Cornelis Drebbel and Salomon de Caus: Two Jacobean Models for Salomon's House
Author(s): Rosalie L. Colie
Source: *The Huntington Library Quarterly*, Vol. 18, No. 3 (May, 1955), pp. 245-260
Published by: University of California Press
Stable URL: http://www.jstor.org/stable/3816455
Accessed: 28/08/2009 09:29

Cornelis Drebbel and Salomon de Caus: Two Jacobean Models for Salomon's House

By Rosalie L. Colie

According to Spedding's conjecture, Francis Bacon wrote the *New Atlantis* in 1624 as a parable to his whole philosophy, a discussion of the "particulars," as he called them, by which all men might understand his pragmatic plan and adapt it to their future uses. As utopias go, the *New Atlantis* offered no extraordinary contributions to the political or social sciences, but it had the effect upon men's minds Bacon intended—and a more practical effect than most utopian schemes: Salomon's House, the academy for the advancement of learning, was the matrix stamped upon the great scientific academies of the seventeenth century, the French Académie des Sciences as well as the English Royal Society.[1] His academy was Bacon's principal instrument in the Great Instauration, the means by which the real work of the scientific revolution was to be carried out. His boast for it was brave, but no braver than his vision required: "the End of our Foundation is the knowledge of Causes, and secret motions of things; and the enlarging of the bounds of Human Empire, to the effecting of all things possible."[2]

Perhaps, as one critic has suggested, Bacon might never have written the *New Atlantis* had not Tommaso Campanella published his *Civitas Solis* in 1623 and thus inspired the Chancellor to a

[1]For the importance of Bacon's influence upon the Royal Society, see Thomas Sprat, *History of the Royal Society* (London, 1667), where the Instaurator's plan is closely related to the original plan of the Royal Society. R. F. Jones, *Ancients and Moderns* (St. Louis, 1936), deals with Bacon's pervasive influence upon the whole century. In outlining his scheme for a French scientific academy, the distinguished scientist Christiaan Huygens, referred to Bacon's academy as a model: "La principale occupation de cette Assemblée et la plus utile doibt estre, à mon avis, de travailler à l'histoire naturelle à peu près suivant le dessein de Verulamius. Cette histoire consiste en expériences et en remarques de tout ce qu'on voit dans la nature." (*Oeuvres complètes de Christiaan Huygens*, 22 vols. [La Haye, 1888-1950], VI, 95-96).

[2]Francis Bacon, *Works*, ed. James Spedding, Robert Leslie Ellis and Douglas Denon Heath (London, 1889-1892). All quotations from the *New Atlantis* occur in Vol. I, between pp. 129 and 166.

description of his own republic.[3] Whatever impetus Campanella afforded, however, his little book with its Platonic academy did not provide the closest original for Salomon's House; for that foundation Bacon had actual non-literary sources closer at hand. As his notes and jottings plainly indicate, Bacon, the practical man, drew upon experience whenever possible; his whole life long he was busy about the "particulars" of natural science, collecting for his "histories," looking for models for his foundation. He followed his own precepts as he laid them down and did not look merely in books. As early as 1608, he jotted down notes on actual models for his ideal "Foundac. of a college for Inventors"—"Westminster, Eton, Wynchester, Spec. Trinity College in Cambridg. St Jhons in Camb. Maudlin College in Oxford." These traditional institutions, however excellent for their own purposes, proved insufficient for Bacon's great innovating ideal; his academy had to have real laboratories for inventors and projectors, not only "a Library and an Inginary" but also "Vaults, fornaces, Tarraces for Isolacion; woork houses of all sorts."[4] As we know, no academy, real or imaginary, existed to provide Bacon with models for this ideal, but in London itself two men were practicing, in circles not far distant from Bacon's own, the "particulars" of natural philosophy in ways necessarily interesting to him. It is to their experiments, often startlingly close to those of Bacon's utopia, that we must look for a partial source of the *New Atlantis*.[5]

In all Europe there were few scientific laboratories at this period. The most famous, and undoubtedly the best, was Tycho Brahe's Uraniborg, a training-point for young astronomers and scientists from all parts of the continent. Another famous "academy" was at Prague, to which for a time the Emperor Rudolph II managed to

[3]Eleanor Dickinson Blodgett, "Bacon's *New Atlantis* and Campanella's *Civitas Solis*: A Study in Relationships," *PMLA*, XLVI (1931), 763-80.

[4]James Spedding, *The Letters and the Life of Francis Bacon* (London, 1868), IV, 26, 66.

[5]It is appropriate to suggest at this point that the *New Atlantis* deserves careful re-editing, with particular attention devoted to Bacon's use of contemporary and ancient experimentation. Bacon could not have been ignorant of Leonardo's experiments in flight; he must have known too such books as G.-B. Porta's *Magiae Naturalis* and the works of Paracelsus and Cornelius Agrippa.

attract Tycho himself with all his staff and movable equipment. Around 1610 other renaissance men of science were drawn to the Emperor's court, among them the Englishmen John Dee and Edmund Kelley and the Hollanders Cornelis Drebbel and Rembert Dodoens,[6] of whom only Drebbel is of great significance in connection with Bacon.

Cornelis Drebbel was born in Alkmaar, Holland, in the year 1572, the year of the new star. He worked for some years in the atelier of the painter-engraver Hendrik Goltzius, whose daughter he married. In 1605 he came to London and entered the sovereign's service; except for his stay in Prague and a few journeys back to his native Holland, England was his home until his death in 1633. In the second decade of the seventeenth century Drebbel was attached first to the household of Prince Henry, the heir, and after the prince's death to that of King James. A laboratory was provided him in Eltham Palace, where he carried on experiments excitingly like those described by Bacon; indeed, visitors to Eltham were as enthralled by the sights there as Bacon's sailors by the wonders of Salomon's House. To two such visitors, a German courtier in the train of Prince Louis-Frederick of Württemberg and the young Dutch diplomat Constantijn Huygens, we owe our partial knowledge of Drebbel's marvels.[7]

A scientific colleague of Drebbel, one who knew and respected the Hollander's accomplishments, was Salomon de Caus, also in Stuart service. Little is known of Caus's life. He was born about 1576 and died in 1626, and from the semi-autobiographical prefaces to his several works we can sketch his career. He was a Frenchman, often designated simply as such in the records of payments of the royal household. He too was assigned to Prince Henry's train, but was later transferred to that of the Princess Elizabeth, Electress Palatine, whom he accompanied to Heidelberg after her marriage with the Elector. When that Protestant couple fell upon difficult

[6]The only account in English of this group is Henry Carrington Bolton's unsympathetically titled *The Follies of Science at the Court of Rudolph II* (Milwaukee, 1904).

[7]William Brenchley Rye, *England as Seen by Foreigners in the Days of Elizabeth and James the First* (London, 1865), pp. 61 ff.; Constantijn Huygens, "Fragment eener autobiographie," *Bijdragen en Mededeelingen van het Historisch Genootschap*, XVIII, 116-21 (Koninklijke Akademie, MS Huygens XLVIII, foll. 835r-837v).

days and were forced to evacuate their territory, Caus did not accompany them to their refuge in The Hague, but apparently put himself at the service of his original sovereign, the King of France.[8]

When Drebbel and Caus were in England, however, Bacon had had ample opportunity to know of their work for his master, King James, to whom with so much hope he had dedicated his *Advancement of Learning*. When to Bacon's disappointment James showed little sign of implementing that great scheme,[9] and as his hopes of that monarch declined, Bacon turned his attention to the heir to the throne, Prince Henry, the most promising of Stuart princes. Both Drebbel and Caus were then among Prince Henry's artificers, attached to his household and under the supervision of Sir Thomas Chaloner, himself an amateur of scientific experimentation and the author of a book on nitre.[10] Bacon was quite aware of Chaloner's commanding position for anyone desiring to reach the prince, as one of his 1608 notes shows: "Makeing much of Russell that depends upon Sr Dav. Murry and by that means drawing Sr Dav. and by him Sr Th. Chal. in tyme the prince."[11] Although the prince died before Bacon could "draw" him and thus never lived to patronize an English academy, his inventor-servants, his "artificers," nonetheless served Bacon's purpose by providing graphic examples of scientific achievement.[12] Beyond this, the Hollander's public experi-

[8]There are three fairly recent biographies of Drebbel, of which one, G. Tierie's *Cornelis Drebbel* (Amsterdam, 1932), is in English. The others, H. A. Naber's *De Ster van 1572, Cornelis Drebbel* (Wereld-Bibliotheek, no. 54) and F. M. Jaeger's *Cornelis Drebbel en zijne tijdgenooten* (Groningen, 1922), are, unfortunately for us, written in Dutch. In his highly derivative and not wholly accurate book, Dr. Jaeger has pointed out some parallels between Drebbel's inventions and those of the *New Atlantis*. My conclusions were reached before I could see his book, and since that book is not readily available to English-speaking readers and its author was content merely to draw a parallel, I have nonetheless presented this study. For Caus, the best biographical article is in the *DNB*, which has an accurate bibliography of his works.

[9]King James was not wholly insensitive to Bacon's idea of an academy. See *Cal. State Papers, Domestic, James I*, CXXXI, no. 70, for a letter from James to Prince Charles, urging him to attend to the foundation of an academy for the arts and sciences.

[10]*A Short Discourse on the most rare Vertue of Nitre* (London, 1584).

[11]Bacon, *Works*, XI, 63.

[12]Bacon was not the only man to make literary use of Drebbel's inventions. Ben Jonson, albeit in ridicule, thrice referred to them. See Ben Jonson, *Works*, eds. C. H. Herford and Percy Simpson (Oxford, 1925-1951), V, 258 (*Epicoene* V. iii); VIII, 62 (Epigram XCVII, "On the New Motion"); VI, 329-30 (*The Staple of Newes* III. ii).

ments were widely attended and, one may asume, widely discussed among Londoners—and even among scholars abroad. Bacon himself may have been present at some such performance—at Chaloner's fireworks on Twelfth Night, 1608, for example, or at Drebbel's demonstration of his magic lantern. He may even have been shouldered by the crowd at the Thames-side in 1620 when Drebbel successfully submerged in his submarine, to the wonder of the citizens. With his great interest in gardening, too, Bacon could hardly have failed to know the gardens Caus laid out for Prince Henry at Richmond. In view of his constant and constantly frustrated hopes of Stuart patronage for the advancement of learning, it is quite possible that Bacon's use of their inventors in the *New Atlantis* was one of his many compliments to the royal family.

"Vaults, fornaces, Tarraces for Isolacion; woork houses of all sorts": in the simple note of 1608, kernel of all the later elaborations, lay Bacon's practical dream of Salomon's House. The visitors to the experimental academy were taken upon a tour of the premises, permitted to observe the operation of the vaults, of the furnaces, of the work-houses or laboratories. First of the "preparations and instruments" shown them were the "large and deep caves" used for "all coagulations, induracions, refrigerations, and conservations of natural bodies"; the second, "high towers" for insulation, refrigeration and conservation. Though Drebbel's laboratory at Eltham was by no means so well-equipped as that on Atlantis, he nonetheless carried on experimentation in refrigeration and observed, as would the Atlantians later, "diverse meteors, as winds, rain, snow, hail; and some of the fiery meteors." As early as 1607, with the publication of his little book, *A Short Treatise on the Nature of the Elements*,[13] Drebbel established his authority in the field of such observation. Much like his were the Atlantian experiments Bacon was later to describe, "in great and spacious houses where we imitate and demonstrate meteors; as snow, hail, rain, some artificiall rains of bodies and not of water, thunders and lightnings." What could Drebbel do in these matters? He "with divers instruments could make it rain, lighten, and thunder, at different times, as if it had come about

[13] *Van de Natuyre der Elementen* (n.p., 1607); later published as *Een Kort Tractaet van de Natuere der Elementen* (Haerlem and Rotterdam, 1621).

naturally from heaven, so that people knew no differently," wrote the chronicler Van der Woude. Godlike, he could also "with certain instruments, make it come about so that in certain places in midsummer it was as cold as if it were midwinter; and this at the request of His Majesty he brought to pass in the Great Hall of Westminster, where he made it so cold on a summer's day that the King and his nobles and many great lords were forced to flee the aforesaid place because of the cold."[14] Spedding has noted that Bacon's reference to "the late experiment of artificiall freezing" must have been to this demonstration of Drebbel's power; perhaps the Instaurator himself was among the great lords forced to flee Westminster on that summer's day.[15]

The "violent streams and Cataracts" which served Salomon's scientists "with many motions," the "engines for multiplying and enforcing winds to set also on diverse motions" were quite familiar to Drebbel and to Caus. Water- and windmills had of course long been in use, and both scientists developed their own versions of such mills. The "moving forces" of Caus's book *Les Raisons des Forces Mouvantes* (Frankfort, 1612), were, as one might suspect, the four elements, earth, air, water, and fire. Caus's particular specialty was water, used as cataracts to decorate his fountains and animate his artificial songbirds, and as steam to propel his engines. However unimportant Caus's elaborate renaissance fountains might appear to the casual student, they were no mere toys for princes and great ones; the complex motions of his moving figures and of his musical fountains resulted from genuinely imaginative experimentation in mechanics. Though not the first of its kind, Caus's steam engine, famous among his contemporaries, was one of the earliest such mechanisms perfected, in principle just as important as the revolutionary steam engine of the Industrial Revolution.[16] In addition to these, Caus developed other machines—mills, cranes, windlasses, and pumps—as did Drebbel also. Drebbel's drainage pump, designed apparently for use in the English fens, was so effective as

[14]Cornelis van der Woude, *Kronyk der Stad Alkmaar* (Amsterdam, 1725), p. 7.

[15]Bacon, *Works*, IV, 417, and I, 628.

[16]A[braham] Wolf, *A History of Science, Technology, and Philosophy of the 16th and 17th Centuries* (London, 1935), pp. 543-45.

to make Huygens say, "So far as I know, no one has made a more ingenious instrument than Drebbel for pumping what we call 'dead' or standing water from pools and for removing it to a proper place —and no one ever will."[17]

Caus's fountains were far more elaborate than those of Salomon's House, which were chiefly "in imitation of natural sources and baths." In his essay "Of Gardens," Bacon treated decorative fountains at greater length than he did in the *New Atlantis*. He preferred fountains to pools, which "mar all, and make the garden unwholesome, and full of flies and frogs"; but because they were not entirely natural, he did not care much for the kinds of fountains Caus designed, the intricate mechanisms of *Les Raisons des Forces Mouvantes* and the *Hortus Palatinus*, with their hydraulically activated birds and supernatural beings. Perhaps Bacon was thinking of Caus's popular designs when he wrote, "for fine devices, of arching water without spilling, and making it rise in several forms (of feathers, drinking glasses, canopies, and the like), they be pretty things to look on, but nothing to health and sweetness."[18] Bacon's fountains were to be functional and no more, and upon functional plans he looked with an approving eye. Drebbel's large but not unpractical idea of piping the Thames so that every house in London might have running water may not have found favor with King James, continually struggling with the problem of insufficient funds, but it was an "experiment of fruit" Bacon would have been pleased to see made effective.

Salomon's House conducted experiments upon plants and trees of which no similar record has come down to us from either Drebbel or Caus; it was otherwise with the experiments on animals. Drebbel's trials upon beasts and birds were remarkable. In his artificial incubators ("furnaces of great diversity") he could "at all times of the year, yes, even in midwinter . . . hatch Duck and Chicken eggs without any Ducks or Chickens by, and that so accurately that he knew precisely when the young would emerge, just as if they had

[17]"Fragment eener autobiographie," p. 118; MS Huygens XLVIII, fol. 836. See *SP, Domestic, Charles I*, 16, CLVIII, 34, fol. 75, for a fen-drainage contract involving Drebbel and the Oxford mathematician Henry Briggs.

[18]Bacon, "Of Gardens," *Works*, VI, 490.

been brooded by Ducks and Chickens."[19] Ducks and chickens were of course designed ultimately for the table, and though the "brew-houses, bake-houses, and kitchens" of Salomon's House may not seem to us the proper laboratories of scientists, we must remember that in this period diet was just beginning to be a medical problem. It may seem improper for Drebbel, described in the eighteenth century as "an exceptional and immeasurably excellent and understanding Philosopher whose great genius and acute comprehension (for his time) in the whole world had no equal among Philosophers,"[20] to have spent his time on recipes for cooking and processes for brewing beer, but this is to miss much of the point of renaissance experimentation. The whole area of science then came under review, and understanding of man's body, the microcosm, was as much a problem of natural philosophy as understanding of God's larger universe, the macrocosm. In his own career, moreover, Drebbel's culinary preoccupation stood him in good stead, for in his impecunious old age he was reduced to keeping "an alehouse below the Bridge" in London.[21]

Another of Drebbel's purely utilitarian experiments, too, would have properly found its way into Salomon's House, which derived part of its income from its "excellent dyes." Drebbel's scarlet dye was so important a trade secret that neither he nor his sons-in-law wished to share the process with anyone else.[22] Such homely experiments were related of course to the more theoretical Atlantian "experiments of light" with the furnaces "that keep great diversity of heats; fierce and quick, strong and constant; soft and mild; blown, quiet; dry, moist and the like." As the learned guide explained to his visitor, "But above all, we have heats, in imitation of the sun's and heavenly bodies' heats, that pass divers inequalities, and (as it were) orbs, progresses, and returns, whereby we produce remarkable effects." Imitation of the heavenly bodies, in designs, in globes, in astrolabes, and other instruments was common practice in the

[19] Van der Woude, p. 192.

[20] Ibid., p. 188.

[21] Bodleian Library, MS Rawlinson B. 158, foll. 174-75.

[22] Cambridge University Library, MS 2206, Ll. v. 8, Part II, fol. 50.

renaissance. Drebbel's perpetual motion, of which we shall speak later, was in his eyes an imitation of the heavenly orbs and in particular of the planet earth, whose ocean currents gave him the model for his "perpetual motion."

Except for his submarine, Drebbel's lenses were his invention best-known among scholars. Since Galileo's observations, natural scientists and virtuosos alike sought good lenses with special eagerness, both for distant and close observation. Salomon's House had "perspective houses," with

> . . . demonstrations of all lights and radiations and of all colours; and out of things uncoloured and transparent, we can represent unto you all several colours, not in rain-bows, (as it is in gems and prisms) but of themselves single. We represent also all multiplications of light, which we carry to great distance, and make so sharp, as to discern small points and lines. Also all colourations of light; all dilusions and deceits of the sight, in figures, motions, colours: all demonstrations of shadows.

Drebbel's camera and magic lantern belonged in this subsidiary of Salomon's House; indeed, the last sentence of the quotation runs like a description of a show Drebbel put on with his lantern. Cameras like his were common enough, variations upon the instrument Kepler had developed and Wotton so enthusiastically described in a letter to Bacon.[23] In 1619, the year before Wotton had seen Kepler's "little black tent," Huygens bought one of Drebbel's cameras and took it home to The Hague, where he demonstrated its power of likeness ("la vie mesme") to his painter friends there. For all of his delight in the new toy, Huygens was disappointed by its one defect: like most crude cameras, it projected its images upside down.[24]

Drebbel's other optical instrument, the magic lantern, of which no complete explanation has come down to us, was even more wonderful in its effects than the camera. In a letter written in 1608 Drebbel described his Faustian achievements with that instrument:

[23]Henry Wotton, *Life and Letters*, ed. L. P. Smith (Oxford, 1907), II, 206.

[24]Constantijn Huygens, *De Briefwisseling 1608-1687*, ed. J. A. Worp, 6 vols. (1911-1918), I, 89-94.

I take my stand in a room and obviously no one is with me. First I change the appearance of my clothing and in the eyes of all who see me. I am clad first in black velvet, and in a second, as fast as a man can think, I am clad in green velvet, in red velvet, changing myself into all the colors of the world. Nor is this all, for I can change my clothing so that I seem to be clad in satin of all colors, then in cloths of all colors, now cloth of gold, now cloth of silver; and I present myself as a king, adorned in diamonds, and all sorts of precious stones, and then in a moment become a beggar, all my clothes in rags. . . .

Miraculous though this may seem, Drebbel could do more: he could present himself with "deceits in figures, in magnitudes," as well. He could become a "tree with all my leaves fluttering as if in a breeze," a lion, a bear, a horse, a cow, a calf, a pig. He could make it appear "that the earth was opening and ghosts arising from it, first as a cloud and then in the forms of good spirits, such as Alexander the Great or another prince or king." He could even call up supernatural beings, giants "such as there were in the old days, twenty or thirty feet high."[25]

The Baconian scientists could also "represent all manner of feats and juggling, false apparitions, impostures, and illusions; and their fallacies," but they did not approve of such demonstrations. "Deceits of the senses," tricks and apparent miracles were not the worthy ends of Salomon's House, where honor was paid to the one true miracle, nature herself. As the philosophers explained to their visitors, they had no need for magic:

. . . surely you will easily believe that we that have so many things truly natural which induce admiration, could in a world of particulars deceive the senses, if we could disguise those things and labour to make them seem more miraculous. But we do hate all impostures, and lies: insomuch as we have severely forbidden it to all our fellows, under pain of ignominy and fines, that they do not shew any natural work or thing adorned or swelling; but only pure as it is, and without all affectation of strangeness.

To study nature's essential miracle, any instrument or help was valuable, and Bacon equipped Salomon's House with the more con-

[25]Kon. Akad., MS Huygens XLVII, fol. 207r-v.

ventional and important optical instruments. The philosophers had procured

> means of seeing objects afar off, as in the heaven and remote places; and represent things near as afar off; and things afar off as near; making feigned distances . . . we have also glasses and means to see small and minute bodies, perfectly and distinctly; as the shapes and colours of small flies and worms, grains, and flaws in gems which cannot otherwise be seen, observations in urine and blood, not otherwise to be seen.

Bacon knew of course what magnifying glasses did, and by the time he came to write the *New Atlantis* he knew the exciting discoveries made possible by the telescope; both telescope and microscope were soon to become part of the virtuoso's standard equipment. Drebbel's lenses, as we have said, were particularly famous. Constantijn Huygens' father, good Calvinist that he was, saw fit to warn his son against Drebbel's "sorcellerie," but nonetheless asked that son to find out from the sorcerer all he could about lens-grinding techniques.[26] From France, Peiresc wrote Selden to ask the truth about "some long glasses, which make writing legible a league away"—no doubt an exaggerated account of Drebbel's glasses, which for years after Peiresc continued to praise.[27] Sir Robert Killigrew sent Dudley Carleton, then envoy to The Hague, a "perspective glass" from London ("after having broken forty others getting it ground"),[28] almost certainly one of Drebbel's instruments, for Drebbel was an associate in the Killigrew circle.

Drebbel invented instruments for other senses as well, with one of which, at least Bacon was familiar. In his *Phaenomena Universi* he referred to "certain Hollanders, recently come among us, who have made a certain instrument of music, which when struck by the rays of the sun emits soft music."[29] Both the German observer and young Huygens recorded their astonishment and pleasure at the "virginals which played of themselves" on view in Drebbel's labo-

[26] *Briefwisseling*, I, 89.

[27] *V. Cl. Camdeni et Illustrium Virorum ad Seldenum Epistolae* (London, 1691), 479; N. Fabri de Peiresc, *Lettres*, ed. Ph. Tamizey de Larroque, 6 vols. (Paris, 1881-1898), VI, 28.

[28] *SP, Domestic, James I, 1619-1623*, p. 77.

[29] Bacon, *Works*, III, 711-12.

ratory. Salomon de Caus knew Drebbel's instrument, for his description of it in *Les Raisons des Forces Mouvantes* follows directly upon his description of Drebbel's famous Neptune fountain—in which Neptune, tritons and nymphs in his train, emerges from a cave behind the jet of water and progresses in a horse-drawn chariot through the water and out of sight again behind the jet. Caus's own musical instruments exhibited many variations upon the self-playing theme, which apparently fascinated him. One of these is a delightful ancestor of the player piano, the secret of whose operation he revealed in a sketch of the instrument. Like the "Pioners" of Salomon's House, Caus could "represent... the voices and notes of... birds": many of his fountains carry directions "Pour contrefayre le chant d'un oyseau en son naturel, par le moyen de l'eau," and most elaborately, "Pour fayre representer plusieurs oyseaux lesquels chantent diversement quand une chouette se tournera vers iceux, & quand ladite chouette se retournera, ils cesseront de chanter." The little owl-conductor of this artificial symphony appears solemnly in the accompanying engraving, hardly larger than the mechanical songbirds whose music he controls.

Bacon's sound-houses also studied "strange and artificial echoes, reflecting the voice many times, and as it were tossing it; and some that give back the voice louder than it came, some shriller and some deeper. . . ." Bacon could have seen these tricks played by Caus, for the French inventor could produce such variations in his fountains. One of them contained a grotto from which Echo answered a satyr's flageolet, another a cave from which Orpheus played a cello for the beasts assembled about its mouth to hear him. If the garden of Salomon's House had boasted such elaborate fountains, the experts from the engine-houses would have had to cooperate with those of the sound-houses, for it was in the engine-houses that the movements of living creatures were imitated. Caus had similar fountains in which artificial songbirds and even swans were made to drink from a cup as long as it was offered them, and of course his adaptation of Drebbel's Neptune fountain imitated the movements of living creatures, as the half-submerged chariot of the water-god was drawn about the central flume.

The engine-houses of Salomon's House were incredibly rich in

machines—this was the "Inginary" Bacon had envisaged so many years before. On Atlantis the scientists had perfected "swifter motions than any you have," such as Drebbel's torpedo, for instance, which was so ineffectually used in Buckingham's expedition to La Rochelle.[30] Even in the ideal commonwealth of the New Atlantis, Bacon could not forget England's specific needs; on that isolated and charmed island, the philosopher-inventors were busy with implements of war and "new mixtures and compositions of gunpowder" for a real island less isolated from unfriendly neighbors. King James had need of arms and ordnance, and for their sporadically warlike employer both Drebbel and Caus turned their hands to such inventions, as well as to "fireworks for pleasure and use." The machine for "going under water and brooking of seas" developed at Salomon's House was for use in war. The original of this ideal boat, one of the first successful submarines, was an invention Drebbel made for King James. In 1620 he demonstrated it in the Thames. Huygens, present among the crowds of courtiers and citizens by the river's edge that day, left a fine description of the event:

> Equal in value to all the inventions put together is the little ship in which he calmly dove down under the water and thus held the king, his court, and several thousand Londoners in excited expectation. For the most part the onlookers thought that he had had an accident in this work of art of his when he did not come up in three hours' time, as he had said he would, when at a great distance from the spot where he had submerged, he emerged again. He called upon the several persons who had undergone the experiment with him to bear witness that they had had no discomfort under the river, but that they had as they listed sunk to the bottom of the river and when they chose risen to whatever height they liked.[31]

According to Huygens, this boat had no funnel; the likelihood is that Drebbel knew the nature of oxygen and used it, in a form derived from saltpetre, to provide the underwater sailors with air. The idea of the submarine was, again, not original with Drebbel, any more than the idea of the camera, but his daring to risk the experiment upon his own body and his spectacular success with it brought

[30] "Fragment eener autobiographie," pp. 99-102.

[31] Ibid., pp. 117-18.

him peculiar renown as the "inventor" of the submarine. As one source tells us, Drebbel owed some of the success of his alehouse to his prowess as a submariner: "He had an invention of goeing under water which he used so advantageously that many persons were perswaded that he was some strange Monstar and that means drew many to drink his ale."[32]

From these practical machines, Bacon turned to the most difficult and captivating physical problem of his period. "We have," said the Atlantian guide, "divers curious clocks, and other like motions of return: and some perpetual motions." The relation between the motion of the heavens and the motion of clocks had long been obvious, for a clock was no more than a metaphor of the earth's relation to the sun. Caus developed a great many clocks, beautifully illustrated in *Les Raisons des Forces Mouvantes*. Another of his books, *Pratique et Demonstration des Horloges Solaires* (Paris, 1624), was written to provide his contemporaries with a modern treatment of the action of the sun's rays; in it he propounded many different kinds of sundials and clocks working in relation to the noonday sun. "Some perpetual motions"—this was the ticklish question, and more than one natural philosopher had attempted its solution until Kepler's law of motion was accepted by scientists and the ideal of perpetual motion dismissed as a practical impossibility. But until friction and attrition were more fully understood, perpetual motion remained the questing-beast of renaissance physics. The well-informed Peiresc wrote asking about the instrument Drebbel had made, "d'un globe de verre, dans lequel il fait representer le flux et reflux de la mer, par un mouvement perpétuel réglé comme le flux naturel de la mer. . . ."[33] There is a sketch of this hydraulically operated machine in Drebbel's book on the four elements, reproduced in Thomas Tymme's partial translation into English.[34] It was

[32]Rawlinson MS B. 158, fol. 175.

[33]*Camdeni Epistolae*, p. 387.

[34]Thomas Tymme, *A Dialogue Philosophicall, wherein Nature's Secret Closet is opened and the cause of all Motion in Nature shewed out of Matter and Form. Together with the wittie invention on an artificiall perpetuall motion (by Cornelis Drebbel)* (London, 1612).

a glass spiral in which the movement of its tides was indicated by the rise and fall of the liquid within it. Although, as Huygens recorded, the instrument was so cleverly constructed that it was impossible to see exactly how it worked even after it was broken, it is nonetheless clear that the instrument was a kind of barometer that responded to air pressure.[35]

The idea of a perpetual motion, a man-made image of God's creation, fired men's minds. Huygens' memorandum of Drebbel's perpetual motion was headed "Gloria in Excelsis Deo," a pious proclamation of the wonders of God's laws. Like Drebbel's perpetual motion, Bacon's instrument, his Salomon's House, his House of the Six Days Work, was another metaphor of the created universe, a compliment to the Lord's authorship of the Book of His Works, the book Salomon's scientists set themselves to study. However metaphorical the name of their foundation, however ideal their plan of universal knowledge, the scientists' work was practical. With so much of his own work left undone—even the *New Atlantis* closes with Rawley's sorrowful note, "The rest was not perfected"—Bacon knew how fragmentary was the work a man could accomplish in his lifetime, knew that his scientists needed far more than the psalmist's literal week for their mortal endeavor. In the perpetual co-operative effort to learn "all things possible" about God's creation, Bacon's inventors had to begin where they could be sure of their material, with the particulars of natural science; indeed, Bacon's "reasons for hope," so stirring to his generation, rose from his belief in those very particulars. From such contemporaries as Drebbel and Caus, like him conducting their business in the sovereign's service, he could perceive the remarkable results of dedicated occupation

[35]Kon. Akad., MS Huygens XLVII, foll. 134r-135v. Speculation on perpetual motion was plainly dangerous; Caus, though he discussed the problem at considerable length in *Les Raisons des Forces Mouvantes*, was careful to reject the idea itself as "blasphemous." Thomas Tymme, Drebbel's translator and disciple, believed that his master's perpetual motion contradicted Copernican and Keplerian astronomy. As Francis Johnson has shown in *Astronomical Thought in Renaissance England* (Baltimore, 1937) such judgment was unfair to Drebbel, as more "modern" partisans than he of the new science adhered to the ideal of a perpetual motion. (See P. P. Rubens, *Correspondance*, ed. Ch. Ruelens and Max Rooses [Anvers, 1887-1909], III, 218, 309, 324).

with particulars; from them the practical method of his academy took its form. To the great parable of Salomon's House the two inventors, the two projectors contributed; their creative imaginations moved Bacon to his visions of an unequaled utopian world, a utopian ideal to be put into practice, a purpose for the perpetual motion of the advancement of learning.