R. N. D. MARTIN

DUHEM AND THE ORIGINS OF STATICS: RAMIFICATIONS OF THE CRISIS OF 1903–04*

ABSTRACT. Much speculation on the sources of Duhem's historical interests fails to account for the major shifts in these interests: neither his belief in the continuous development of physics nor his Catholicism, when his Church was encouraging the study of generally Aristotelian scholastic thought, led to any interest in mediaeval science before 1904. Equally, his own claim that he was merely testing his views on the nature of physical theory is easily squared only with earlier work with no trace of mediaeval science. Behind this discontinuity lies a major crisis. Though not a positivist, Duhem had based all his work on assumptions acceptable to positivists. One of these, the sterility of the Middle Ages, was refuted by his chance discovery of evidence of genuine mediaeval science in the autumn of 1903, but that left the doctrine of scholastic sterility intact.

1. INTRODUCTION: INTERPRETING DUHEM AND THE 1913 ACADEMY DOCUMENT

Since it covers both the history of science and its philosophy, the work of Pierre Duhem provides a suitable test case on which to focus discussions of the mutual interaction of these two studies.[1] To what extent, we may ask, did Duhem's philosophical writing control his historical investigations? To what extent were the historical investigations a main source for his distinctive philosophical positions? Like Agassi (1963) and Lakatos (1971), Duhem fully expected that the mutual relationship would be close, but the outcome of his labours was not what he or anyone else would have expected. A study of that outcome can tell us a good deal about Duhem's other concerns.

In 1913 Duhem authorized one interpretation of his historical work, in his submission to the Académie des Sciences at the time of his election as a nonresident member.[2] His attempt to present his philosophical and historical studies as ancillary to his physics bears all the marks of the occasion for which it was drafted: it was as a physicist that he was up for election, and it was as a physicist he was going to present himself. Whatever other interests he may have had, they were not relevant on that occasion or, if they were relevant, it was for the light they shed on his career as a physicist.

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The picture he presented then lies behind one school of Duhem interpretation, of which Armand Lowinger with his Columbia thesis (1941) is perhaps the most prominent representative. Duhem the physicist had developed a scientific programme to reduce the whole of physics to the laws of heat via a general thermodynamics or Energetics; in defence of that programme he had developed a philosophy, a critical analysis of scientific knowledge, and set this out in a number of writings up to the *Théorie Physique*. But to the good scientist, theories, including theories of scientific knowledge, require testing, and for the facts to test this theory he turned to history. On this showing, the historical writings are apologetics for the Energetic method.

This interpretation of Duhem's philosophical and historical interests aligns him with the common practice of late positivism, and makes of him a practitioner of the rigidly internalist critical history for which perhaps Mach[3] is best known (and which some latter day positivists are still trying to keep alive in the face of the flood of externalist historiography), a practitioner of a type of 'history' in which the only factors allowed to appear are those which the logic of the philosopher-historian accepts as relevant. This account represents also a highly integrated rigid view of Duhem with no room for development, with all the parts interconnected, and no joins showing. Most obviously, it makes no allowance for Duhem's undoubted and never concealed religious and political concerns.

There is much to be said for this view of Duhem's philosophy and historical interests. Both his love of and dedication to theoretical physics, and his commitment to his Energetic programme are beyond doubt, and apologetics for his Energetic method seems a reasonable description for the brilliant classic short works he wrote before and up to about the turn of the century, works like *Les Théories Électriques de J. Clerk Maxwell* (1900–1901), *Le Mixte et la Combinaison Chimique* (1902) and the *Évolution de la Mécanique* (1903). Nonetheless, it is a nonsense: the detailed discussions in the *Systéme du Monde* (1913–59) of the philosophy and theology of Aquinas and of the condemnations of 1277 have no conceivable connection with Duhem's Energetic programme. The Academy document and the school of Duhem interpretation springing from it would have been a pretty fair description up to 1903. It was not in 1913.

At this point, readers may be tempted to appeal to Duhem's doctrine of continuity.[4] According to this much-discussed doctrine, good physics

builds on what came before instead of seeking to destroy it, usually also claiming that the appearance of revolutions in the history of physics conceals an underlying continuity discoverable by closer analysis. It is commonly supposed that the idea of a seventeenth-century scientific revolution offended against this doctrine and so drove Duhem into seeking the mediaeval antecedents of modern science. Duhem's belief in continuity is beyond question, but as Malocchi has shown, it was common among late nineteenth century positivists, and it will not do the work required of it. If his continuism is an adequate explanation of Duhem's work on mediaeval science it is remarkable that it did not have that effect before 1904.

2. MEDIAEVAL SCIENCE AND THE 'NEO-SCHOLASTIC' ALTERNATIVE

There is another theory of the origin of Duhem's philosophical and historical interests which is even more implausible: that it was an outgrowth of late nineteenth century and early twentieth century neo-scholasticism.[5] This programme for reviving scholastic thought is particularly associated with Pope Leo XIII,[6] and as a Catholic Duhem must be supposed to have been aware of it. The ultimate source of this theory is a little unclear, though it seems to have been current in the Vienna Circle,[7] and it also got publicity from Antonio Favaro.[8] In epistemology it seems to rest on superficial resemblances between Duhem's doctrine of the autonomy of physics,[9] its independence of all metaphysical and extra-physical considerations, and scholastic theories of the classification of the sciences. In history of science its basis seems to be Duhem's interest in the Middle Ages, and his many publications in neo-scholastic journals such as the Brussels *Revue des Questions Scientifiques*,[10] and the Paris *Revue de Philosophie*.[11]

It depends on what counts as scholastic. If all that is meant is taking mediaeval thought seriously, Duhem is included; he is also included if it means no more than a genuine attempt on the part of Catholics to grapple with modern science, and he may have seen the *Revue des Questions Scientifiques* in that light.[12] In the eyes of the Catholic authorities, however, it meant very specifically the revival of the thought of Thomas Aquinas, and his supposed reconciliation of Christian thought with Aristotle.[13] It was a definite ecclesiastically sponsored movement with definite ideas, forwarded by particular people. Duhem

could, the evidence is, tolerate some of these, like Jean Bulliot, the editor of the *Revue de Philosophie*, but many of them could rouse him to express his disgust in extremely violent terms.[14] They in their turn found him an embarrassment: the lengths Jacques Maritain went to refute him[15] is evidence of that, and equally symptomatic is the way Étienne Gilson avoids citing the passages from Duhem's *Systéme du Monde*[16] this Thomist must have found particularly uncongenial.

But the most obvious difficulty facing any kind of 'neo-scholastic' theory of the origin of Duhem's interests in the history of mediaeval science in particular is the discontinuity, discussed above, in the career of the continuist philosopher of physics. Duhem's mediaeval interests came so very late in his life: all the works on which Duhem's reputation as a historian of mediaeval science rests are later than 1904.[17] The 'neo-scholastic' theory of Duhem's philosophical and historical interests could have had some plausibility in 1913, but it has none for the Duhem of 1903, whose works showed no interest in or knowledge of mediaeval science. In the first part of his career Duhem seems to have been totally immune to all ecclesiastical pressures in favour of mediaeval thought, while in the second part, his researches were increasingly controlled by concerns outside physics. A serious account of the various interests of the historical Duhem has to take account of this discontinuity, and pay attention to just what was happening at the watershed of 1903–1904 and in the years that followed.

3. THE DISCOVERY OF 1903–1904

In 1974, I began examining systematically those of Duhem's works deriving from that crucial period. I found what had not to my knowledge been documented before: Duhem's discovery of mediaeval science took him completely by surprise in the winter of 1903–1904 while he was working on *Les Origines de la Statique*. In a paper published by *Annals of Science*,[18] I documented the surprise and sought to interpret the evidence: I saw the discovery of mediaeval science as provoking a crisis of a far-reaching kind, some of whose ramifications I attempted to indicate. It is now clear to me that I did not see anything like the full picture, but, nevertheless, a very brief summary is in place here. In what follows I do not speak of a crisis in the Kuhnian[19] sense of an interregnum between paradigms, when nobody can understand each other, but in the Biblical sense of a judgement, a time when one's acts

and one's doings are in question, under judgement, and it is unclear what will stand or fall.

In the autumn of 1903 Duhem had just completed his *Évolution de la Mécanique*, of which a principal theme had been the dynamics of Lagrange, a theory of moving bodies and of the forces that moved them built on a principle (virtual velocities) having to do with bodies, not in motion, but at rest. This principle of the theory of forces at rest, or statics, had a long history, and Duhem now set out to write a work on the origins of that theory, under the motto title *Les Sources des Théories Physiques*. Like much else that he wrote, he published this work in serial parts in a journal, in this case the quarterly *Revue des Questions Scientifiques*. The first instalment of four chapters, appeared in the October 1903 issue, and in the ordinary course of events, the next would have appeared in the January 1904 issue. It did not: when it did appear in April it was flagrantly inconsistent with the first. The first instalment, unusual though it was for the emphasis it placed on Leonardo's ideas and their influence, otherwise broke little new ground, and in particular flatly announced that the commentaries of the scholastics on Aristotle's Μηχανιχὰ προβλήματα (actually there were no such commentaries: the work was unknown in the Middle Ages[20]) had added nothing to our knowledge. The second, however, started with the admission that Duhem had so far given only a crude sketch of the early development of the subject, and now needed to gather up the Alexandrian sources of mediaeval statics. He was also now laying heavy emphasis on the previously unmentioned thirteenth century figure of Jordanus de Nemore.

What brought Duhem to this *volte face* is even now not clear. He seems, in late October or early November 1903, to have become bothered by the inadequacies of his sources and asked Paul Tannery for help in locating a certain Euclid text. Tannery's postcard reply of December 1903,[21] volunteers the following additional information:

There is also, under the name of Euclid, another piece on statics, *Euclidis de Ponderibus*, sometimes confused with the work *Jordanus Nemorarii de Ponderibus* (see Rose's *Anecdota Graeco-Latina* II, 291). I have seen this treatise in manuscript, but don't really know it – it seems of Arabic origin. Woepcke (*Journal Asiatique* XVIII, 1351, p. 217) has given the translation of a Euclid piece 'on the balance' connected with it. Maurice Gallien, retired artillery commander (Toulouse, 5 rue Traversière) was going to make a special study of these writings, so that I have not concerned myself with them, but I have not heard from him since 1900.

That postcard seems to have set him off: at any rate, in 1905, in his preface to the book form of his work (otherwise a verbatim reprint of the articles, including the inconsistencies), he told the world that the only thing for it was to get hold of and analyse everything relating to mediaeval statics in the Bibiliothèque Nationale and the Bibilothèque Mazarine. Duhem's response, it might be felt, was perhaps a little extreme: did he really need to go that far to fill in the gaps in his sources? For a critical historian, Duhem had always been unusually careful with his sources, making sure he got his facts right before his critical analysis got going, but this is going beyond even ordinary care. It is hard to resist the conclusion that for Duhem important issues were at stake.

4. THE CONSEQUENCES OF THE DISCOVERY

My 1976 paper attempted to say what these issues were. I suggested that in Duhem we had to do with a physicist, with the prejudices physicists imbibed in their training, and among these prejudices, I suggested, was the doctrine, in all his sources from Lagrange[22] to Dühring[23] and Mach, that the mediaeval period was scientifically sterile. In Jordanus, however, he encountered evidence, which his training as a physicist compelled him to recognize as evidence, of worthwhile mediaeval science. I also suggested that the refutation of the doctrine of mediaeval sterility had knock-on effects in other areas of Duhem's thinking: it called in question his historiographical assumptions and the methodological principles that guided these assumptions, particularly the autonomy of physics. As he had explained in the *Théorie Physique*,[24] the kind of history of interest to the physicist, was one bare of all personal details, containing only the occasions in which an important new fact was discovered, a principle clarified or false idea refuted, and in this he was advocating a 'critical' approach to the history of physics rather like the 'rational reconstruction' method advocated by Imre Lakatos.

Duhem was, however, conscious of the limitations of this 'historical' method. In 1903, in an extended essay review of the French translation of Mach's *Mechanik*,[25] he discussed Mach's exclusion of nonscientific ideas from his story, and remarked that this was acceptable for recent physics, since it was now generally agreed that physics was and should be separate from religion and metaphysics. This general agreement,

however, did not obtain in earlier periods, and the historian who wanted to bring the past to life had to take account of such ideas. Bringing the past to life again was what Duhem was certainly not doing in 1903. In the following year, however, he was doing it, and because he was doing it, he could no longer assume the autonomy doctrine in his analysis. But equally, he had nothing to replace it with, and the lack of such a principle shows in the chaotic nature of much of his work over the next decade. With *To Save the Phenomena* in 1908,[26] however, he had the outline of a replacement, in which the *problem* of autonomy replaced autonomy: the standing of physics and its degree of independence from other disciplines was now the central issue.

Thus far this is the account of my 1976 paper. With qualifications, it still seems generally correct, though something would need to be added about the positivistic atmosphere in which the physicist had been trained, as has been so admirably done by Roberto Maiocchi, but a great deal more needs to be said about the crisis of those years.

5. WIDER RAMIFICATIONS OF A CRISIS

What I did not see in 1976 was that bringing into question the historiographical applications of Duhem's methodology had much wider effects on the whole orientation of a man in an extremely sensitive political and religious position. I did not then see these wider effects, nor see it for what it was, a crisis imperilling his whole life strategy, I did not see that beyond the time invested in a particular approach to the history of science, founded on a particular set of historiographical assumptions linked to a particular methodology, lay a particular way of coping with the political and religious conflicts all around him. Duhem had developed an integrated strategy for coping with these conflicts, and this strategy was now at risk. I have no time or space here for a detailed account of the pressures Duhem as a Catholic scientist in the Third Republic was exposed to, and in any case the job has been very well done by Harry Paul,[27] but some understanding of these is essential for understanding the religious motifs in his writing, and for making any kind of sense of his later output, and I give a brief summary here.

The France Duhem grew up in and in which he made his career was deeply unstable, its instability marked by a succession of crises that split the country from top to bottom.[28] The most famous of these was the Dreyfus affair of the closing years of the nineteenth century and

early years of the twentieth century. This concerned the Jewish army colonel, Albert Dreyfus, who was imprisoned in 1894 on Devil's Island after being falsely found guilty of espionage, and the long political campaign for his rehabilitation that finally succeeded only in 1906. The Third Republic was in practice the constitution imposed by one party on another, imposed by people who were atheists on Catholics who hankered after a restored Bourbon monarchy, imposed by people whose ideological inspiration was positivist[29] on Catholics who had every reason to resist that ideology, imposed by people who appealed to the authority of science as the counterweight and answer to the authority of religion. The educational system was the key to the strategy against the religious enemy: a schoolmaster in every parish was to undermine the authority of the priest. It was an all-embracing system, from the elementary school to the university, unless you opted for mostly underfunded Catholic schools and universities of low prestige. Duhem made his career as a Catholic in the state system, and was not alone in this even if he was perhaps the most visible, and the obvious question is what strategy he adopted to ensure his survival and protect his integrity. That strategy will throw light on the rationale behind the nonsense of the 1913 Academy document discussed in my opening paragraphs.

In a like political situation the founders of the Royal Society of London responded to it by forbidding all discussion of politics and religion at its meetings. The strategy is common in conflict-ridden societies, and was available to Duhem; if, for example, as a Catholic (and therefore drawn to the side of the reactionary opponents of the campaign for Dreyfus's release from the Devil's Island) he wanted to stay on good terms with his friend and colleague, the left-leaning mathematician Jacques Hadamard[30] who just happened to be the brother-in-law of Albert Dreyfus and organiser of the campaign for his release. The correspondence with Hadamard continues right through the Dreyfus affair, and after Duhem's death Hadamard contributed to the memorial volume on his work [31] and spoke at the 1936 memorial meeting in Paris organized by Aldo Mieli.[32] He also referred to him in friendly terms in his *Psychology of Invention* (1945) many years afterwards. It is no surprise that letters from Hadamard at the time of the affair are on purely technical matters (the stability of the solar system[33]) and do not

refer to politics. Duhem's strategy is the obvious one: make your stand on your scientific excellence, and let your work speak for itself: never ever appeal to your faith or politics in your scientific work. The French Catholic who made his career as a scientist within the Third Republic at no point appealed to his religion: his work, acceptable to the positivists on their own terms, was to be its own argument. The thing was to seek truth and broadcast what he found to the winds,[34] avoiding unnecessary religious or political polemic.

Duhem was thus involved in a strategy of defeating the enemy from within using the assumptions and methods of the positivists, excelling at the science and using only the methods of the science that was their paradigm of knowledge and rationality. Only by thus presupposing physics as a neutral ground for debate, valid in its own terms, could Duhem attempt to expose the limitations of claims to authority based on that science. Hence the rigorous analysis of the bases of physical theory, underpinning a particularly abstract approach to the problems of theoretical physics, in which all that counted were just those things the positivists said counted: agreement with observation and experiment. Hence also the brilliant historical sketches of the 1890s and early 1900s in which alternative less abstract approaches to physics and physical chemistry based, for example, on atomic hypotheses were shown as leading into contradictions and dead ends while the abstract approaches Duhem favoured triumphantly overcame these obstacles. Hence finally the brilliant attempt to show that within its own terms an account of physical theory relying on nothing but observation and experiment was incomplete, unable to explain its own goals and procedures.[35]

Duhem's strategy had only partial success. Close colleagues like Hadamard often came to make allowances for his combative disposition and respect his integrity, but those who controlled his career and wrote reports on him saw him as something of a Trojan horse who had to be neutralized: they held back his professorial grading as long as they could and made sure that he never got the Paris job that was the normal expectation of an academic of his standing. As Harry Paul has shown, to them he was a dangerous enemy to be dealt with at arm's length. That may be no surprise, but it is more surprising that Duhem's strategy was hardly more acceptable to his fellow Catholics.

6. NEO-SCHOLASTICISM AGAIN

Duhem's neutralizing strategy can be contrasted with the neo-scholastic alternative. This offered an alternative philosophy, based on the work of St. Thomas Aquinas, and an alternative rationality in which the authority of science was to provide an independent rationale for the authority claims of the Catholic hierarchy, its right to command obedience both in the religious sphere and the political. Thomist scholasticism offered a philosophical environment that facilitated the elaboration of a natural theology offering proofs of God's existence to underpin the teaching of the Christian revelation and assist the articulation of that revelation. At the same time it facilitated the erection of a system of natural law underpinning Catholic moral theology, giving it a solidity that it might have lacked if it had to rely on the teachings of the New Testament and its tradition. Such claims to authority were very much at issue when Duhem was writing, as the Catholic community descended worldwide into its so-called modernist crisis,[36] of which France was the principal focus. The principal document of that crisis, the encyclical *Pascendi Dominici Gregis* of 1907,[37] specifically pointed out the dangers 'modernism' posed to natural theology, and went on to identify a distrust of scholasticism as a principal symptom of the 'heresy' so named. Through the 1890s Duhem did not object to the idea that a rationale for the method of physics might be found in a metaphysics of generally scholastic type, but he did not encourage it, and in the meantime ensured, to neo-scholastic protests,[38] that any such metaphysics would have no power whatever to dictate the contents of his autonomous physics.

Duhem did not, moreover, do anything to encourage any suggestion that there was a mediaeval science, scholastic in form, worthy of attention in his own time. Such suggestions could have been very welcome to the ecclesiastical authorities: a constant theme of Catholic apologetics has been to show how the Church supported education and learning in the Middle Ages, and to show the beneficence of the church's control in matters intellectual. Moreover, a plausible scholastic science would have made easier the job of the natural theologian wanting to update the proofs of God's existence. But a science under scholastic auspices was not a likely prospect for Duhem's apologetic purposes: what he needed was one under nonscholastic auspices. There should be no difficulty in seeing why: it was and is a commonplace that the seventeenth century scientific revolution was at heart the replacement of

scholastic sterilities by experimentally controlled mathematical precision,[39] and that received wisdom meant that the Church that was supposed to have encouraged these sterilities could make no convincing claim to the attention of scientific intellectuals. There was a high price to pay for taking pride in just that feature of mediaeval thought universally agreed to have been overcome by the rise of modern science. Duhem's strategy had no room for mediaeval science, or at least for what was then known of it, and little room for a synthetic programme of absorbing science into metaphysical framework of scholastic inspiration.

But that strategy had serious consequences: Duhem was now in effect sitting on the fence in the midst of his Church's battle for survival, refusing it the weapons it needed to win the war. His difficulties were now more severe than they had been in the early 1890s. Then, when his early near-Machian assistance to the memory account of physical theory[40] had come under scholastic attack, he had responded with a theory of natural classification, according to which the classifications imposed on the world by his purely mathematical abstract systems approached the truth asymptotically. He was even prepared to hazard the guess that reality might be truly describable by a metaphysics of scholastic type. The concession cost him little, for he had never doubted that there was a real world out there, and he had not conceded metaphysics any right to dictate the contents of his physics. He seems to have thought that such partial concessions to scholasticism, welcomed as they were by Belgian friends associated with the *Revue des Questions Scientifiques*, would be enough to fulfill his obligations as a loyal Catholic, but the events of the following decade proved otherwise.

After the death in 1916 of his student friend, the historian of philosophy Victor Delbos, Duhem, who had himself only a couple of months left to live, remarked to Blondel[41] that he had sometimes heard him accused, particularly by priests, of not being open and forceful enough in his Catholicism: to be insufficiently strident was to leave oneself open to suspicions of treason. Astonishing as it may now seem, Duhem was exposed to just this suspicion, that in his philosophy he had compromised with the enemy. In this he was in a like position to those other Catholics, increasingly accused by their opponents of modernism, who sought intellectual and political dialogue with non-Catholics. Throughout the 1890s and into the beginning of the following decade, Duhem had avoided aligning himself either with such Catholics or against them. He was now to be forced to take sides. In 1905 his student friend

Maurice Blondel invited him to collaborate with the *Annales de Philosophie Chrétienne*,[42] which he had just acquired on the death of its previous owner and editor Charles Denis. Duhem hesitated: he was not prepared to give up his previous collaborations and rather wished that Catholics would unite against the common enemy instead of shooting at each other. He did, however, agree to collaborate with it and it carried both his 'Physique de Croyant' (October–November 1905) and *To Save the Phenomena*. But in due course it also carried Maurice Blondel's long attack (1909–10) on the reactionary politics of Action Française[43] and those Catholics, mainly neo-scholastic, who hoped for an alliance with this atheistic positivist-led monarchist movement. When, as a result of that campaign, it was denounced to Rome and condemned in 1913,[44] Duhem's sympathies were only too clear. He had made his choice.

7. CONCLUSION

The reason for Duhem's mediaeval interests and the discontinuity in his career should now be clear. In October 1903 he stumbled on what he did not know he was looking for: a nonscholastic mediaeval science. It seems that, much as he distrusted many of the scholastics of his acquaintance, he had assumed that the story they told of the Middle Ages was factually correct: the 'science' of the period was indeed scholastic and (therefore) sterile. Loyal to his Church as Duhem wished to be, his loyalty did not go so far as to proclaim the fertility of that sterile nonsense. But now, it seems, impressions had been mistaken and Duhem went in search of more of the newly discovered gold. He discovered that the scholastics could not be relied on to give an account of mediaeval thought, of its science, of its philosophy, or even of its theology. He discovered that when first stated the doctrines now being made normative for Catholics had actually been condemned by the ecclesiastical authorities of their day in the name of Christian orthodoxy, in his view rightly so. He discovered that the famed synthesis of Christianity and Aristotle was no synthesis at all, merely incoherent, for Aristotle's philosophy, like much else from the ancient world, was irrevocably vitiated by the pagan principles on which it was built, and so he was able to satisfy himself that the system of thought needing to be discarded if modern science was to make its appearance was equally inimical to Christian orthodoxy.

Duhem pursued these discoveries with all the persistence and energy of a detective on the trail of a fraud, for fraudulent was certainly how he regarded it, and the massive results of his industry were the *Études sur Léonard de Vinci*, *To Save the Phenomena*, and the monumental incomplete *Système du Monde*. Without the crisis of 1903–1904 nobody would now be remembering Duhem the historian of science, and without it his work would lack its special flavour and interest. The ramifications of this major upset need to be borne in mind by readers of any of his writings of these years. Duhem took a while to establish the new directions in which his thought would go, but while the argument of this paper has concentrated on his historical work, it is a safe bet that no area of his work was left untouched.

NOTES

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[1] Useful general accounts of Duhem are D. M. Miller's (1971) DSB article, and S. L. Jaki's (1984) biography.

[2] See P. Duhem, 'Notice' (1971), a translation of the relevant part of which was circulated with the preparatory papers for this conference.

[3] See Mach, *Geschichte und Wurzel* and *Mechanik*.

[4] Heavily emphasized by Agassi in his *Historiography*. Maiocchi, *Chimica e Filosofia*, gives a very full treatment of this aspect of Duhem's work and its antecedents among his late nineteenth century predecessors.

[5] The only full presentation of this common interpretation I know of is that of Paul, *Contingency* (1979), chapter 5, pp. 136–78. For a detailed discussion of it with full references see my essay review 'Darwin and Duhem' (1982).

[6] See his encyclical *Aeterni Patris*. There are full discussions of the movement in McCool, *Catholic Theology* (1972), and Thibault, *Savoir et Pouvoir* (1972). The relevant articles in the *New Catholic Encyclopedia* ('scholasticism', 'thomism', 'sciences, classification of') give something of its intellectual commitments.

[7] See Philipp Frank's reiterated but unargued claims in his 'Introduction, Historical Background' (pp. 1–51) to his *Modern Science and its Philosophy* (1949).

[8] See his 'Galileo...' (1921).

[9] See *Théorie*, part I, chapter I.

[10] On this journal see Nye, 'Moral Freedom' (1976).

[11] On this journal and Duhem's role in its foundation see Paul, *Contingency*, pp. 177–8, and Hélène Pierre-Duhem, *Savant*, p. 105.

[12] See his letter of 3 July 1897 to Paul Tannery.

[13] Dom David Knowles, *Evolution of Mediaeval Thought*, offers one version of this theme, and Gilson, *Christian Philosophy*, a more sophisticated version.

[14] Solicited by Maurice Blondel to collaborate with the *Annales de Philosophie Chrétienne* of which Charles Denis was then the editor, he replied (12 January 1896) thus (translation mine):

> The Abbé Denis may be a decent man, but as for the Société St. Thomas d'Aquin, whose organ his journal is, it too may well contain some decent people, but it also contains some beings puffed up with vanity – Count Domet de Vorges for example – as well as some dirty poisonous beasts, like the individual who hides in the *Annales de Philosophie Chrétienne* as well as in *Le Monde*, behind the name 'Congressist' – I have no desire to mix my prose with people of that ilk, who think they are authorized to tell lies because they wear a cassock.
>
> Moreover I will confess to you that such people have put me off the Catholic world – not Catholics, which isn't the same thing – more than I can say. The Lille Catholic University had already given me the measure of the degree of sincerity in that world when the Brussels congress completed my education: scribes and Pharisees, hypocrites!

The congress referred to was the third in a series of international meetings of Catholic Academics. The congress report (vol. 1, 1895) prints the text of Duhem's interventions and the Thomist A. Gardeil (1894) gives a highly suggestive account of events.

[15] See his *Distinguer pour Unir* (1932, pp. 84–90, 123–5, 385).

[16] His *Christian Philosophy* (1955) cites the chapter of volume v of the *Système* dealing with Albertus Magnus but not the equally extensive adjacent chapters on Thomas Aquinas and Siger of Brabant.

[17] The *Origines* (1905–6), the *Études* (1906, 1909, 1913), and *Système* (1913–59).

[18] My 'Genesis' (1976), which analyses the chronology of this episode in detail.

[19] According to P. L. Rose, and S. Drake (1971). I owe this reference and much else to the late Dr. Charles Schmitt, then the member of the editorial board of Annals of Science responsible for handling my paper.

[20] See his well-known *Structure* and *Essential Tension*.

[21] So dated by the editors from the postmark.

[22] See Lagrange, *Mechanique Analitique* (*sic*) (1788, 1811–15, 1853–55).

[23] *Kritische Geschichte* . . . (1873, 1877). Dühring actually states explicitly that the mediaeval period was a historical desert.

[24] *Théorie*, Part II, Chapter VI, Section VI.

[25] This twenty-page essay review (1903) of Mach's *Mécanique* (1904) has all the marks of an inside job done on advance proof copy. The translation was only published the following year, and Duhem got the title wrong, reading *Étude* for *Exposé*. See also Hentschel (1988).

[26] This is a natural interpretation of Duhem's preface (pp. 1–2).

[27] See particularly his 'Crucifix and Crucible' (1969), and 'Quest of Kerygma' (1969).

[28] Bury's *France 1814–1940* (1949–1976) gives a useful general history of the period, while Adrien Dansette's *Boulangisme* (1938) gives a fascinating account of one of the crises.

[29] On nineteenth century positivism see Gouhler, *Jeunesse d'Auguste Comte* (1933–41); Hayek, *Counter-Revolution of Science* (1952); and Simon, *European Positivism* (1963).

[30] The *Encyclopedia Judaica* has a useful account of him.
[31] 'L'Oeuvre de Duhem dans son aspect mathématique' (1917).
[32] Hadamard (1937).
[33] *Théorie*, part II, chapter III, sections III and IV, citing an article by Hadamard, are largely the fruit of this correspondence.
[34] With Catholic critics in mind, the letter to Blondel cited above continues:

> My firm intention is never to get mixed up with these people: seek the truth, and when I think I've found a particle of it, throw the news of it to the four winds and let the crows caw.

Cf. this response from Lucien Laberthonnière (9 January 1909):

> The stuff of yours that I've read and the conversations I've had with you have considerably clarified, by confirming it, the idea I had of the intellectual apostolate. I am very grateful. Yes you are right: what matters and counts is to work away believing in the value of the truth

I haven't been able to see the other side of this correspondence.
[35] See *Théorie*, part I, chapter IV, section X and elsewhere.
[36] The essential secondary source on modernism is Émile Poulat's *Histoire Dogme et Critique* (1962, 1979).
[37] On the analysis of this encyclical (1907) and its origins see Vidler, *Variety* (1970), and Daly, *Transcendence and Immanence* (1980).
[38] See e.g., Vicaire, 'Valeur Objective' (1893); Paul, *Contingency*, presents a mass of evidence of neo-scholastic criticism of Duhem.
[39] See e.g., Burtt, *Metaphysical Foundations* (1924, 1932); Butterfield, *Origins of Modern Science* (1949, 1957, 1962); Hall, *Scientific Revolution* (1954, 1962); Koyré, *Études Galiléennes* (1966); Westfall, *Construction of Modern Science* (1971, 1977).
[40] See his 'Réflexions' (1892).
[41] Letter of 8 August 1916.
[42] Blondel's letter seems to have been lost, but Duhem's reply is dated 25 July 1905. Laberthonnière's response to Duhem's offer of the article that became 'Physique de Croyant' is dated 16 August 1905. Both the published Blondel-Wehrlé (1957) and Blondel-Valensin (1969) correspondences contain material relating to this journal implying that Blondel was at least financing or had actually bought it.
[43] The standard work is Eugen Weber's classic study (1962), but see also Paul, *Second Raillement* (1967).
[44] *Index* (1948). Laberthonnière was forbidden to publish anything at all or say anything about this further ban. There are full letters from Duhem to Blondel dated 27 June and 20 July, and from Blondel dated 16 July 1913. I thank Donald G. Miller for copies of letters from Duhem when on loan to him, and G. Mosseray for copies of letters from Blondel. I hope to make a fuller study of this important correspondence in the future, and I thank Duncan McGibbon for discussing its significance with me. Extracts from Duhem's second letter are published in L. Lecanuet (1930), pp. 478–9, and the Blondel-Wehrlé correspondence.

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Philosophy Dept.
London School of Economics
Houghton Street
London WC2A 2AE