

Alchemy and Economy in Seventeenth Century England.

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What is gold? This apparently simple question may be answered in a variety of ways. Under today's conditions of knowledge, one may answer with chemical formulations: boiling point 3130k, melting point 1337.58k. Further, it can be considered as an element in the periodic table: Au (from the Latin Aurum – gold, or Aurora – dawn), atomic number 79. One could also consider geology, as to how it is distributed and where it may be found. It has particular properties; it is malleable, ductile and relatively unreactive. Then again, one can talk in a more human-oriented fashion: what industry is required to produce it, to what ends it is used, whether in production or for display, expenditure.

Whereupon we come to economics. Gold is valuable. What does this deceptively simple statement mean? Since the end of the gold standard, one can't even consider answering: money; now it is just one commodity amongst many. Marginalist economics even disputes the category of value, measuring items purely in terms of supply and demand. Yet gold is considered to have intrinsic value, for otherwise why would it be held by central banks, chosen for ostentatious displays of wealth, or awarded as medals?

If this question is difficult now, so it was in the seventeenth-century. There were a number of different approaches, each with different answers. Gold had a multiplicity of forms and uses. It was coin, plate and bullion. It was symbolic of wealth and power, in its use for jewellery and decoration. It was a metaphor for moral value, especially that of purity. And it had high cosmological meaning, being associated with the sun. Yet for all this, it was a specific entity. Did these different facets relate to each other, or were there contradictory findings?

This essay examines two seventeenth-century approaches to gold, alchemy and economics, both of which esteemed gold as 'valuable' and pursued it practically. The former sought to create gold from base matter using chemical reactions and laboratory procedures. This was accompanied by a spiritual quest to reach a higher wisdom. The latter was concerned with understanding certain phenomena associated with precious

metals, conducting an analysis in terms of 'value', in order to use what gold they had to amass more.

Although they coexisted at this time, one came to be generally regarded as a fantasy or fraud, its ambition shown to be impossible, whilst the other took off and continues to this day. The classical explanation of alchemy's fate is that the mystical and metaphysical aspects were overturned by the 'scientific revolution.' Rationality and objectivity were the guiding standards, not analogy and speculation. The result was chemistry, which inherited the techniques and an incomplete body of knowledge, but discarded the program of transmutation and the spiritual quest. Gold holds no 'value' in the physical sciences, it has no privileged place; it is just one element amongst many. The fate of alchemy is not the theme of this essay. However, if there was a scientific revolution, one may make a case for economics being a part of it, for it was in this period that, according to Letwin,

some men, in thinking of economic phenomena, forcefully suspended all judgements of theology, morality, and justice, [and] were willing to consider the economy as nothing more than an intricate mechanism, refraining for the while from asking whether the mechanism worked for good or evil.¹

Although it may be considered a soft or social science, it certainly has a greater call than biology to be included in the intellectual sea-change of the time.² Although classical histories of economics begin with Adam Smith, the 1600s produce a literature that has concerns and methods recognisably similar to modern economics and fundamentally different to anything preceding it.

The question, then, is not what gold is or was, but how men tried to understand it, what analytical tools they developed for this purpose, and how they reacted to and employed their findings.³

Alchemy was a mixture of allegory, ritual and mystical cosmology employing chemical apparatus and based upon the mineral world. The basic precepts were drawn from ancient Greek philosophy, that all things were made of the four elements earth, water, fire and air. Thus, by changing the proportions of these elements, any one thing could be turned into another. Medicine was based on this idea, disorders being diagnosed as an excess of one element, treatment being the correction of this imbalance. The vegetable world offered another parallel, alchemy being to mineralogy what agriculture was to botany.⁴ The

theoretical possibility of transmutation led to practical attempts to turn base matter into the purest, gold. The search for this allusive method became a symbol for the regeneration and transformation of man himself, a spiritual quest intimately bound up with the nature of the universe. The knowledge was symbolised as the Philosophers' Stone, a substance embodying all the mysteries of the universe. An elaborate cosmology relating the metals found on earth to the planets was erected:

Metals are in number seven, viz Saturn, Jupiter, Mars, Sol [the sun], Venus, Mercury and Luna [the moon], called by the Vulgar Lead, Tin, Iron, Gold, Copper, Quicksilver and Silver.⁵

Whilst the arcane details varied according to time and place – alchemy has a long history spanning Europe, Arabia and Asia – sixteenth-century Europe saw alchemy developing as part of the Natural Philosophy, the comprehension of God through his works. As Newton wrote:

For alchemy does not trade with metals as ignorant vulgars think, which error has made them distress that noble science; but she has also material veins of whose nature God created handmaidens to conceive and bring forth its creatures... This philosophy is not of that kind which tends to vanity and deceit but rather to profit and to edification inducing first the knowledge of God and secondly the way to find out true medicines in the creatures... the scope is to glorify God in his wonderful works, to teach a man how to live well...⁶

Gold was not only a mystical symbol, but also a real and secular substance. Consequently, it was a concern of temporal powers. Alchemy, or more strictly, transmutation, was prohibited in England in 1403 by an act of Henry IV. "It is ordained and established, that none from henceforth shall use to multiplie gold or silver, nor use the craft multiplication, and if any the same doe, that he incurre the paine of felonie in this case."⁷ Quite why this was done remains obscure; White suggests that a successful transmutation would contradict religious teachings and threaten the secular status quo.⁸ Given that the same year a law was enacted against gilding base items to prevent them being passed off as fully gold, it may be suggested that it was a measure taken against fraud.⁹ This can further be seen as a strategy on the part of the King to control the flow of precious metals. Henry IV had the previous year passed a law forbidding the export of gold and silver,

obliging merchants importing goods into England to spend the receipts on English commodities.¹⁰ Considering that alchemists were granted licences by Henry VI and welcomed at the courts of Edward VI, Elizabeth and James I the law can be seen as an assertion of a royal monopoly.¹¹ Alchemy was another way for the monarchy to manipulate the currency, alongside lowering the standard or adulterating the coin.

By 1626, the alteration of the coin according to royal whim was being strongly criticised as a deceit, gold and silver having some intrinsic value that could not be arbitrarily proclaimed. Historical examples were given:

Thus we see it was with Henry VI; who, after he had begun with abating the measure, he after fell to abating the matter; and granted commissions to Missinden and other to practise Alchemy to serve his Mint.¹²

The brief devaluation of that year was swiftly remedied; a notable victory for the rising merchant class. But this begs the question of knowing the value of the metals; Cotton espoused a supply and demand model, but this simply puts off the question; how is one then to know how much gold and silver there is, and what need for it? These problems were the very origination of economic theory. The flood of treasure into Spain had not enriched that country, nor impoverished others. All the while, international trade was growing and transforming the countries involved. For England in this period, silver, required for coinage, was being exported and gold imported.

The analysis began by studying the substances concerned. For example, Vaughan in 1625 begins his Discourse listing those qualities that make gold suitable for commerce: it is useful, hence valuable in itself, not over-common, enduring, imprintable.¹³ And also:

[Precious metals] are hardly subject to any natural corruption, especially Gold, of which the continuitie and incorruptibleness whereof the Alchymists, who have most vexed that body, do write wonders; so as one affirmeth That it is harder to destroy Gold than to make it...¹⁴

But if both gold and silver are used as money, there is the problem of the ratio between them, and whether it is fixed or not. Vaughan's reasoning is both practical and cosmic:

And for my part, I do rather incline to this Proportion, because 12 of all the numbers is the most proper for Money, being the most clear from fractions and

confusion of an accmpt This Proportion seems like to square with the concept of the Alchymists, who call Gold Sol, and Silver Luna, whose motions do come near upon the point of 12 for 1¹⁵

Clearly, alchemy had some real knowledge in it. This, in some ways made it all the more dangerous, for it could be used to defraud. Just as kings had devalued and debased the coinage, so could criminals:

.... There is nothing that the counterfeiters of money and their forefathers the Alchymists, do more fear and apprehend, knowing that they cannot suborn base and abject metals, as copper, lead, tinn (the materials of counterfeiters) for Gold or Silver, but that the piece will instantly be discovered, because the Moneys made in the Mill will always be equal and of like volume, greatness and thickness....¹⁶

Vaughan is extolling the virtues of the mechanical press for producing a uniform coinage: the condition of the coin was a continual problem, reaching critical mass in the 1690s; this is discussed below. For the moment, it is worth noting that Vaughan associates alchemists with criminals, but does not take them as identical. The admission of knowledge creates a fear of misuse.

The creation of wealth is the aim of the economists, and in this they resemble alchemists. This was a century of projectors, men with schemes for developing trade, inventing money, improving industry. Base matter may well be turned into gold, by exchange if not transmutation. Few of the pamphleteers were disinterested, and where they solicited the state with their ideas, they expected a return of some sort.

What did the alchemists make of the uses of “the purest of all Metals, and the very perfection of the Mineral kingdom”?¹⁷ Having been associated with greed and fraud, they often disassociated themselves from base concerns. Boyle claimed that “being a Batchelor, and through Gods Bounty furnish’d with a Competant Estate for a younger Brother, and freed from any ambition to leave my Heirs rich, I had no need to pursue Lucriforous Experiments....”¹⁸ He further justified alchemy as being an opportunity to “set many poor people at work”, rejecting the idea that “may threaten the welfare of States, if it should fall into unworthy hands.”¹⁹

A more robust response is found in the pamphlet *Secrets Reveal’d*.²⁰ Apparently written in 1643 by a 23 year old, and published in English in 1669, it is a product of the

'enthusiasm' of the civil war period. The collapse of censorship and religious authority led to an outpouring of alchemical publications, more than ever before or since.²¹ Although it looks like a standard alchemical work, replete with mystical cosmology and praise of Gods works, promising the recipe for the philosophers stone, halfway through it explodes into millenarian prophecy.

Explaining why he has written this book without "obscure enigmas, or sophisticated operations, or a heap of rough and uncouth words", the author wishes "that Gold and Silver would at last be of as mean in esteem as Dirt, which hath been hitherto the great Idol adored by the whole World."²² Alchemists are cursed like Cain, hounded through the nations, by those set upon "some private, base, and unworthy end" and consumed by "the most greedy thirst after gold."²³ Alchemical knowledge is a burden, inevitably attracting unwelcome attention. By revealing it, the author hopes to set off an apocalyptic inflation: "I know these my Writings will be to most Men like the purest Gold, and Gold and Silver will (through these my writings) become as vile as dirt."²⁴

I do hope and expect, that within a few years, Money will be like dross; and that prop of the Antichristian Beast will be dashed in pieces. The People are mad, the Nations rave, an unprofitable Wight is set in the place of God. These things will accompany our so long expected and so suddenly approaching Redemption, when the New-Jerusalem shall abound with Gold in the streets, and the gate thereof shall be made of entire Stones, and most precious ones....²⁵

Now there's a theory of inflation! And it deserves to be taken seriously, because the author recognises gold as useful, as well as having a price: he speaks of "living philosophical gold over dead vulgar gold (in the form of a ring, a vessel or mony)."²⁶ Consequently, he does not fear for alchemy in the inflation.

Similar prophecies were made, such as that of Mary Rant, to whom John Langius, translator of *Secrets Revealed*, refers in his preface: "Yea, if those things which Mary Rant (an English woman) by inward Revelation promised concerning the making of Gold (that it would become vulgar or common in the year 1661) come to pass within an hundred years after, then I doubt not at all but it hath taken some beginning from this [book]."²⁷

Langius dedicated his translation to Lord Gabriel Vogtius, Warden of the Elector of Saxony's Coin and Metallic Affairs.²⁸ At this point it may be worth considering the position on the continent. During and after the Thirty Years War, there were many tales of

transmutation, in front of whole courts, carried out by wandering alchemists. Rudolph of Prague and Christian in Copenhagen were renowned for their patronage of magicians, but Emperors Ferdinand III and Leopold I also rewarded those who could prove their skills publicly, making medals out of the results.²⁹ Why was alchemy taken more seriously by the rulers of these countries than in England, and conversely, how did alchemy come to have a radical edge in England?

I suggest that it was because of the aristocratic and feudal nature of Germany. Trade and production was governed by policey, government fiat. There was no theory of the economy, but *oeconomia*, rules for running an orderly state as if it were a household, ruled by a father figure. The aim was to directly increase state revenues. The alchemist and projector Becher was reduced to trying to find common ground between the 'true' credit of the nobility and the financial credit of the merchant, as found in the Netherlands.³⁰ The economic conditions, especially the place of gold, affects the nature of alchemy. As Jonson put it:

But in a monarchy, how will this be? The Prince will soon take notice, and both seize you and your stone, it being a wealth unfit for any private subject.³¹

The economic conditions, or the rules of governance thereof, changed dramatically in England with the 'glorious revolution' of 1688-9. In the space of a decade, there was a new financial settlement between king and parliament, entry into a Europe-wide war, the beginnings of a national debt, the creation of a national bank, the failure of a land bank, a near collapse of the domestic specie, and a recoinage of the entire stock of silver money. And the law against multiplication was repealed.

Henry IV's prohibition was lifted in 1688, the first legislative session under William and Mary, "An act to repeal the statute made in the fifth year of King Henry IV, against the multiplying gold and silver" getting Royal Assent on 20 August 1689.³² Robert Boyle has been credited with this, having written of the ban, that it was "a great discouragement to the industry of skilful men, which is very happily improved in this inquisitive age" and that repeal of "so darkly and ambiguously penned" an act would "much conduce to the public good."³³ Together with Bishop Burnet he testified before parliament that they had witnessed the transmutation of base metal into gold.³⁴ Boas makes it sound as if this was pure will on Boyle's part; he "went so far as to have the laws against the chemical manufacture of gold repealed."³⁵ Maddison states that "Boyle advocated, and undoubtedly was mainly instrumental in securing, the repeal So that experimental work connected

with transmutation should not be impeded on legal grounds.”³⁶ Hunter is a little more cautious, saying “Ostensibly, the Act repealing the antiquated statute was simply about the extracting and refining of precious metals from ore.”³⁷ Boyle later wrote that these techniques were especially valuable “at a time when many industrious persons of this nation are excited to look after profitable minerals”, but that alchemy was foremost in his mind.³⁸

Given the lack of evidence – we don’t know what parliament thought of Boyle’s statement, nor who else spoke on this matter, whether for or against – it is a presumption to give Boyle the credit for the repeal. Reading the legislation in its historical context, casts doubt on alchemy being of great concern.

Firstly, it is incredible that, in the midst of a constitutional revolution and at the start of a war, that parliament should be concerned with this matter if it was of little importance. And gold is never unimportant.

Secondly, the act was not simply about extraction and refinement. The third paragraph gives an important proviso, demanding:

that all the gold and silver that shall be extracted by the aforesaid art of melting and refining of metals, and otherwise improving of them be from henceforth employed for no other use or uses whatsoever, but for the increase of monies;

having to be minted at the Tower of London, for the full value “according to the assay and fineness thereof.”³⁹

By being made into money – as opposed to plate or ingots – the gold and silver was forced into circulation in England, and prohibited from being exported. The state may not gain directly, and the King may have rescinded his rights to transmutation and the mining of gold and silver,⁴⁰ but by obliging the metal to be minted, control was asserted and the economy of the nation was served.

At this time, the coinage was in a terrible state, worn down through years of use. Little silver was being minted, it being more profitable, owing to the exchange rates, for foreign merchants to pay for English goods in gold. Simultaneously, there was a drain of silver out of the country, to pay for imports and subsidize allies, and a tendency to hoard due to the uncertain political climate.⁴¹

Thus the necessity of minting silver. But the situation was even worse than this. Monetary crime was rampant, debasing the coin through clipping (shearing off the edges of a coin, thus reducing its silver content) and counterfeiting (debasement of the content). “The

consequent shortage [of good coin] raised prices And a complex, accelerating distortion of England's trade balance, exchange rates and domestic economy followed."⁴² This grew to such an extent that the government was obliged to remint the entire silver coinage, an unheard-of act in the midst of war.

The debate over clipping and recoinage was a long and bitter affair, focusing the great minds of the day on the nature of gold, silver, money and value, producing an enormous pamphlet literature. The lobby against devaluation won out, even if a cast iron case wasn't made; the decision may have had more to do with parliamentary machinations than truths and principles. But no real truths were settled in the debate – and the debate has continued until the present day.

The essential problem was that searching for natural laws of economics led to the unpleasant discovery that these laws could, and were, being broken. This led to charges of a criminal alchemy. Thomas Aicken wrote that "the chief cause of the prevailing of this vice, is the studying of Experimental Philosophy, Alchimy and Chymistry, to which this age is so much addicted...."⁴³ Attempting transmutation was an indirect cause: "When our Chymist has spent all his Estate in endeavouring to find out the Philosophers Stone, but instead thereof, finds little else but broken Pots and Glasses He falls to counterfeiting the Coin of the Nation, for his former study is a great help and assistance to him in this."⁴⁴ As evidence, he cites the works of Glauber and Johannes Baptista O Porta, but especially Salmon's Polygraphice, demanding that this be burnt and forbidden "because it teaches both to Cast and Stamp."⁴⁵

Aicken plainly doesn't believe in transmutation. Does Salmon? His Polygraphice is a compendium of arts, covering drawing, engraving, limning, washing, varnishing and palm-reading, along with chemistry and medicine. What is noticeable about his alchemy is the lack of allegory or praise of God. The metals are related to the planets, but there is no explanation of this. The spiritual quest is abandoned for pragmatics:

The Alchymist designs one of three things, to wit, 1. Either the counterfeiting of the fine metals. 2. Or the separation of fine metals out of the base: Or 3. The Generation of the fine metals out of the base, by transmutation."⁴⁶

These are explained as follows:

The counterfeiting of the fine Metals, is done by giving the colour, and body, of a fine metal to that which is base

The Separation of fine metals out of base, is done by attracting of the particles or atoms of the fine (contained in that baser) into one heap or mass, that they might not be carried away by the wings of the Volatile or baser Metal.

The matter of transmutation is done by that great powder, tincture, Elixir, or stone of the Philosophers, which according to the opinion of Paracelsus and others the most learned, we shall signifie in few words.

By this tincture or Elixir according to the judgement of Philosophers the whole body of any Metal (being separated from its impurity) is changed into fine Gold.⁴⁷

Transmutation here is a very down-to-earth matter, even if the recipe for the tincture isn't given. What has happened? Were alchemists now criminals, without any spiritual agenda? Perhaps the criminals had become chemists?

I venture that in the course of the century, increasing monetarization in England had brought most of the population into contact with gold and silver on a daily basis. The purest, most sacred metal had been brought down from the heavens to earth, made a commonplace and tarnished. It was manipulable by the meanest artisan; all that was required to clip a coin was shears. Economics now took up the study of value, to comprehend exchange rates, and also protect the intrinsic worth of the currency against the vulgar.

Newton should provide the conclusion to this tale. In private, as an alchemist, he read *Secrets Revealed* "with great interest [and] scribbled marginalia on almost every page of his copy."⁴⁸ In public, as warden then master of the mint, he tested the qualities of coins from all around the world.⁴⁹ He wrote against the use of artificial metal for half-pennies and farthings.⁵⁰ He also tracked down and prosecuted counterfeiters. He embodied all of what was known of gold at the end of the century. Economics won out.

FOOTNOTES

1. Letwin, W., *The Origins of Scientific Economics* (New York, 1964), 158-9.
2. See Cunningham, A., and Williams, P., 'De-centering the 'big picture': The Origins of Modern Science and the modern origins of science', *British Journal for the History of Science*, 26 (1993), 422.
3. There was, alongside the magical and scientific, another way of considering gold and value, namely the religious. But this approach was in steep decline to the point of extinction by 1640 or 1660. Space precludes discussion of this. See Letwin, 85-88.
4. Holmyard, E.J., *Alchemy* (Harmondsworth, 1968), 114.
5. Salmon, W., *Polygraphice* (London, 1675), 456.
6. White, M., *Isaac Newton The Last Sorcerer* (London, 1998), 140.

7. 5 Hen 4 c.4. A number of sources give 1404, but it comes under 1403 in Statutes at Large.
8. White, 115.
9. 5 Hen 4 c.13.
10. 4 Hen 4 c.15.
11. Holmyard, 16, 204-6, 214.
12. Cotton, R., 'A Speech touching the Alteration of Coin' [1626] in Shaw, W.A., ed., English Monetary History 1626-1730 (London, 1896), 28.
13. Vaughan, R., 'A Discourse of Coin and Coinage' [1625] in McCulloch, J.R., ed., A Select Collection of Scarce and Valuable tracts on money (London, 1856), 11.
14. Vaughan, 11.
15. Ibid., 43.
16. Ibid., 55.
17. Salmon, 465.
18. Principe, L.M., The Aspiring Adept, Robert Boyle and his Alchemical Quest (Princeton, 1998), 185.
19. Ibid., 185, 305.
20. "Eyraeneus Philaletha Cosmopolita", Secrets Reveal'd (London, 1669). The author is George Starkey, and it was written between 1651 and 1654, according to Newman, Gehennical Fire (Cambridge, Mass, 1994), 60.
21. Thomas, K., Religion and the Decline of Magic (Harmondsworth, 1984), 270.
22. "Eyraeneus Philaletha Cosmopolita", 32.
23. Ibid., 33-5.
24. Ibid., 48-9.
25. Ibid., 48.
26. Ibid., 42.
27. Ibid., preface, n.p. See also Hill, C., Antichrist in Seventeenth-Century England, revised edition, (London 1990) 119, n.4.
28. "Eyraeneus Philaletha Cosmopolita", dedication.
29. Holmyard, 128-134; Bolton, H.C., Alchemy and Numismatics (Boston, 1887), throughout.
30. Smith, P.H., The Business of Alchemy (Princeton, 1994), 129, 133.
31. Johnson, B., The Alchemist [1610] (Harmondsworth, 1974), 268.
32. Maddison, R.E.W., The Life of the Honourable Robert Boyle (London, 1969), 176 n.3.
33. Hunter, M., 'Alchemy, Magic and Moralism in the Thought of Robert Boyle', British Journal for the History of Science, 23 (1990), 404.
34. Ibid., 405.
35. Boas, M., Robert Boyle and Seventeenth Century Chemistry (Cambridge, 1958), 102.
36. Maddison, R.E.W., The Life of the Honourable Robert Boyle (London, 1969), 176.
37. Hunter, 404.
38. Ibid.
39. 1 W&M c.30.
40. 1 W&M c.30 paragraph 4, clarified 6&7 W III c.17.
41. The repeal of the act against multiplying does not appear to have led to increased minting.
42. Roseveare, H., The Financial Revolution 1660-1760 (Harlow, 1991), 38.
43. Aicken, J., The Mysteries of the Counterfeiting of the Coin of the Nation fully detected (London, 1696), 4.
44. Ibid., 4.
45. Ibid., 4, 12.
46. Salmon, 457.
47. Ibid., 457-8.

48. Hill, 119.
 49. 67 coins are analysed in Newton, I., 'Sir Isaac Newton's Mint Reports' in Shaw, W.A., ed., *English Monetary History 1626-1730* (London, 1896), 158-161.
 50. *Ibid.*, 187.

BIBLIOGRAPHY

Primary Sources

- Aicken, J., *The Mysteries of the Counterfeiting of the Coin of the Nation fully detected* (London, 1696).
 Cotton, R., 'A Speech touching the Alteration of Coin' [1626] in Shaw, W.A., ed., *English Monetary History 1626-1730* (London, 1896), pp.27-35.
 "Eyraeneus Philaletha Cosmopolita", *Secrets Reveal'd* (London, 1669).
 Johnson, B., *The Alchemist* [1610] (Harmondsworth, 1974).
 Newton, I., 'Sir Isaac Newton's Mint Reports' in Shaw, W.A., ed., *English Monetary History 1626-1730* (London, 1896), pp.147-204.
 Salmon, W., *Polygraphice* (London, 1675).
Statutes At Large.
 Vaughan, R., 'A Discourse of Coin and Coinage' [1625] in McCulloch, J.R., ed., *A Select Collection of Scarce and Valuable tracts on money* (London, 1856), pp.1-119.

Secondary Sources

- Boas, M., *Robert Boyle and Seventeenth Century Chemistry* (Cambridge, 1958).
 Bolton, H.C., *Alchemy and Numismatics* (Boston, 1887).
 Cunningham, A., and Williams, P., 'De-centering the 'big picture': The Origins of Modern Science and the modern origins of science', *British Journal for the History of Science*, 26 (1993), pp.407-432.
 Hill, C., *Antichrist in Seventeenth-Century England*, revised edition (London 1990).
 Holmyard, E.J., *Alchemy* (Harmondsworth, 1968).
 Hunter, M., 'Alchemy, Magic and Moralism in the Thought of Robert Boyle', *British Journal for the History of Science*, 23 (1990), 387-410.
 Letwin, W., *The Origins of Scientific Economics* (New York, 1964).
 Maddison, R.E.W., *The Life of the Honourable Robert Boyle* (London, 1969).
 Newman, W.R., *Gehennical Fire* (Cambridge, Mass, 1994).
 Principe, L.M., *The Aspiring Adept, Robert Boyle and his Alchemical Quest* (Princeton, 1998).
 Roseveare, H., *The Financial Revolution 1660-1760* (Harlow, 1991).
 Smith, P.H., *The Business of Alchemy* (Princeton, 1994).
 Thomas, K., *Religion and the Decline of Magic* (Harmondsworth, 1984).
 White, M., *Isaac Newton The Last Sorcerer* (London, 1998).