysis.

Finally, it is worth emphasizing that in addition to the work of Boris Hessen analyzed here, all the other works had the characteristic of providing a kind of research program and that they exerted a great influence in their respective areas.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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