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Godly Men and Mechanical Philosophers: Souls and Spirits in Restoration Natural Philosophy

The Argument

Recent historiography of the Scientific Revolution has challenged the assumption that the achievements of seventeenth-century natural philosophy can easily be described as the 'mechanization of the world-picture.' That assumption licensed a story which took mechanization as self-evidently progressive and so in no need of further historical analysis. The clock-work world was triumphant and inevitably so. However, a close examination of one key group of natural philosophers working in England during the 1670s shows that their program necessarily incorporated souls and spirits, attractions and congruities, within both their ontology and their epistemology. Any natural philosophical strategy which excluded spirits and sympathies from its world was condemned as tending to subversion and irreligion. This examination shows that the term 'mechanical philosophy' was a category given its meanings within local contexts and carries no universal sense separate from that accomplished by these natural philosophers. It also shows how the experimental praxis was compelled to treat souls and spirits, to produce them through experimental labor, and then to extend these experimentally developed entities throughout the cosmos, both social and natural. The development of mechanical philosophy cannot be used to explain the cognitive and social structure of this program, nor its success: instead, the historical setting of experimental work shows how a philosophy of matter and spirit was deliberately constructed by the end of the seventeenth century.

The Troubles of the Mechanical Philosophy

> It is therefore upon this *Mechanical Operation of the Spirit* that I mean to treat, as it is at present performed by our *British Workmen*. I shall deliver to the Reader the Result of many judicious Observations upon the Matter; tracing, as near as I can, the whole Course and Method of this *Trade*, producing Parallel Instances, and relating certain Discoveries that have luckily fallen my way.
>
> Jonathan Swift, *A Discourse Concerning the Mechanical Operation of the Spirit* (1710)

"The mechanization of the world-picture" and the accomplishment of the Scientific Revolution of the seventeenth century have usually been taken as synonyms. This

identification has bred some rather odd historiographic troubles: for example, in order to trace the roots of this revolution, historians of an intellectualist bent have sought some candidate family of ideas which could have spawned a theoretical drive to mechanism, to the exclusion of talk of final and formal causes, and to the great division between primary and secondary qualities. Philosophies of nature lacking signs of mechanism have commonly been seen as utterly inimical to progress, and then branded as too occultist or too lowly to have had the status of science. Such an exclusion then compels historians to privilege that philosophy which did banish sympathy, congruity, or attraction from its ontology. This search has been rather sterile. Only recently have historians begun to see how natural philosophers of this period incorporated occult qualities in their discourse rather than excluding them. Similarly, the practical mathematical sciences, in which the practices and instruments of the new experimental strategies appeared, have too often been spurned. Instead, we are told of a mysterious set of coincidental confrontations with ancient beliefs, notably classical atomism and forms of neo-Platonism and Aristotelian naturalism.[1]

In this paper, I wish to present a further difficulty confronting this intellectualist program. There are three important challenges to the assumption that a monolithic mechanical philosophy accurately represents the practical life and theoretical labor of the natural philosophers of the late seventeenth century. *First,* the new philosophies formed a body of practices for the social organization of the production of natural knowledge. The mechanical philosophy was principally celebrated as a manner of talking about the right forms of inquiry into the world and the means of regimenting that inquiry. The dangers and obstacles connected with the stipulation that the world was an autonomous machine were too obvious to be ignored. *Secondly,* the deep theological structures of seventeenth-century natural philosophy showed clearly how undiluted mechanism was more than suspect for its own practitioners. *Last,* in important cases like those of Newton and Leibniz, the term "mechanical" seems not to be very apt or useful. The meanings of this term were accomplished and fixed in the course of disputes between such workers, and cannot easily be stipulated by a historian seeking some transcendent account of the mechanical philosophy. By examining one moment in England in the 1670s when a specific group of workers found it impossible to sustain a natural philosophy limited by mechanism, I will show that spirit and the soul occupied the central place in English natural philosophy at this period.[2]

My argument depends on an analysis of the ways of working in the community of natural philosophy, of its production of matters of fact about a carefully delimited world, and of practices which captured and then tried to fix the interests of its supporters and allies. It rejects recent suggestions that the relation between theology, social life, and natural philosophy are to be explored only on the theoretical

[1] On mechanical philosophy see Hall 1952; Dijksterhuis 1961, 241–47; Westfall 1977, 30–31. For occult qualities see Hutchison 1982; Millen 1985; Curry 1985.

[2] On theology and epistemology see Westfall 1973; Klaaren 1977. On the politics of mechanism see: Easlea 1980; Jacob and Jacob 1980; Webster 1982.

level, and does not account for the establishment of one version of natural philosophy through the superiority of its grasp over nature or its theoretical homology with certain social ideas. In the second half of the seventeenth century, the soul functioned in natural philosophy on a variety of levels. *First,* their religious office made it necessary for natural philosophers to describe a world in which souls were present. *Second,* in order to explain the safety and significance of their work and its effect on witnesses and practitioners, natural philosophers had to show how the soul responded to their practices. *Finally,* natural action could be represented only through the work of spirits, gradations of subtle fluids that informed and activated the cosmos. Spirits and souls were the limit, the constituent, the source, and the target of this enterprise. For Restoration natural philosophers pneumatics, their central area of concern, shaded into pneumatology. In this paper I begin with spring and elasticity in pneumatics, and move via work on the air to more obviously spiritualist practices on the human soul and the cosmos. If a mechanical philosophy was to be possible, the minimum condition was the establishment of a proper space for spirit.[3]

During the Restoration this proper space was already well guarded and occupied, most notably by the clergy. Those who exploited spiritual life, such as the enthusiast claimants to special inspiration, or who denied it, such as the tyrannic dogmatists of Hobbism and Spinozism, demonstrated only too palpably the dangers of illegitimate poaching on this territory. Propagandists for experimental philosophy reassured themselves against such threats by claiming the role of "priest of nature," in the phrase of Robert Boyle (Fisch 1953). Thus Henry Power stated in 1664 that his colleagues in the Royal Society "may be well placed in a rank specifically different from the rest of groveling Humanity" (p. 192), while Thomas Sprat warned in 1667 that "whoever shall impiously attempt to subvert the authority of the divine power on false pretences to better knowledge, he will unsettle the strongest foundation of our hopes, he will make a terrible confusion in all the offices and opinions of men, he will destroy the most prevailing argument to virtue, he will remove all human actions from their firmest center, he will even deprive himself of the prerogative of his immortal soul" (p. 346). Such dangers could be avoided by showing the natural philosophers to be godly men, fit to be ranked alongside the orthodox defenders of polity and religion. In 1674, Boyle published his mature and careful definition of "the Excellency and Grounds of the Mechanical Hypothesis," radically differentiated from either atomism or Cartesianism, as a supplement to his lengthier *Excellency of Theology Compared with Natural Philosophy* (Boyle 1772, 4: "Excellency of Mechanical Philosophy," 67–69). Naturalist saints, such as Boyle and Bacon, reported their dramatic conversion experiences to the vocation of inquirer. Boyle refused the offer of a priestly living, lest he be accused of a conflict of interest in his arguments for the faith from the works of nature (Shapin and Schaffer 1985, 318).

[3] For theoretical links between natural philosophy and culture see Jacob and Jacob 1980, 254; for the program of pneumatics see Shapin and Schaffer 1985, 22–79.

Glanvill (1665, preface "To the Royal Society") agreed that "the profest servants of the Almighty" were less able defenders of the true religion than were the members of the experimental community. As Robert Hooke suggested in 1661, for the members and defenders of this community, the experimental life was "certainly the most likely way to erect a glorious and everlasting structure and temple to nature," and, ultimately, to Nature's God (p. 42).

For just these reasons, it was necessary to locate a safe space where the evidence for spirits could be displayed and managed, without lapsing into the excesses of inspired heresy or materialist atheism. According to their publicists, natural philosophers would enjoy a special role in a future millennial state, and deserved special privileges in the here and now. In the Restoration the threat to established religion and the vivid memory of civil and theological strife made it necessary for these men to produce knowledge of spirit and simultaneously to limit and control that knowledge. The strategy adopted was to model a range of subtle fluids, increasingly active and insensible, which through their action made the work of the natural philosophers safe, effective, and proper. Charles Webster has shown how Power pursued this plan: "The corporeal was allowed to merge imperceptibly into the incorporeal." Power held that "these subtle spirits . . . are universally diffused throughout all bodies in the world, and that Nature at first created this aethereal substance or subtle particles and diffused them throughout the Universe."[4] In a letter titled "Of celestial influences or effluviums in the air," Boyle offered what he called an "apology for astrology" in very similar terms: "Our spirits are more near and more analogous to the nature of light than the air, so they must be more prone to and easy to be impressed than it." So "planetary virtues and lights" affected spirit and body alike: "These spirits being the only principle of energy, power, force and life in all bodies wherein they are and the immediate causes through which all alteration comes to the bodies themselves, it is impossible therefore spirits should be altered and changed and yet no alteration made in the bodies themselves, and therefore a less limit or extreme cannot be set to the power or operation or force of the superior bodies upon the inferior" (Boyle 1772, 5:641). The struggles of the 1670s centered on these boundaries between inferior and superior bodies, and thus on the boundaries around the world of matter and of natural knowledge. Some allies, such as the royal physician Thomas Sherley in 1672, found it easily possible to work within natural philosophy and to marry Boyle's corpuscular pneumatics with the seeds and spirits of the Helmontians in accounting for "the Generation of Natural Bodies" (Debus 1980). Some critics – such as Henry More – argued that to remain within this boundary was to subvert the religious function of natural knowledge; others – such as Thomas Hobbes – argued that to admit such incorporeal substances was to destroy the claim of natural knowledge to be true and safe philosophy. Spirits and souls were the fundamental categories of this enterprise just because of their relation with the very possibility of sustaining its social and intellectual life (cf. Dobbs 1975, 48–92; Hannaway 1975).

[4] For the gradation of pneumatics into pneumatology see Webster 1967, 174; Power 1664, 61.

Spirits in the Laboratory

It is useful to consider the troubles of mechanical philosophy in terms of social geography. The space in which spirits and souls were to be displayed was the space in which experimental life was pursued. Its boundary enclosed the inmost world of subtle matter and active virtues; the operative contents of barometers, cupping glasses, and air pumps; and, finally, the small number of sites at which the experimenters worked on the spring of the air, its vital properties, and its role in cosmology, meteorology, and optics. Within this space, the social technology of collective witnessing allowed the production of secure matters of fact. Individual testimony on the behavior of such spirits reeked too much of enthusiasm and dogmatism. Collective labor showed how the circulation of spirit activity in the laboratory was a successful map of nature: "If the world be temple, man sure must be a priest, ordained (by being qualified) to celebrate the divine service not only in it, but for it," wrote Robert Boyle (1772, 2: "The Usefulness of Natural Philosophy," 32). The network examined here centered on London and the Royal Society, where Henry Oldenburg played the role of office of address and Robert Hooke, as Curator of Experiments, dominated public proceedings, while working closely with Boyle at his sister's house in Chelsea. Lively debates on reform of the Society raged from the summer of 1673, while in 1676 Hooke and his colleagues formed a "Philosophical Club" which met at his rooms in Gresham or at the residence of Christopher Wren. In Cambridge, the Lucasian professor Isaac Newton developed his mathematical and optical work, and from 1669–70 became increasingly devoted to alchemical and theological research. The divines at Emmanuel and Christ's Colleges produced a long series of philosophical texts on theology and cosmology, which during the 1660s and 1670s began to challenge some of the preconditions of the experimental philosophy. At All Souls in Oxford, the physician John Mayow experimented on respiration and combustion. Provincial naturalists kept in touch via Oldenburg. This network dominated the production of that series of texts too often treated as isolated classics of experimental philosophy: Newton's papers on light and color; Boyle's examination of pneumatics, combustion, and respiration; and Hooke's Cutlerian lectures on spring, cometography, and practical mechanics. These series were intimately connected and provide the best illustration of the contemporary work on soul and spirit.[5]

The collective program developed in four stages during the 1670s. In February 1672 the London experimenters received Newton's initial paper on light and colors, followed in the summer by Huygens's report from Paris on the anomalous behavior of water and mercury barometers in his air pump. Newton raised in acute form the problem of the interaction of light with subtle fluids, while Huygens challenged Boyle's assumption that no sensible subtle fluid remained in an exhausted air pump.

[5] For the technologies of experiment see Shapin 1984. For the London community see Hunter 1981. For Oxford see Frank 1980. For Cambridge see Gascoigne 1985. Important case-studies of the work of this group include Dobbs 1975, 93–125; Bechler 1974.

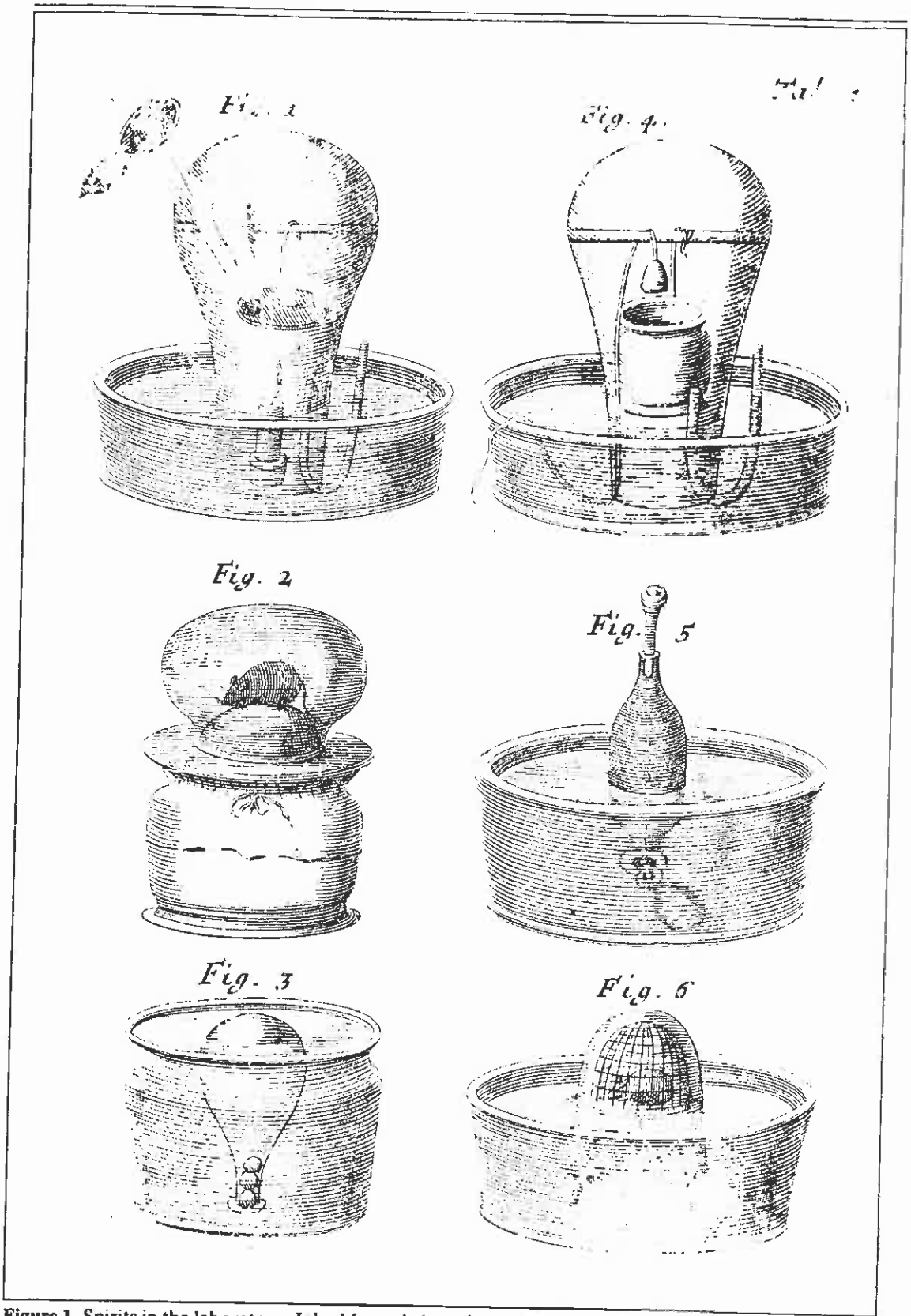

Figure 1. Spirits in the laboratory. John Mayow's experiments on combustion and respiration performed at Oxford and Bath in 1668–1673 demonstrating the role of nitro-aerial spirit in the vitality and elasticity of air. Source: Mayow 1674, tabula 5. (Cambridge University Library.)

During the autumn of 1672, the London experimenters sought to replicate and account for these phenomena. The following year Boyle published the results of a series of experiments on combustion and respiration, and Mayow completed his revised *Tractatus quinque* on the cause of the air's vitality and spring, which he attributed to the active "aerial niter." Thus by late November 1673, when Hooke and Petty launched a campaign to reanimate the Society's work, they concentrated in their public presentations on the connections between the behavior of subtle fluids and the phenomena of spring, combustion, and respiration.[6] The second stage, between October 1674 and the spring of 1675, was marked by further attempts to stimulate debate in London. Oldenburg received a series of papers from Jesuit natural philosophers attacking Newton's optical papers; Hooke met Mayow in London and talked with Matthew Hale and John Wallis, both of whom published critical texts on gravitation and the phenomena of the air pump. Hale began to use terms such as *virtus activa* to account for these phenomena (1677, 8–10). Hooke began preparing a spring apparatus to illustrate his views on elasticity (1935, 130). Petty read to the Society his *Discourse Concerning the Use of Duplicate Proportion* (1674, 126–30), in which a mathematical relation of spring was extended throughout the instrumental and cosmological worlds, and then bolstered by a remarkable section on the magnetical "Male and Female" properties of ultimate atoms (see Birch 1756–57, 3:143, 156–57). During the winter Newton was rumored to be preoccupied with "Chimicall studies and Experiments." When in London during the spring of 1675, to petition for relief from the requirement to take holy orders, Newton came to the Society for the first time. There he often talked about light and color with Hooke, who now began to compose his announcement of the law of spring and its application to machine designs. By the autumn Hooke had completed his lecture "Lampas" for publication at the Society, a text which linked gravitation and optics with the elastic structure of air and ether (Newton to Oldenburg, 5 December 1674 and Collins to Gregory, 29 June 1675, in Newton 1959–77, 1:328–29, 345; Hooke 1935, 148–49, 153, 191–93; Birch 1756–57, 3:177).

These two initial stages formed the background to the Society's response to Newton's celebrated "Hypothesis" and "Discourse of Observation" on the properties of light, received in December 1675. Much of this lengthy account had been drafted by Newton from 1672, and involved his first and fullest public presentation of the alchemical account of spirit which dominated his own experimental program. His audience construed this "Hypothesis" in terms of its own grammar: its linked practices on active fluids, and the connection between light, gravity, and spring. Hence the London experimenters sought with difficulty to replicate Newton's trials on electrification, which were supposed to evince "elastic effluvia" made of "an aethereall nature condens'd in bodys." In January 1676 Hooke and his allies formed a

[6] For the texts of the optical debates of 1672 see Newton 1958, 47–235. Huygens's challenge is discussed in Shapin and Schaffer 1985, 271–72. For life and fire see Boyle 1772, 3:563–84; Mayow 1957, discussed in Frank 1980, 246–74, and McKie 1953. For events at the Society see Birch 1756–57, 3:58–61, 109.

secretive "New Philosophical Clubb," whose very first sessions were preoccupied with refuting Newton's doctrines on light and ether and using the elasticity of subtle fluids to explain the motions of the Moon, the motion of light, and "the vibrations of a magicall string without sound by symphony." The members of the Club began to construct an aerial cosmology in which elasticity and vibration would play the fundamental roles, and pneumatics and optics provide the basic sources of evidence. They also concerned themselves with a reply to the attack on the alleged atheism of experimental pneumatics launched by the Cambridge Platonist Henry More in his *Enchiridion metaphysicum,* a copy of which Hooke obtained in the same month. Hooke presented his views on More in a lecture before the Society and corresponded with More's colleague Isaac Newton on a possible resolution of the optical controversy.[7]

The final stage of this joint enterprise was reached during 1678. In January Hooke lectured the Society repeatedly on the significance of the aerial research program (see Birch 1756–57, 3:370–73). The aether was viewed as the most significant "menstruum, vehicle or most fluid part of air," through which all pneumatic and optical phenomena were produced. Newton expressed very similar views when he was compelled to answer Boyle's publications on alchemy produced during this period (Boyle 1772, 4:219–30, 371–79). Newton was concerned by Boyle's unwise decision to publish such views, "not to be communicated without immense damage to the world." He wrote to Boyle of "an aethereal substance capable of contraction & dilatation, strongly elastick, & in a word much like air in all respects, but far more subtile." Active airs were raised from solid matter in the Earth and gave life and power to the cosmos.[8] The original concerns of the program in experimental pneumatics were here subsumed within a much bolder account of the elastic and aetherial contents of the world. Newton's manuscripts of the late 1670s and early 1680s, directed at Boyle and Flamsteed, spelled out the active properties of such fluids in pneumatics, optics, and astronomy. Ultimately, by 1684, Newton found it possible to abandon the material or mechanical mediation of these powers and to construct a cosmology of divinely sustained mathematically defined forces. Hooke also emphasized the enormous scope of this accomplishment. His speech to the Society on 17 January 1678 was a bold manifesto for the enterprise: "The experiments that had been formerly made by the Society for the examination of the nature and properties of the air, though they had hitherto been the opprobrium of the Society from such persons as thought themselves masters of all knowledge a priori and by revelation and despised all such as was acquired by experimental inquiry [e.g. Hobbes] yet there is no subject in nature more proper for the Society's examination and exercise." Hooke stressed that "an exact and thorough knowledge of that is of more concern to

[7] For Newton's optical communications see Newton to Oldenburg, 7 and 21 December 1675, and Newton to Hooke, 5 February 1676, in Newton 1959–77, 1:362–89, 404, 416; Birch 1756–57, 3:247–305. For Hooke's activities see Hooke 1935, 205–6, 211, 214–15; Gunther 1931, 8 (contains Hooke's *Cutlerian Lectures,* published in 1679):187–95.

[8] Newton to Oldenburg, 26 April 1676 and Newton to Boyle, 28 February 1679, in Newton 1959–77, 2:1–2, 288–95.

mankind than all other physical knowledge in the world. For it is by air that we continually subsist, and without it we cannot live one tenth part of an hour. It is from these proceed the causes of infinite diseases, and it affords as many remedies for those distempers. It is that, in which we continually reside: it is the cause *sine qua non* of all vegetables and animals upon the land, and influences even the fish in the sea. Infinite and unspeakable are the uses of it to the husbandman, the merchant, the tradesman, the mechanic etc. And that age will be deservedly famous which shall perfect the theory of it" (in Birch 1756–57, 3:378).[9]

Hooke's manifesto accurately summarized the aim and structure of the collective program we have analyzed. The experimenters sought to capture the interests of other groups who were concerned with the management of souls and spirits: physicians, priests, agricultural writers, astronomers, mathematical practitioners. These interests could be captured because the experimental program made matters of fact in the secure space of their community. These interests could be extended and developed because the experimenters situated spirits in active fluids and then located these fluids throughout the microcosm and the macrocosm. The extent and activity of aerial spirits were therefore directly dependent on the matters of fact discovered in pneumatics. Earlier authorities such as the physicians Charleton (1654, 33–34, 44, 280) and Power (1664, 101–2, 191–92) had already made spring an "essential quality" of such fluids, "diffused throughout the Universe" and placed in the world by the "protochymist," just as Newton appealed to the "protoplast" in the celebrated "Hypothesis" of 1675 (in Newton 1959–77, 1:364).[10] Boyle's research during the 1650s and 1660s involved the construction of a set of facts about the power and range of these principles. When he left Oxford for London in April 1668, the pneumatic program drew on the security of these facts to understand combustion and life. His former employees, Hooke and Mayow, used Boyle's technology to show how niter, the active principle, "a vital, igneous and highly fermentative spirit," was "fixed" in substances such as saltpeter and then could be used to explain the widest range of phenomena. Volume changes in cupping glasses and the air pump measured the power of this active elasticity. Then active elasticity, once quantified, was made the measure of fitness for life. Both Mayow and Hooke showed how this experimental pneumatics could be developed into a cosmology full of spirits and souls and made relevant to the concerns of physicians and divines. Their close contact helped this development. Nitro-aerial particles held an innate power of motion, conferred by the initial divine creative act. Their function in giving air its vitality was a mediation of God's role in sustaining created life. Mayow beautifully summarized the godly role the experimenters' niter must play: since respiration deprived air of spring, corrupted air was circulated and restored through the atmosphere. "Otherwise there would be no society at all of men or even of animals, for we should be obliged to

[9] For Newton's work at this period see Westfall 1971, 363–77; Dobbs 1975, 194–230, together with reevaluations in Westfall 1984, 315–36; Dobbs 1982. I follow Westfall's dating of the development from the "Hypothesis" to "De aere et aethere" (1679?).

[10] For the relation with medical chemistry see Davis 1973, 22–23; Debus 1977, 469–92; Pagel 1982, 120.

spend our lives single and separate, namely where a ration of nitro-aerial spirit sufficient for sustaining life might be obtained for each. And indeed between mortals there would be perpetual strife about the acquisition and the determinations of the boundaries not so much of fields as of tracts of air." God's role in sustaining social order and cosmological harmony was thus performed by the active "nitro-aerial spirit, the most necessary Elixir of life" (Mayow 1957, 1, 52–66, 68–71, 88, 116–18)[11]

Hooke and Newton both followed similar strategies in their own development of an account of universal activity. Where Mayow made vitality the measure of divine activity in nature, Hooke used vibration and spring to show how his active spirits were diffused through the world. This "Rule or Law of Nature" was evinced in the experiments on sound, light, combustion, and spring, and then used to explain the behavior of planets and comets, magnets and machines. This argument was drawn from Hooke's early doctrine of *congruity,* on which Newton made notes in his reading of *Micrographia.* Newton's doctrine of "sociability," presented in his communications to Boyle in the late 1670s (Newton 1962, 401; Newton to Boyle, 28 February 1679, in Newton 1959–77, 2:292), was partly drawn from this active principle. Because of this "tenacious and attractive power," Hooke consistently maintained that similar particles in nature would engage in harmonic vibration. As we have seen, this formed the topic of research at the Philosophical Club from 1676 and in the controversies with Newton about optics. The vibrations of musical strings corresponded to the phenomenon of refraction of light or of memory and the soul. A range of subtle fluids was described to account for finer spirit phenomena. "All the sensible part of the world is almost infinitely the least part of the body thereof, and but, as it were, the ... outward Filme of things." This closely resembled Newton's "active cosmology," in which the importance of sensible matter was minimized and the powers encompassed by ranges of active fluids were used to explain all natural phenomena in terms of a set of short-range forces (Gunther 1931, 8: "De potentia restitutiva," 336–39, 341; Hooke 1665, 15–16, 29–31; Hooke 1705, 365–70. Cf. Gouk 1980). Boyle often agreed. In an essay written for Oldenburg during the 1670s, he wrote that "the chiefest functions" in medicine and natural philosophy were performed not by visible conflicts of bodies but by "a very agile and invisible sort of fluids, called spirits, vital and animal, and partly perhaps ... by little springy particles, and perhaps, too, by somewhat that may be called the vital portion of the air; and by things analogous to local ferments" (Boyle 1772, 5:"Disquisition about Final Causes," 442). Newton was compelled to use the terms of these accounts. In his "Hypothesis," he referred to a "vital aereall spirit requisite for the conservation of flames and vital motions," and then ordered Oldenburg to excise the comment that "I mean not ye imaginary volatile saltpeter," lest "it should give offence to somebody." The year before, John Mayow had similarly contrasted the virtues of his nitrous spirit with the earlier views of some physiologists on a vital flame: "Fires of this sort and new lights, no less in Anatomy than in Religion, have always seemed to

[11] For the pneumatics of Mayow and Hooke see Frank 1980, 250–74. Hooke's doctrine of combustion and life is first presented in Hooke 1665, 25–32.

me vain and fanatical" (Newton to Oldenburg, 7 December 1675, in Newton 1959–77, 1:365; Mayow 1957, 109).[12]

The active spirits of the experimental philosophers had to be safe, both as experimental facts and as theologically correct accounts of divine action. Nature was modeled as a laboratory in which activity was circulated and restored. In this way the artefacts and processes of their laboratories could be supposed to exist throughout nature, the realm to which experimental philosophy applied could be extended, and the central role of the experimental spirits could be reinforced.

The Extension of Spirit

Experimental pneumatics in Restoration England spoke of a set of inner causative principles responsible for an ever-increasing range of evident phenomena. Efficient causes could be vital and spiritual, and analogized with the action of the human soul, harmony, congruity, and sympathy. Each step in this expansionist program involved the stipulation that these causative principles were located in active vital spirits, along with an appeal to other groups of practitioners to see their own concerns in terms of the experimentally manifest work of such spirits. In this section I use the cases of the human soul and the behavior of comets to see how these experimenters managed the development of their enterprise. Other examples could be chosen, notably the research of Boyle and his colleagues in Oxford and London on aerial niter as a source of agricultural fertility. Both the Georgical Committee of the Royal Society and the Oxford experimenters energetically debated the production of agricultural surplus through the fixing of such aerial spirits, thus appropriating the authority of the farming writers and economists (see Lennard 1932–34; Debus 1977, 410–25). The epistemology of active principles demonstrably transgressed the boundaries of mechanism and vitalism, and its claim to competence transgressed the boundaries of priestcraft, economy, and physic.

A divorce between mechanical and occult philosophy does not, then, assist us in reaching a historical understanding of this experimental work. Nor is it illuminating to refer this program to a sempiternal conflict between contrasting models of natural causation, where actors are supposed to be moved by their unconscious loyalties to great intellectual methodologies and styles of inquiry. As Koyré (1956) pointed out, "no science has ever started with a treatise on method and progressed by the application of such an abstractly derived method" (brilliantly discussed in Schuster 1984). An active cosmology was being deliberately constructed in England during the 1670s. This deliberation involved contests within different communities of interpretation and experimentation. Those who challenged this experimental philosophy saw it as subversive (since it sought to provide material and controllable models

[12] For notions on the "vital flame" see Frank 1980, 248–50; Guerlac 1977, 245–74.

of spirit) or tyrannic (since it sought to capture the interests of a wide range of other groups and denied the testimony of those outside its community).

To encompass the action of the human soul was necessarily to confront the power of the clergy and the Scriptures. The experimental philosophers moved well beyond a straightforward argument from mechanical ingenuity to the evidence of divine design; biblical accounts of creation and salvation were indispensable resources in their own cosmology. In January 1681 Newton corresponded with Thomas Burnet, the Cambridge scriptural natural philosopher, about the Mosaic account of creation (Newton to Burnet, 24 December 1680, in Newton 1959–77, 2:319). He used experiments on the dissolution of saltpeter and generation of aether to explicate "the present face of the Earth philosophically" and in conformity with Genesis. In his lectures on comets given at this same date, Hooke appealed to Genesis for an analogy to his aetherial harmonic cosmology. He told the Society that "the two great Laws of Motion, light and gravity," were obviously "very consonant to the sense I understand of the History of the Genesis of the World, delivered by Moses in the first chapter of Genesis." In Hooke's "Hexaëmeron," the fundamental contrast lay between "*Materia, material substance, or Mater,*" which was "without form, and void, and dark, a Power in itself wholly unactive," and God's "second Principle, which may represent the *Pater* and may be call'd *Paternus, Spiritus.*" He even used the dangerous term of the Cambridge Platonists, "hylarchic spirit, as some call it, without whose conjunction nothing or no alteration can be produced." In his *Cometa,* composed in 1664–1666 and printed after the cometary transit of 1677, Hooke appealed to the "History of Creation" – the order of *creation of active fluids* was the license for their *ontological order* (Hooke 1705, 172–76; Gunther 1931, 8: "Cometa," 230–31).[13]

These analogies with Genesis were commonplaces (see Figala 1977; Schuler 1980). The experimenters helped themselves to this resource with some care. Newton used such a technique in his 1675 "Hypothesis" (Newton 1959–77, 1:364, 369, 393) and the earlier alchemical draft titled, from its *incipit,* "Of Natures Obvious Laws and Processes in Vegetation" (discussed in Dobbs 1982 and Westfall 1984). He proposed a circulatory cosmology which drew on the Scriptural picture of divine power, and applied this throughout the world, notably including both optical and chemical phenomena and the "aetheral Animal Spirit in man." Conversations with Boyle during the spring of 1676 confirmed Newton's commitment to his "conceit," as he described it, of extending the vital power of the aether to human and cosmological phenomena.

Boyle summed up these aims in drafts for a second part of his "Christian Virtuoso" (1772, Vol. 6), dividing the cosmos into "supernatural, natural in a stricter sense, that is, mechanical, and natural in a larger sense, that which I call supra-mechanical" (pp. 754–56). It was the larger sense which his colleagues began to investigate experimentally. Using these resources, Mayow, Hooke, and Newton all sought to

[13] For mechanical philosophy as the denial of sympathies and attractions see Hall 1952, 417. For the interpretation of Boyle as such a mechanist see Alexander 1985, 62–67.

offer theologically proper accounts of the vital structure of the soul itself. Here the religious demands and constraints on their work were vividly displayed. It was necessary to speak of the soul, but dangerous to mechanize its action. As Robert Frank has shown (1980, 259–60), for example, Mayow used "nitro-aerial *particles*" and "nitro-aerial *spirit*" interchangeably in his *Tractatus quinque:* he could use this ambiguity when borrowing from the work of chemical writers like Michael Sendivogius or Kenelm Digby, and then apply their views to attack the unacceptable account of animal spirits offered by his Oxford colleague Thomas Willis (Mayow 1957, 34–37). His own model of the sensitive soul was thus both spiritist and particulate. "The sensitive soul consists of a special subtle and ethereal matter, but the nitro-aerial particles are its chief instrument." This soul was "a divine *aura* endowed with sense from the first Creation, and coextensive with the whole world." Just as Boyle wrote at this period of "celestial and aerial magnets" in "the vital portion of the air," so Mayow displayed a "spiritual material existing out of the bodies of living things," though he was careful to emphasize the theological property of this agent. Some historians have seen in Mayow's celebrated accomplishment a "contradiction" between the mechanical and chemical philosophies; but in fact his program was a fully coherent extension of the experimental pneumatics of the 1670s (Mayow 1957, 255–59; Westfall 1972, 188–90).

Hooke continued this program on the spiritual soul after Mayow's death in 1679, and in June 1682, just before his lectures on comets, he gave three lectures on his own model of the human soul. He insisted that he did *not* intend "to prove the soul mechanical," but sought to offer experimental demonstration of "certain corporeal ideas" whose arrangement would account for perceptions of time, memory, and mental confusion and association. The soul had a "Directive and Architectonical Power": vibration and sympathetic harmony showed how thought and perception worked both here and in the phenomena of astronomy and optics, "the most spiritual Action of all we are sensible of in the world." Forgetfulness was compared with a lunar eclipse, and "the Radiation of the Soul" was linked with "the Radiation of the Sun, which is, as it were, a Representation of the Soul of the World" (Hooke 1705, 138–48, reprinted in Singer 1976).

These models of the soul sustained the extension of experimental pneumatics. Stories reported by Joseph Glanvill and glossed by Hooke, Newton, and his Cambridge colleagues, showed that the soul could act beyond its material seat. The evidence of "Imagination & Phantasie & Invention" collected by them demonstrated that the soul could influence external bodies by will, just as light could operate through these fluids upon the nerves. So spirit possession and fascination, hitherto the preserve of faith healers and enthusiast sectaries, could be managed within experimental philosophy. Hooke told the Society in 1682 that the soul had "a much bigger sphere of influencing power, and thereby may extend it, . . . even out of the Body." He cited Glanvill's stories about gypsies and "a multitude of observations and reasons," including evidence of mind reading and hypnotism (Hooke 1705, 147). Newton also made full use of this testimony which he recorded in a notebook of

1664–65. In a manuscript of the late 1660s now entitled "De gravitatione," he made the claim that "God can stimulate our perception by his own will," analogized it with the working of the human soul, and used these matters of fact against Cartesian mechanism, which he claimed would "manifestly offer a path to Atheism." Throughout the 1670s, in the 1675 "Hypothesis" and in subsequent notes, Newton expounded his cosmology on the basis of this developing account of natural space as a divine sensorium, and of the analogy with the motion of bodies by their souls.

The Cambridge Platonist Ralph Cudworth agreed with Newton in 1678: he argued against Hobbes that an incorporeal deity "moves Matter not *Mechanically* but *Vitally,* and by *Cogitation* only. And that a *Cogitative Being* as such hath a *Natural Imperium* over *Matter* and *Power* of Moving it without any *Engines* or *Machines,* is unquestionably certain, even from our own *Souls:* which move our Bodies and Command them every way, meerly by *will* and *Thought*" (p. 888). The work of Newton and his contemporaries on the structure and function of the human soul shows the theological and natural philosophical interests of their enterprise. Atheism was to be combatted by showing that Scripture sanctioned their cosmologies, and by showing how divinely sustained vitality informed even the most material of interactions. Yet here the danger remained that the experimenters were poaching upon the preserve of the divines, as Cudworth also recognized. To many, experimental talk of souls seemed to smack of precisely that atheism which these natural philosophers claimed to have refuted. In consequence, as Alan Gabbey rightly emphasizes (1985, 9, 25) in his perceptive study of the "inherent conceptual difficulties" of the Mechanical Philosophy when it treats of conservation of motion and voluntary action, there were "indissoluble links between mechanics and theories of mind and the will in the seventeenth century." This was true of Leibniz' glosses on the failings of Cartesianism, and it is true of Restoration experimental pneumatics (Newton 1961, 138–39, 142–43).[14]

My other example of the extension of pneumatics is drawn from cometography. Comets, formerly objects of meteorology, were now to be redefined as significant bearers of active spirits through planetary space. Changes in the account of natural motion in the heavens derived from a redrawing of the boundaries of natural knowledge. The novelty of Newtonian mechanics was fully dependent upon this project in experimental philosophy. Only in 1684 was Newton able to inaugurate his mathematical analysis of the motion of celestial bodies through effectively void space under the influence of a gravitational force law (see Whiteside 1970). This break was marked by his use of the crucial resources developed in debates with Hooke and Flamsteed on cosmography and the behavior of subtle fluids, starting in 1679. Similarly, work in matter theory and theology was fundamental in the genealogy of this cometography. This natural philosophy did not banish teleology and significance from the heavens; it rather reemphasized with renewed vigor that comets were God's

[14] For comments on the "sensorium model" see Tamny 1987.

Figure 2. Spirits amongst the godly. Ralph Cudworth contrasts the mechanic atheists with their philosophical rivals and constructs a genealogy for Cambridge Platonism. Source: Cudworth 1678, frontispiece. (Cambridge University Library.)

agents for the circulation of activity through the cosmos.[15] Newton had been making notes on comets since the mid-1660s, but his work of the 1670s showed him the range of functions which they might fulfill for the planets and the Earth. In his 1675 "Hypothesis" Newton stated that both Earth and Sun needed to "imbibe this Spirit" to conserve their vitality (in Newton 1959–77, 1:365). Hooke held similar views on vitiation and restoration through the celestial fluids. Only *after* his debates with Hooke and Flamsteed was Newton convinced that comets would return and that their tails could serve this key restorative purpose. Lengthy passages in successive editions of the *Principia* spelled out this purpose, and in 1705 he told David Gregory that this restoration was not mechanical, but to be understood of "that subtle spirit that does turn solids into fluids (in Hiscock 1937, 26). A very small Aura or particle of this may be able to do the business." The periodic return of comets, dependent on the bold assumption that they moved in ellipses, was closely linked with the activating purpose (Newton 1934, Book 3, prop. 31:529–30 [Newton 1687, 506]).[16]

Newton's views were directly connected with those of the experimenters on pneumatics, particularly those given in Hooke's lectures of the 1670s and 1680s. Hooke held that the nuclei of comets dissolved and expanded into the aether, emitting light and activity. Since they behaved like terrestrial combustibles, they would be ancient and periodic: the comets of the 1660s which so impressed Newton were, according to Hooke, "both as ancient and as lasting as the world" and "may continue yet for many ages before it be quite dissolved into the aether." As Ruffner has suggested (1966, 166–84), Hooke's strategy in these London lectures was to show that *no kinetic hypothesis* could save cometary phenomena without an accompanying *pneumatic account of their constitution.* Newton was also impressed by this relation between the material structure of such bodies and the paths they followed. The authority of experiments on pneumatics and magnetism governed the astronomical models of cometography (Hooke 1705, 180, 195; Gunther 1931, 8: 229, 243–50, 267–69; Hooke to Wren, 4 May 1665 in Wren 1750, 220; Bennett 1975). From 1666, Hooke claimed that gravity, a form of magnetism, worked through interplanetary space just like his other principles of congruity. As J. A. Bennett (1981) has demonstrated, this magnetical cosmology was a central resource for the English experimental philosophers. Magnetism was a potent analogue of centripetal action, a concept which Newton lacked until the mid-1680s. For example, Hooke spoke of "this magnetical virtue (which may be called one emanation of the *Anima Mundi*) as gravity may be called another." The experiments he performed with the London committee on magnetic variation showed that such magnetism and gravity were produced by a "virtue" which was "more spiritual" and which acted "more according to Magical and Mystical Laws than Light, Sound or the like." Hooke's cometary system of the world thus deliberately drew on experimental pneumatics and magnetism, and then showed how spirits could be extended through the world (Gunther

[15] For Newtonian cometography and its connections with matter theory and teleology see Kubrin 1967; Schechner Genuth 1985; Schaffer 1987.

[16] For Newton's development of the model of active principles see McGuire 1968.

1931, 8: "Cometa," 227).[17]

The same issues as those discussed by Hooke in 1679–1682 were raised in an exchange between Newton and Flamsteed in 1681. The Astronomer Royal was preoccupied by the great comet of December 1680 and January 1681, which, as he told Halley and Newton, was a single body inflected at the Sun, not two moving in rectilinear paths. Newton was only brought to accept this claim in 1684, at the key stage of his research on mechanics and astronomy. In the interim they debated the material constitution of comets and the origin of the powers which might incline them near the Sun. Flamsteed relied on experimental work in pneumatics and magnetism, which he used again in 1693 to explain earthquakes as nitrous explosions in the air. Flamsteed gave detailed consideration to Hooke's notion of aethereal dissolution as an explanation of the comet's tail, but preferred the claim that "the Sun attracts all the planets and all bodys that come within our Vortex," and that this attraction would vary "according to the different substance of their bodys and nearness or remoteness from him." He suggested that the power acting between comet and Sun was magnetic, and appealed to the analogy with combustion and the evaporation of hot liquids. It was now necessary to show how the evidence from experimental pneumatics and magnetism could embrace the astronomy of cometary transits.[18]

Flamsteed and Newton argued at greatest length on the relation between experimental pneumatics and magnetism and the forces acting on the comet or comets. Flamsteed said that magnets in orbit would be redirected in the way the comet was, and that though hot bodies were not magnetic, nevertheless the Sun might have a constitution which allowed it to preserve its active power. Newton conceded that there might be "an attactive power" in the Sun, but insisted that it could not be magnetic, and must be "of another kind from any we know" (Flamsteed to Crompton for Newton, 7 March 1681, and Newton draft for Flamsteed, April 1681, in Newton 1959–77, 2:351, 359). Crucially, Newton had not yet established any conception of centripetal circumsolar force, nor had he been convinced that a comet would respond to such a force. In December 1679 he told Hooke of bodies orbiting under the alternate overbalance of *centrifugal* force and gravity, and repeated this notion in comments to Burnet in December 1680 and to Flamsteed in April 1681. The controversy with Flamsteed was the first time that Newton, on the basis of the evidence from experimental magnetism and pneumatics of the active principles between Sun and comets, considered the possibility of a permanent attractive virtue in interplanetary space. Only now, and ultimately in his draft lectures on motion in Cambridge in 1684, did Newton at last arrive at a distinctive conception of centripetal forces. Newton was then persuaded by Halley to insert these passages into his drafts for the *Principia.* In the *Principia,* the term "attraction" was supposed to embrace

[17] On magnetic cosmology in England see also Freudenthal 1983.

[18] For the exchange between Newton, James Crompton, Halley, and Flamsteed in January-February 1681 see Newton 1959–77, 2:319–48. See also Flamsteed's exactly contemporary lectures on cometography at Gresham College which also suggest the magnetic vortical behavior of comets and planets (printed in Forbes 1975, 20–35, 105–16, 360).

mutual endeavors due to "the action of the bodies themselves, as tending to each other or agitating each other by spirits emitted or . . . from the action of the ether or the air, or of any medium whatever, whether corporeal or incorporeal." This was precisely the range of active principles constructed by experimental philosophers. The exchanges of the early 1680s thus occupied a crucial place in the very rapid construction of Newton's mathematical principles of natural philosophy, and were themselves drawn directly from the work of the 1670s on the properties of magnetic and etherial active fluids.[19]

In this section I have traced various sites at which experimental philosophèrs sought to extend and dominate cosmology and pneumatology. Activity was displayed in terms of a set of posited agents visible in the laboratory. Critics of this natural philosophy denied that the strategy was possible, because natural philosophy could not include the soul, or else denied that it had been accomplished, because effective persuasion of spirit was lacking. Newton's rejection of any purely mechanical fluid as a bearer of such actions was an integral part of this controversy. I shall now consider the most spectacular cases, where the charges of atheism and occultism did their work. Here the bounds of experimental philosophy were marked and the role of the experimenters defined.

Ghosts and Machines

The difference between the spirit testimonies produced in Restoration laboratories and those produced outside them was of enormous significance. Within the laboratories, the experimental philosophers showed how their pneumatics displayed the innate active principles which had been occult. Outside, they appropriated realms which had been the prerogative of other disciplines. Experimental instruments were used to show spirits working. Proper reporting allowed the dissemination of these matters of fact through a society of otherwise vulnerable subjects. Collective witnessing and organized labor controlled the reproduction of phenomena lest they lead to dogmatism and illusion. Using these technologies, the experimenters sought to naturalize the spirit world by bringing it under their own control. Divines who charged this experimental project with atheism were countered with the claim that it did produce evidence of active spirits in nature and that the transcripts of pneumatic experiments were the very best way to win over the victims of unbelief. So the experimental philosophers sought to escape the taint of atheist mechanism by showing the vitalism of their ontology (thus redefining the term "mechanical"), and the charge of enthusiasm by showing the discipline of their technology (thus redefin-

[19] For the development of Newton's account of centripetal force in the 1680s see Whiteside 1970, 13; cf. Koyré 1952. For Newton on attraction see Newton 1934, 164, 192.

ing the term "spiritual"). They were constrained by the forms of the experimental life.

What of spirit testimonies produced outside this realm? A vast range of such testimonies had long been available to priests, physicians, and lawyers in their campaigns against skeptics and sectarians: anecdotes of wondrous natural phenomena drawn from natural magic, accounts of witchcraft and possession, miraculous cures, the weapon-salve, transmutation, palingenesis. "If there be once any Invisible Ghosts or Spirits acknowledged as Things Permanent," argued Cudworth in 1678, "it will not be easie for any to give a reason why there might not be one *Supreme Ghost* also, presiding over them all, and the whole world" (p. 701). Boyle agreed: experimental evidence of "intelligent beings that are not visible" would aid "the reclaiming" of atheists. Experimenters actively participated in the accumulation of such stories: during the Restoration Boyle and Glanvill worked with Henry More in compiling lists of spirit testimonies, while Newton, Hooke, Robert Plot, Elias Ashmole, and Boyle all expressed active interest in the alchemical project of the redemption of matter (Boyle to Glanvill, 18 September 1677 and 10 February 1678, in Boyle 1772, 6:57–60).[20] In his commmonplace book of the 1670s, Edmond Halley listed phenomena drawn from natural magic (Cohen and Ross 1985); more famously, John Aubrey put long collections of "Hermetique" phenomena into his *Naturall Historie of Wiltshire* during the 1670s, inserting many under the heading "Air," and then published them separately as *Miscellanies* in 1695. Halley was his source for some impressive accounts of dream visions and other occult phenomena. However, such work was always deeply troubled. Aubrey recognized that denial of spirits was taken as atheism, but that "the Imagination of fearfull People is to admiration" (Aubrey 1972, xxix–xxx), and was himself criticized by John Ray for credulity. The *translation* of spirit testimonies into the public space of experimental philosophy was considered dangerous; but at the same time their *presence* was considered indispensable (see also Hunter 1975, 103–4, 126–32).

The dangers in letting spirit testimonies transit the space of experiment were twofold. *Epistemologically,* these anecdotes had to be made into controlled, replicable, public experience. But the spirit world was notoriously the realm of popular enthusiasm or of patrician wit and satire. Experimenters joined with the godly in their cultural politics: both enthusiasm and skepticism were contested with matters of fact. Ontologically, this contest needed a redefined map of nature. Each community had a different account of the *natural.* Experimenters held that the space of their laboratories was truly natural. Spirits were naturalized by showing how active principles worked in matter. In 1700 this was the dominant form of English natural philosophy. Physicians diagnosed enthusiasts as the unfortunate victims of vaporous spiritual fluids. Dangerous visionaries were now treated by medicine and law as subjects led on by material powers. Yet this made natural philosophy easily vulner-

[20] For interest in alchemy see Dobbs 1976; Figala 1977; Westfall 1984; Hunter 1975, 139–41 (for Hooke and Aubrey); Taylor 1949. For collections of natural magic see Walker 1985 for the elite and Thomas (1973) and Zambelli (1982) for popular culture.

able to the charges of enthusiasm and of subversion. Spirits now visibly lived inside the "nature" owned by the experimenters. Such appropriation was always contested. Hence Boyle and Newton, for example, were very attentive to the forms in which alchemical trials should be reported. Newton's researches of the 1670s convinced him that "there is therefore besides ye sensible changes wrough[t] in ye textures of ye grosser matter a more subtile secret and noble way of working" due to "an exceeding subtile inimaginably small portion of matter diffused through the masse." His publication of such views in 1675 was carefully redrafted for the consumption of Oldenburg and his London colleagues. In 1674–78 Boyle wrote three essays on alchemy and celestial magnetism, and published two of these in forms appropriate to the report of anecdotal conversations with adepts, made for the Royal Society. We have seen that Newton strongly criticized this decision and counseled Boyle to "high silence." In 1678–80 Boyle established close contact with Georges Pierre, self-styled Patriarch of Antioch, with a view to establish methods for the "great work." The effort to make these public was a spectacular failure.[21]

The same troubles arose about the format of the witch testimonies which More and his colleagues collected when they sought to "talk with the Naturalists in their own dialect." This dialect had to allow speech concerning "a Principle transcending the nature and power of matter, that does umpire and rule all." More wrote that "the Mechanical Philosophy" was not "the Experimental Philosophy which the Royal Society professes." When publicly denying that he had broken with the Royal Society in 1671, More defined the mechanical philosophy "in the sense which I oppose": this was the Cartesian profession that matter and conserved motion would explicate all phenomena. "This Profession cannot rightly be called the *Mechanical Philosophy,* but the *Mechanical Belief or Credulity*" (1662, "Preface General":iv–v, xv–xix, and "Antidote against Atheism":43–46). The point of this enterprise was that the experimental life could make spirits *visible, safe,* and *effective.* Even Hobbists could be won to the faith by stories about haunted houses and spiritual healing. As Schwartz (1980) has shown, precisely the same conflict arose in Augustan London when Huguenot refugees claiming divine commission began to attract patrician support for their visions and prophecies. Historians of demonology have also emphasized the problems posed by the unique and extraordinary character of explicit spirit testimony. This was a juridical, natural philosophical, and theological issue: it is not best treated as an aspect of the conflict between rationalism and the occult. As Restoration and Augustan politics demonstrate, the crisis of such testimony was endemic throughout this period.[22]

[21] For the dangers of enthusiasm and their medicalization and control see Macdonald 1982; Heyd 1981. For alchemical work by Newton and Boyle see Dobbs 1982; Boyle 1772, 4:97, 219–30, 371–79; Newton to Oldenburg, 26 April 1676 and Newton to Boyle, 28 February 1679, in Newton 1959–77, 2:1–2, 288–96; cf. Ihde 1964; Maddison 1969, 166–76 (on Pierre).

[22] See also Glanvill 1671, 154–58. For Restoration witch testimonies see Tourney 1972; Jobe 1981. For studies of More on the natural philosophy of spirits see Staudenbauer 1974; Gabbey 1982; Shapin and Schaffer 1985, 207–12. For the political implications of the collection of spirits see Hill 1975, Chap. 14; Jacob 1977; McKeon 1975.

The most important aspect of this crisis was the challenge posed by spirits to disciplinary boundaries and established roles. In the experimental world, spirits must obey the rules of the experimental game. For this reason, More was attacked by experimental philosophers who found it hard to accept that these testimonies of the "hylarchic spirit" could be successfully integrated into experimental forms. Hooke told his Philosophical Club and the Royal Society in 1676 that More's stories "perplex our minds with unintelligible Ideas of things, which do no ways tend to knowledge and practice but end in amazement and confusion." Boyle fought this out with More in a pamphlet war in 1671. More had argued that his stories must be recognized by the experimenters; Boyle replied that this would be possible only if the stories were collected under the experimenters' control. While supporting More's "grand and laudable design," Boyle demanded that More play the right game: he must do experiments for himself, rely on properly witnessed trials, and never "deny the matter of fact to be true." More held that these were tyrannical conditions, redolent of the loathsome Cartesians and Spinozists: as he had written in the 1660s, "there will be a spiritt of nature for anything that ever will be alledg'd to the contrary" (Gunther 1931, 8: "Lampas," 187–95; Boyle 1772, 3:"Hydrostatical Discourse," 608–9, 624, 627–28; More to Anne, Lady Conway, 17 March 1666 in Nicolson 1930, 269; Gabbey 1982; Shapin and Schaffer 1985, 212–24). This conflict over the epistemology of spirits gave point to the exactly contemporary exchanges in the Royal Society concerning the proper way of enquiry. As Michael Hunter and P. B. Wood have shown (1986), the 1670s were marked by intense exchanges within the Society about the reform of its working. Proposals to encourage reports from members had stimulated those papers on pneumatics, spring, gravity, and magnetism we have already documented. An anonymous contributor interested in physiology wrote sharply of the difficulty of handling reports on spiritual and mechanical nature received from beyond the space controlled by the experimenters: "An Artist or Experimenter, is not to be taken for maker of gimbals, nor an observer of Nature for a wondermonger. . . . The one is to be accepted as the Author or advancer of an Art of his own; the other, as a finder out of those Arts which are divine. In short, . . . the one may be truly styled a Master of Nature; the other, one of God Almightys Scholars." By producing evidence of spirits, the experimenters made themselves masters of nature rather than mere gimbal makers. By ensuring this evidence was reputable, they made wondermongers into God's scholars (ibid., 81).

The redefinition of the roles of scholar and mechanic demanded the redefinition of the nature which they owned and studied. It was in this polemical context that the meaning of the mechanical philosophy was estabished and contested. Boyle had lengthy experience of this process: in troubled contacts with prophets such as Walter Gostelo in 1655 (see Capp 1984, 183–84), with faith healers such as Valentine Greatrakes in 1666 (see Kaplan 1982; Duffy 1981), in his exactly contemporary essay on "the vulgarly received notion of nature" (Boyle 1772, 5:158–254) and in his exchanges with More in the 1670s, he defined a nature of the "physiologers," in

contrast to that of other disciplines. He discriminated between the allowable interventions of "immaterial beings" and inadmissible explanatory items such as the "hylarchic principle," which were "not physical" (Jacob 1977).

Historians have too often assumed that the "mechanical philosophy" was obviously progressive and so self-evidently defined. Yet in this period it was a resource and a target of dispute, its meaning always contested. *Its structure and fortune needs explanation.* First, the discourse of mechanism sustained the status of experiment. Second, however, it called into question the relation of experimenters with other social roles which claimed command over spirit, notably priests, lawyers, and physicians. Spirits were to be shown through the practical technology of experimental philosophy, and the authority of that technology relied on the authority of instrumental work. As J. A. Bennett has shown (1986), the language of the mechanical philosophy was a powerful legitimation of the use of instruments by natural philosophers when such artifacts had hitherto been the preserve of the artisans and the mathematical sciences. This process incorporated the important transformation of "mathematical magic" during the century. In *Micrographia* Hooke found it necessary to make use of congruity and active powers. His mechanical philosophy was the explicit license for the use of those new instruments which revealed these powers in "the small *Machines* of Nature, which are not to be discern'd without these helps." So, "Natural Textures, which some call the *Plastick faculty,* may be made in *Looms,*" and the experimenters "are no more puzzled about them, then the vulgar are to conceive, how Tapestry or flowred Stuffs are woven" (Hooke 1665, preface). The experimental life needed such defence precisely because of the ease with which its critics satirized its claims to authority. "Not every one that brings from beyond sea a new gin, or other jaunty device, is therefore a philosopher," wrote Hobbes in 1662 (p. 436). In 1665 Thomas White argued that experiments "belong to Artificers and Handy-Craft-Men, not Philosophers, whose office 'tis to make use of Experiments for Science, not to make them" (p. 77). Here it was argued that machine philosophy and spirit philosophy could not reach the status of the mechanical philosophy. Hooke and his allies responded that the experimental program, which showed active principles working within their instruments, was the only enterprise that deserved the name of "the real, the mechanical, the experimental Philosophy" (Hooke 1665, preface; Shapin and Schaffer 1985, 126–28).

This issue of status was directly connected with the politics of elite and popular culture. The role of the godly was to discipline the consciences of irreligious and enthusiast plebs and, on the other hand, of skeptical drolls and court wits. It was a commonplace for Restoration divines that "plebians and mechanics" had "philosophized themselves into principles of impiety," and, in the terms of Richard Baxter, that "the rabble that cannot read" would "raise an army to extirpate knowledge and religion." This was one of the more sensitive resonances of the key term "mechanical." So the public production of controlled spirit had targets which were potent threats in Restoration culture. Witchcraft, prophecy, and healing were the most obvious regions in which the godly and their rivals defined their authority.

Restoration divines larded their sermons with exemplary cases of spirit testimony. Robert South, Clarendon's chaplain and high Church orator at Cambridge, compared the "secret spirit of niter" in rainwater with the regeneration of fallen man through "an hidden, divine influence that imprints a holy disposition upon the soul" (cited in Guerlac 1977, 265).[23] The experimental naturalization of spirit touched the most sensitive issues of the Restoration polity. "Physical" accounts of healing offered by Boyle and his colleagues were necessary and dangerous.

As Marc Bloch's magisterial investigation of the royal touch demonstrated (1983, 369–97, 420–29), the ability of the sanctified and restored monarch to cure the King's Evil by touch raised all the problems we have discussed. The Restoration revival of this custom was a spectacularly visible instance of the return of spiritual action. "God hath entailed a *Miraculous Gift of Healing as it were on purpose to raise up our Hopes that we shall owe one day to those sacred Hands,* next under God, the healing of the Church's and the People's Evils, as well as of the *King's.*" Twenty-three thousand subjects had been touched by the monarch by September 1664. Divines and natural philosophers strenuously debated the natural, supernatural, and material causation at work here: advocates of divine right were advocates of the divinity of this gift. Some held it "partly Miraculous," and others "ascribe it to the power of fancy and an exalted imagination." Physicians, jurists, and experimenters explicitly argued whether "mechanical or physical hypotheses" about sacred and royal actions would be politically proper and compelling.[24]

Conclusion

In this paper I have analyzed the work of a group of experimental philosophers in the 1670s as they sought to incorporate the spirit world. The "mechanical philosophy" has emerged here as a locally constructed discipline. I have suggested the important connections between the production of natural philosophy and the structures of popular and elite cultures. The historiography of popular culture has been an important resource. As Alan Macfarlane (1977, 87) has argued about the culture of witchcraft in seventeenth-century England, "overlapping with the ordinary physical world was a world full of 'power' both good and evil." Disputes about the character of these powers were disputes about who should manage them. Thus lawyers developed accounts of retributive rather than restorative justice, which allowed juridical rather that popular control over witch trials. Carlo Ginzburg (1983, 127–28) demonstrates how clerics and physicians used their rival accounts of the "natural" to dispute control over spirit possession. Michael Macdonald (1982) has shown how physicians and natural philosophers developed naturalistic accounts of healing and prophecy

[23] Hill 1965, 127, 166; Hill 1984, 207; Aylmer 1978. For the godly state see Lamont 1969.

[24] For the dangers of accounts of "mechanical or physical hypotheses" in healing see Steneck 1982; Jacob 1983, 143–53.

The Manner of His Majesties Curing the Disease,

CALLED THE

KINGS-EVIL.

THE Ministers of the Kings Majesties Chappel reading the Common-Prayers and Liturgy allowed in the Church of *England*, when the Ordinary Prayers with the Epistle and Gospel is ended, the diseased persons are brought by the Kings Chyrurgeons into His Majesties presence, where by Faith and fervent Prayer they desire help. Then is read the Gospel next following: and when these words are read, viz. *They shall lay their hands, &c.* The King layeth both his hands on the diseased persons, and with his hare hands doth stroke them: which being done, the diseased persons stand a little aside. Then the rest of the Gospel is read, viz. *So then when, &c.*

The Gospel written in the xvj of *Mark*,

JEsus appeared unto the eleven as they sate at meat, and upbraided them with their unbelief and hardness of heart, because they believed not them which had seen that he was risen again from the dead. And he said unto them, Go ye into all the world, and preach the Gospel to all creatures: He that believeth and is baptized, shall be saved: but he that believeth not, shall be damned. And these tokens shall follow them that believe: In my Name they shall cast out devils, they shall speak with new tongues, they shall drive away serpents, and if they drink any deadly thing, it shall not hurt them. THEY SHALL LAY THEIR HANDS ON THE SICK, AND THEY SHALL RECOVER. *So then when the Lord had spoken unto them, he was received into heaven, and sate on the right hand of God. And they went forth, and preached every where, the Lord working with them, and confirming the word with miracles following.*

Repeat the same as often as the King toucheth the Kings person

Which Gospel being read, then this Gospel next following is also read: And when these words are read, *That light was the true light, &c.* The King ariseth, and the diseased are again brought before him; then he taketh a piece of Gold called an Angel, of the value of 10 shillings, with a hole made therein, and making the sign of the Cross on the diseased place, with Prayer and Blessing, he hangeth the Gold in a Silk string about the Neck of every diseased person. When the King hath so put an Angel of Gold about the Neck of every one of the diseased persons, then the rest of this Gospel is read, viz. *He was in the world, &c.* The diseased persons standing in the mean time a little aside.

The Gospel written in the first of St. *John*.

IN the beginning was the Word, and the Word was with God, and God was the Word. The same was in the beginning with God. All things were made by it, and without it was made nothing that was made. In it was life, and the life was the light of men, and the light shineth in the darkness, and the darkness comprehended it not. There was sent from God a man, whose name was John. The same came as a witness to bear witness of the light, that all men through him might believe. He was not that Light, but was sent to bear witness of the light. THAT LIGHT WAS THE TRUE LIGHT, WHICH LIGHTETH EVERY MAN THAT COMETH INTO THE WORLD. *He was in the world, and the world was made by him, and the world knew him not. He came among his own, and his own received him not. But as many as received him, to them gave he power to become sons of God, even to them that believed on his Name, who (where) born, not of blood, nor of the will of the flesh, nor of the will of man, but of God. And the same word became flesh, and dwelt among us, and we saw the glory of it, as the glory of the only begotten Son of the Father, full of grace and truth.*

Repeat the same as often as the King toucheth the Kings person. Angel about his neck.

This Gospel being ended, then the King with the whole company of the Church upon their knees do pray thus:

LOrd have mercy upon us. *Christ have mercy upon us.* *Lord have mercy upon us.*

Our Father which art in Heaven, hallowed be thy Name. Thy Kingdom come, Thy will be done in Earth, as it is in Heaven. Give us this day our daily bread. And forgive us our trespasses, as we forgive them that trespass against us. And lead us not into temptation.

Answer. *But deliver us from evil.* Amen.

Minister, *O Lord save thy servants.* Answer. *Which put their trust in thee.*

Min. *Send unto them help from thence.* Ans. *And evermore mightily defend them.*

Min. *Help us O God our Saviour.* Ans. *And for the glory of thy Names sake deliver us, be merciful unto our sinnes, for thy Names sake.*

Min. *O Lord hear our prayers.* Ans. *And let our cry come unto thee.*

ALmighty God, the eternal health of all such as put their trust in thee, hear us we beseech thee on the behalf of these thy servants, for whom we call for thy mercyful help, that they receiving health, may give thanks to thee in thy holy Church, through Jesus Christ our Lord. Amen.

Then the Prayers are concluded with this Blessing, viz.

THE peace of God which passeth all understanding, keep your hearts and minds in the knowledge and love of God, and of his Son Jesus Christ our Lord: And the blessing of God Almighty, the Father, the Son, and the Holy Ghost, be amongst you, and remain with you always. Amen.

Which being ended, the healed persons depart, first giving thanks to God, and to the Kings Majesty, and congratulating one another for their recovery.

Figure 3. Spirits and the godly state. A broadside of 1679 specifying the procedures to be followed in the ceremony of the royal touch for scrofula. Source: Crawford 1911. (Cambridge University Library.)

that treated enthusiasm as low pathology rather than as divinely elevated vision.[25] Skeptics among the learned wits challenged the process of spirit trials. There was no correlation between endorsement of the reality of spirits and support for witch trials. The learned critic John Wagstaffe (1671, 112-13, 123-24) held that "the being of spirits" was undeniable. But both he and his probable source, Thomas Hobbes, held that trials and testimonies of spirits were due to "a sort of men who by a pretended holiness and I know not what kind of saucy acquaintance with the Deity have set themselves off unto the people to a great advantage" (compare Hobbes 1651, 7).[26]

All godly men who claimed authority over spirits were subject to such attack. Hogarthian satires against "credulity, superstition and fanaticism" depicted plebeian enthusiasm, represented by Wesleyan sermons, as identical with the experimental philosophy of spirits, represented by Glanvill's witch stories. The experimental philosophy I have discussed tried to extend its control over this spirit world. In 1704 Newton put it like this: "Since all matter duly formed by generation and nutrition is attended with signes of life . . . the laws of motion arising from life or will may be of universal extent." So were the implied boundaries of his natural philosophy.

Perceptive critics of this enterprise could uncover the experimenters' enthusiast ambitions. This was particularly apparent in the early eighteenth century. Leibniz held that Newtonians had "grown weary of rational romances and are become fond again of the tales of fairies." As usual, Jonathan Swift was an acute observer of this process. In 1704 he produced *A Tale of a Tub,* which satirized enthusiasm and pneumatics under the guise of "Aeolists" who "maintain the Original Cause of all Things to be *Wind* . . . whence it is very justly observed by Naturalists, that *Wind* still continues of great emolument in certain *Mysteries* not to be named." He accompanied this attack with *A Discourse concerning the Mechanical Operation of the Spirit,* which examined "the *Phenomenon* of *Spiritual Mechanism*" as manifested in the public assemblies of philosophers and sectarians. In the same year he composed a brilliant pastiche of Boyle's spiritual rêveries, A *Meditation upon a Broom-stick.* Swift was just as keen as some of our own intellectual antiquarians to find sources for seventeenth-century philosophies in Plato and Aristotle. But he saw very clearly that experimental pneumatics was a modern political practice which, like enthusiasm, sought to make spirit "an effect of Artifice and *Mechanick Operation.*" This was great wit and good history.[27]

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[25] On witchcraft and the conflict of social roles see also Larner 1984, 58–60. For surveys see Foucault 1969; Hirst 1982.

[26] For the role of godly men see Wrightson 1982, 199–221; McGee 1976.

[27] For Newton on active principles see McGuire 1968, 165–66, 205. See also Leibniz to Clarke, 18 August 1716, in Leibniz 1956, 92. For Swift and Hogarth on enthusiasm see Porter 1983. For Swift's satires on pneumatics and pneumatology see Swift 1975, 95, 175, 177, 193–94.

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