CORNELIS DREBBEL

(1572-1633)

PROEFSCHRIFT TER VERKRIJGING VAN DEN GRAAD VAN DOCTOR IN DE WIS- EN NATUUR-KUNDE AAN DE RIJKSUNIVERSITEIT TE LEIDEN, OP GEZAG VAN DEN RECTOR-MAGNIFICUS, Dr J.J. BLANKSMA, HOOGLEERAAR IN DE FACUL-TEIT DER WIS- EN NATUURKUNDE, VOOR DE FACULTEIT DER WIS- EN NATUURKUNDE TE VERDEDIGEN OP VRIJDAG 10 JUNI 1932, DES NAMIDDAGS TE 3 UUR, DOOR

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INTRODUCTION

Cornelis Jacobszoon Drebbel (1572 - 1633) was undoubtedly the best known of the numerous inventors we find in Europe at the beginning of the 17th century and his fame, which spread over the whole of the civilized world of that day, remained undimmed for many years after his death.

It seemed to us that it might be of interest, therefore, to publish a short account of the life and work of this remarkable man, a great part of whose life was spent in the service of English Kings *James I* (1603-1625) and *Charles I* (1625-1649) — and whose inventions were worked out later by others, especially after the foundation of the Royal Society of London.

Fig. 2 - From 'The Elements' (Ed. 1621).

CHAPTER I
CORNELIS DREBBEL : THE STORY OF HIS LIFE

§ 1 - Drebbel in Holland (1572-1605)

Cornelis Drebbel was born at Alkmaar in 1572 as the son of *Jacob*. The chronicler of the city of Alkmaar, *Cornelis van der Woude*, tells us in 1645 that *Drebbel* 'is descended from an honourable and well born family, who have occupied the ruler's chair.' [1]

De Peiresc (1580-1634), a French savant, to whom, as we shall see in chapter III, we are indebted for many details concerning *Drebbel*, informs us, that the *Drebbel*s were land-owners. [2] In all probability *Drebbel* was given only an elementary education. Both he and his sons-in-law tell us, that it was only in later life that he learned Latin. [3] Fairly early *Drebbel* became apprentice or assistant to a celebrated engraver of those days, *Hendrick Goltzius*, (1558-1617) and went to live at his house at Haarlem. Besides being a highly capable engraver, *Goltzius* was a man of all round culture, from whom *Drebbel* learned much. Further, G*oltzius* was passionately devoted to the study of alchemy. We read, that once when he had held his face too close to a glass vessel and this exploded, he almost lost an eye. [4]

In 1595 *Drebbel* married a younger sister of *Hendrick Goltzius*, '*Sophia Jansdochter*'. She was a little older than *Drebbel*. [5]

There is a fine portrait of her in 1597, — a drawing done by her brother *Hendrick*, the original of which is to be found in the 'Kupferstich-Kabinett' in Berlin.

After his marriage *Drebbel* settled at Alkmaar and in 1596 his first- born child was buried there. [6] According to *Cornelis van der* Woude, he lived at the corner of the 'Coningsweg, where Hoorn hangs out.' Several members of the Goltzius family settled in Alkmaar at this time. (See further Chapter II, p. 20).

At first *Drebbel* devoted himself to the engraving and publishing of pictures and maps, but a patent granted him in 1598 for a pump and a clock with 'a perpetual motion,' shows us, that he very soon began his career of inventor. [7] He made a name for himself as such in a very short time, for in 1601 we find his name mentioned in the accounts of the municipality of Middelburg, as having constructed a fountain outside the Noorderpoort (North-gate) and several other things, which are not itemised.[8] On the 16th of February 1602, *Drebbel* was again given a patent as a citizen of Alkmaar for a model of a chimney. [9]

In March, 1603, *Drebbel* bought a house in Haarlem, and a deed dated May 26 of the same year shows that he was then actually settled there. We read in a contract between *Jacob Goltzius*, brewer, (*Drebbel*' s brother-in-law) and *Willem Claeszoon Brammer*, brewer at Haarlem, that 'the honourable Cornelis Jacobs *Drebbel* , — living in Haarlem - also appeared to stand surety for this *Goltzius* for the sum of fl. 350.[10]

Drebbel did not live in Haarlem long, for the album, Amicorum of *Daniel van Vlierden* shows him again resident in Alkmaar in 1604.[11]

§ 2 - In England (1605-1610)

Shortly after this *Drebbel* left Holland and moved to London. He probably thought that at the court of *James I* (1566- 1625), who was much interested in all sorts of discoveries, new constructions and other remarkable things, he would be more likely to have the opportunity of setting up his apparatus on a larger scale and of devoting himself to his inventions without being further troubled by financial considerations.

An 'inventor' like *Drebbel* was just the right man to be at the English court, where on many a festal occasion he was able

to entertain the king and his suite in all sorts of ways. As he himself informs us, he was taken into the special service of *Henry*, Prince of Wales (1594-1612). This very amiable young man twice paid him £ 20, in 1609 and 1610. [1]

After the completion of the great perpetuum mobile, *Drebbel* occupied himself more particularly, in about 1608 and 1609, with the improvement of the magic lantern and the clavichord, which was made to play 'by the rays of the sun'[2]. Very soon his fame as an inventor began to spread through the whole of Europe. Rulers like the Duke of Wurtemburg came to see him at work at Eltham, where his instruments were set up while, the Emperor of Germany, *Rudolf* II (1552-1612) , invited him to the royal residence in Prague in 1607.[3]

§ 3 - In Bohemia (1610-1613)

It was some time before *Drebbel* was able to take advantage of this invitation, but on October 3rd, 1610, he received a free pass from *Rudolf*, permitting him to travel to Prague with his family. [1] On the 18th of that month we already find him in that city and on that date the ambassador of Tuscany, *Guglio de Medici*, wrote a letter to Galilei, in which he informs him, that a Fleming has come to Prague, who is able to construct a *perpetuum mobile*. [2] According to a petition, which *Drebbel* addressed to the English King, *James II*, a few years later, he had received permission from Prince *Henry* to make this journey to Prague only a short time previously:

`Some years ago, most exalted and mighty King, I left for Prague to make for your Majesty a work of art after that which your Majesty has seen. With your Majesty's approval and by the permission of the most exalted Prince *Henry*, of saintly memory, I vowed (laying it to heart very earnestly myself) that I would return within six months. But as his Imperial Majesty took unusually great pleasure in my inventions, one of which he had seen, I was not able to free myself again within so short a time and he has kept me with him till his death.' [3]

Here, too, *Drebbel* began by demonstrating his *perpetuum mobile* to *Rudolf* II, so that he might make a good impression with that, before displaying his other inventions. Although a man

of very different character, *Rudolf* shared with James I a very great interest in matters of this sort, devoting himself to them completely with his many ever-changing co-workers in his famous castle, Hradschin, near Prague and troubling himself as little as possible with affairs of state.

According to de Peiresc, *Drebbel* devoted himself chiefly at Prague to the contructing of the perpetual motion machine, to alchemy and to the making of gold alloys for the German mint. [4]

In February, 1611, Matthew, *Rudolf* ‘s brother, conquered a part of Prague, by which act this Matthew, who had some years previously received the crown of Austria-Hungary at the hands of the not very energetic Emperor, came into possession of Bohemia also. He even tried to divest *Rudolf* of the Imperial honours but bef ore he was able to achieve his end, *Rudolf* died. In 1612 his wish to wear the Imperial Crown was fulfilled.

Now it is possible that *Drebbel* was taken prisoner by *Matthew* in 1611 and in this connection, his future sons-in-law, the *Kuffler* brothers, told *de Peiresc* the following:

‘When the Archduke *Matthew* surprised Vienna (this should be Prague. Transl.) and took his brother prisoner, he threw into prison all who belonged to the council of the Emperor, amongst others, *Drebbel* . The latter's house was plundered, all his ovens and instruments were destroyed and the house was given back to Cardinal *Clesel*, to whom it really belonged. The above mentioned Archduke ordered all the privy Councillors to be put to death and erected the scaffold on which they were to be beheaded in the square in front of the palace of the Emperor. When the latter saw these preparations from his window and asked his guards what they were for and was told it was to kill *Drebbel* he was much troubled and when the Archduke came to see him and saw that he was so sad, he asked him whence this unusual attachment arose, and the Emperor answered, that it was because he was about to kill the greatest man in the world, who had invented that glass bulb (*perpetuum mobile*), which he showed him, and had designed the fountain below. The Archduke ordered *Drebbel* to be set free and granted an amnesty; and when this had been done, he profered apologies for the bad

treatment he had received because he was not known, but said that if he would be willing to render to him the service he had rendered to the Emperor and to complete, what he had begun, he would double the reward the Emperor had promised him. *Drebbel* answered that he very much appreciated his offer to take him into service but that he was in the service of the king of England, without whose order he could undertake nothing, and who had asked him, when he left him, to let him know whether he agreed to remain in his service. The Archduke *Matthew* then sent an express messenger to England; but meanwhile *Drebble* sent a request to the king, begging him not to give permission for him to stay longer, but to say that on the contrary, he was commanded to return, for he was too badly treated here to allow himself to be longer detained. When all this had been done by the king of England, this king promised the Archduke to send him back within one or two years to finish for him that which he had begun. This little trick caused the Archduke to send him back to England in a fine carriage with a gift of two thousand thalers.' [5]

Official records show that the above mentioned sum was in reality six hundred thalers.[6]

As we shall see later, we learn from other sources also that *Drebbel* was imprisoned in Prague. These tell us, however, that this was after the death of *Rudolf* II, which, taking the few authentic data into consideration, seems more likely.

As already stated Emperor *Rudolf* II, in whose service *Drebbel* had remained until his death, died soon after this event on the 20th of January, 1612. From the fact that *Drebbel*, together with an Englishman named *Rogerus Cock*, asked for a pass, it may be infered that he was now making an effort to leave Prague. [7] He did not however achieve this end but was prevented. As regards the cause of this opinions differ. *Drebbel* himself says in a letter to *James II* which we have already mentioned: 'Meanwhile the emperor's death had reached the ears of Prince *Henry* (whose memory can never be sufficiently lauded); therefore he insisted earnestly by letter that I should return to him. Consequently I begged the Emperor *Matthew* urgently to permit me to go to Great Britain. But he would not grant my request,

saying that he needed my help so much in other things and on no account would permit me to leave his court until, in due course, I should have received a command from Prince *Henry* of blessed memory. At last I received the letter and I showed the letter to His Imperial Majesty, who after reading it, gave me permission to return here, while favouring me by the gift of a plentiful sum of money with which to accomplish my journey.'

As already mentioned, *Drebbel* actually received three hundred crowns for the journey.

He continues: 'While this was happening I heard to my unspeakable sorrow and misfortune of the death of Prince *Henry*.' [8]

Prince *Henry* had died in November 1612, so that *Drebbel* had been bereft of two of his chief protectors within one year. As evinced by a petition to be allowed to hold a lottery presented by *Drebbel* to Prince *Henry* in 1612, in which these words occur 'has no other means of subsistance', *Drebbel*'s financial condition after the death of Emperor *Rudolf* was very precarious. [9] According to *Svatek* and *Gindley*, two Bohemian historians, *Drebbel* was mixed up in a case of embezzlement of money and jewels belonging to the Museum and Treasury of Prague. This crime was perpetrated by a gentleman in waiting named *Rucky*. Soon after the death of Rudolf II this *Rucky* was imprisoned and with him a number of others, among whom was *Cornelis Drebbel*. [10] *Rucky* commited suicide. *Svatek* and *Gindley* do not know what became of the others.

We know that *Drebbel* received three hundred crowns to pay for his journey; from which we may conclude that he was not guilty of any very serious misdemeanour. On the other hand it is clear from what *de Peiresc* tells us, that *Drebbel*, although perhaps undeservedly, was put into prison. The following story, told by *Cornelis van der Woude*, is probably wrongly dated, but it too indicates that something of the sort happened to *Drebbel* in Prague.

§ 4 - In England again (1613-1633)

Soon after *Drebbel* had received this money, after February

1613, he returned to England from Prague. After petitioning *James I* to allow him to enter the service of the King himself now that the Prince was dead, he must have displayed his masterpieces as an inventor at court again. [1] In the Municipal Finance Archives there is an entry on December 31, 1615, in which the Bohemian chamber is requested to find out whether all debts to *Drebbel* had been paid. [2] But from this it is not clear, whether *Drebbel* had already left Prague at this time or not. It is certain however, that at the time of another similar request dated September 18th, 1617, he was no longer there, for we know from a deed drawn up in Haarlem concerning the estate left by *Drebbel*'s brother-in-law, *Henrdick Goltzius*, that on July 3rd of that year he lived in London. [3]

According to the chronicler *van der Woude*, Drebbel was in Prague in 1619 when this city was taken by the Count Palatine, *Frederick*, who reigned one winter in Bohemia. This *Frederick* V (1596-1632) was married in 1612 to *Elizabeth*, a daughter of James *II* and a sister of Prince *Henry*.

In November, 1619, Drebbel was most certainly in London. This is shown by the fact that his signature appears in the album amicorum of *Joachim Morsius*, the editor of *Drebbel*'s `De Quinta Essentia' (see Chapter II p. 26 and Chapter III P. 33) , [4] and is further proved by a letter from *Willem Boreel* to *Pierre Borel*, in which the writer states that *Drebbel* showed him a microscope in London in 1619.[5]

Drebbel was probably also in London in 1620. In a note appended by *Gerbier* in 1620 to his Elegy on the death of *Hendrick Goltzius*, *Drebbel* is called 'naturalist, servant of His Royal Majesty of Great Britain.'[6] He was however also on the Continent in 1620. Both the above mentioned letter from *Boreel* and the statement by *Joh. Sachariassen* (the son of the well known lens grinder *Sachariassen Janssen* of Middelburg) indicate that in that year he visited Middelburg, probably for the purpose of renewing his old connections with the glass factory of that town — connections dating from 1600.[7] From *de Peiresc* we learn that *Drebbel* never intended to return to Prague; nor does the Belgian historian *Sweer-*

tius make any mention of a second journey thither, [8] from all of which we may conclude, that *Drebbel* ‘s second sojourn in Prague in 1620 is of uncertain authenticity. Further historical research on this point will have to be made.

In England *Drebbel* devoted himself especially to the construction of a submarine, while, as is obvious from his journey to Middelburg in 1620, he was also interested in optical instruments. About this time the *Kuffler*s, two brothers, became closely associated with him. Further details concerning them will be given in chapter II and we shall content ourselves here with the mention of only one or two points.

About 1620 *Abraham* and *Jacob Kuffler*, sons of a Dutchman, who had taken up his residence in Cologne, came to England in the hope of gaining the favour of James I by presenting him with a book. They were not successful, however, whereupon they went to Drebbel for help. Very soon *Abraham* married *Drebbel*’s daughter, *Anna*, and both brothers became closely associated with the inventor as his assistants and as promotors of his new inventions. Presently *Jacob* was sent to France and Italy to find a market for microscopes and lenses, but he died of plague at Rome as early as 1622.

Abraham, who was still in England, then sent for his two other brothers, *Dr Johannes Sibertus*, who had studied at Padua, and *Aegidus* or *Gillus* to come to England too. *Johannes Sibertus* married *Drebbel*’s second daughter, *Catherina*, in 1627. It was he who after *Drebbel*’s death did most to make his inventions known.

§ 5 - In the Service of the British Navy (1626-1629)

When *James II* died in 1625, we read, that in the funeral ceremony ‘Drebbel, the Engineer', walked with 'Baston le Peer, the Dauncer' and under-officers of the Mynte. [1]

After successfully demonstrating his submarine on the Thames, Drebbel found his services gradually more and more requisitioned for the English navy, it being clear to the authorities how useful his invention would be in time of war. Also his skill in the contructing of 'watermines' and 'waterpetards' made him valuable to the Admiralty.

In the orders issued for *Buckingham's* expeditions we find orders given to him mentioned under the dates January 26 and June 16, 1626. (See Chap. VII, p. 72). On July 4th of the same year a workshop and dwelling house were assigned to him by the king in the Minories (or Minorites):

`Sends a warrant for lodgings and workshops to be provided in the Minorites for *Cornelis Drebbel* and *Arnold Rotispen*, who are to apply their skill for his Majesty's service.' [2]

There in the Minories, between Aldgate and the Tower, just outside the walls of London, *Drebbel* dwelt for the whole term of his service in the British navy; assisted by his son-in- law, *Abraham Kuffler*, he made the special equipment for *Buckingham's* ill-managed attempts on the Isle of Rhé and especially for the relief of La Rochelle.

La Rochelle, which was in the hands of the Huguenots, was besieged by the French troops during the summer of 1627. The English, under command of *Buckingham*, made three attempts — in October 1627 and in May and September 1628 — to relieve the town but all three were fruitless and in October 1628 La Rochelle was taken by the French troops, whereby it was again delivered into the hands of Louis XIII (1610-16-43).

On June 6th, 1627, *Drebbel* and *Rotispen* were again paid £ 100 'for forging the diver and water engines.' [3]

Abraham Kuffler accompanied the second expedition, of which fact mention is made in the Calendar of State Papers on June 13, 1628.

`Petition of *Abraham Kuffler* to the high and mighty Prince, *George*, Duke of Buckingham. Being shortly to go again to La Rochelle and having in the former expedition a valu- able cargo of wheat, which is now spoiled and cast overboard, prays for £ 100 to supply the present needs of himself and his family.' [4]

Despite all the ill-successes of the first two expeditions, *Drebbel* contrived to keep himself in favour with the Admiralty, for on July 13, 1628, we read:

`For preparation of the extraordinary fire-ships, according to directions of the Lord Admiral, with allowance of pay to the officers of the same fire-ship and engines; among whom are

Abraham Kuffler, 20 shillings per diem, and *Cornelis Drebbel* 150 £ per month.' [5] Very high pay indeed, especially when we consider the value of money at that date, but then the working of such fire-ships was a dangerous and precarious occupation. [6]

This last expedition to La Rochelle was a failure like the two previous ones. Available data, which we shall record more fully in Chap. VII, show that it was not a success from *Drebbel*'s point of view either. According to *Constantijn Huygens* this was due to the fact that the British Navy showed less courage than usual on this occasion (see Chap. VII p. 72). Certain it is, that after this expedition a great discussion arose, the outcome of which was naturally not favourable to *Drebbel*, a Dutchman, and he was dismissed from the service of the British Navy. We hear of this in a petition presented on March 13th, 1630: 'Petitioners were employed in the last expedition to La Rochelle, but have never been able to obtain debentures out of the office of Ordnance. Pray for orders to the officers of Ordnance, that petitioners may have such debentures.' [7] This request produced no result. On March 19th the report of the officers of the Ordnance was presented to the Admiralty: 'The officers explain the nature of the employment of the petitioners under the authority of a letter from the Council, of which a copy is enclosed, and state what payment had been made to them. On the return of the expedition to La Rochelle, the captains of the leading ships and fire-ships were questioned by the Council of War, and order made by them to forbear making out debentures for the remainders of the allowances."[8]

§ 6 - Last years (1629-1633)

After this difference of opinion between himself and the Admiralty concerning the value of his inventions, *Drebbel was* obliged to devote himself to other work in order to obtain a living. From the Rawlinson Manuscript we learn that he became a brewer and innkeeper.

`He was very poore, and in his later time kept an Ale-house below the [London] bridge. He had an invention of going under water which he used so advantageously, that many persons were

perswaded that he was some strange Monstar, and that means drew many to see him and drink of his ale.' [1]

A part of the collection `for the understanding of brewing, baking, making of cider and meade, ordering and preserving all sorts of wines, cooking,' preserved in the Cambridge MS. (see Chap. III, p. 35) probably dates from this time.

Drebbel perhaps acquired a part of his knowledge of these matters from his brother-in-law, the brewer, *Jacob Goltzius*, during the time that he still lived in Holland.

In 1630 we find *Drebbel* taking part in planning an extensive drainage scheme, which was carried out under the direction of *Sir Cornelis Vermuyden*.[2] That *Drebbel* was conversant with hydraulics is shown by the patent he applied for on pumps as early as 1598, and his knowledge is further commended by *Constantyn Huygens* and later by *Cornelis van der Woude*. (See Chap. IV, p. 46). The Harleian MS. proves that *Drebbel* had already leased in 1623 'certeyn parcells of land and Marsh ground in the Mannors or Bromley and Poplar', probably in order to drain them; perhaps it was on or near these "parcells" of land that later a dye-works was erected by his sons-in-law. [3] On January 11th, 1630, we read: 'Propositions of Sir *Anthony Thomas* and *John Worsopp* for making the bargain with the country, and *Henry Briggs*, professor of mathematics at Oxford, *Hildebrand Prazen*, citizen and salter of London, and *Cornelius Dribble*, engineer, with the rest of the undertakers for draining the level within cos. Norfolk, Suffolk, Cambridge, Isle of Ely, Huntingdon, Northampton and Lincoln, on the south side of Gleane. These are renewed and altered propositions. The previous course of the negotiation is here set forth and explanation given of opposition raised against Sir *Anthony Thomas* by Sir *Thomas Crooke* and *William Burrel*.' [4]

It seams from this, that the original plans had been made some time earlier. A few years later *Drebbel* died in the parish of Trinity, Minories, in 1633. His will has been preserved to its: `Being of good health of hodie and of perfect minde and me uttered and spoke: I do give and bequeathe the whole of my estate to be equally devided between my four children, *John*

Dreble, Jacob Dreble, Catherine Kiffler and Anne Kiffler. Witnesses: *Henry Penson, Abraham Kiffler*.' Then follows: 'November 7th, 1633, commission issued to *John and James Dreble*, sons of the deceased, to administer the goods, etc. of the said deceased, no executor.'

CHAPTER II

DREBBEL's PERSONAL CHARACTERISTICS, FAMILY AND FRIENDS

§ 1 - Some remarks on the history of science

In *Drebbel*'s day scientific research was beginning gradually to free itself more and more from the ban under which it had suffered during the middle ages.

Such men as *Roger Bacon* (1210-1293) were already rejecting the teachings of *Aristotle* (384-322 B.C.) as these were set forth during the middle ages, but this attitude found but few sympathisers at first. It was only at the beginning of the 16th century that it found support in the work of *Leonardo da Vinci* (1452-1519), *Copernicus* (1473-1543) and many others.

It was especially the observations of *Tycho Brahe* (1546- 1601), although the latter was himself a follower of *Aristotle*, and those of his successor, *Joh. Kepler*, (1571-1630) at Prague that, with the help of *Galilei* (1564--1642), were largely instrumental in showing in connection with astronomy, that the teachings of *Aristotle* were not universally applicable.

Drebbel also shows himself an adherent of the Copernican system, as is clear from a letter from *G. P. Schagen*.[1]

Alchemy, which during the middle ages had spread all over Europe, naturally attached great value to experiment and observation, but all sorts of conceptions and ideas — chemical dogmas, as it were, based on no reasonable grounds — had so strong a hold on men's minds, that it was not until long after *Drebbel*'s

time that a right insight was gained into the constitution of matter.

The times in which *Drebbel* lived were very troubled.

Although it was almost a century since the Reformation began, a fierce struggle was raging throughout the whole of Europe, one of the chief causes of which was to be found in religious differences. Sometimes the religious question gave rise to political intrigue and machinations of various kinds, without immediately producing open strife. The efforts of rulers to obtain absolute power became part of the same struggle, and in England especially this brought about serious conflicts between the king and parliament. The king tried to extend his power and the aim of the representatives of the people was to restrict the financial excesses of their monarch.

On account of all this, the great courts of *James I* in London and of *Rudolf* II in Prague, at both of which *Drebbel* sojourned as inventor, were very unsettled and furthermore, finances were generally in a sad condition, because the splendid entertainments that followed each other in rapid succession, soon impoverished the exchequer.

Now *Drebbel*, who like all inventors and artists of his day was largely dependent on the favour of kings, was obliged to do all in his power to maintain his position at court. He had many rivals, who sought to gain the royal favour. In order to obtain this himself and insure its continuance, he was forced to wrap his inventions and demonstrations in secrecy and say very little about the theories, whereby he explained his discoveries.

`He had to be showman as well as scientist, or his noble patrons would have lost all interest in his ingenious machines, and mysterie is half of the showman's game.' [2] And yet *Drebbel* was often in difficult financial circumstances, especially after his return from Prague in 1613 and after the expedition to La Rochelle in 1628, when he was obliged to exert himself to the utmost, to provide himself and his family with the necessities of life. (See Chap. I, p. 8 and p. 12).

§ 2 - Drebbel's outward appearance and character

All *Drebbel*'s contemporaries without, exception agree in giving a favourable report as to his personal appearance. The secre-

tary of the Duke of Wurtemburg, *Wurmsser von Vendenheym* writes in 1609: 'His Royal Highness went to the park in Eltham to see the *perpetuum mobile*. The inventor's name is *Cornelis Drebbel*, who was born in Alkmaar, a very light- haired and handsome man, and of very gentle manners all together different from such-like characters.' [1]

Constantyn Huygens, who, as we shall see later, met *Drebbel* repeatedly in London in 1621, informs us that he looked like a Dutch farmer.[2]

De Peresc gives us most of the details we possess. According to his own statement he received them from the *Kuffler* brothers (about 1627).

`He is a man of good understanding, sharp-witted and full of ideas about great inventions.

Returning to the life of the said *Cornelis Drebbel*, *Kuffler* narrated that as his years increased his inventions also increased. The latter welled up spontaneously out of his consciousness without benefit from the reading of books, which he always depised, being firmly convinced that the truth and perfection of the sciences lay in the secrets of Nature, in which they are all concealed and it is recalled that he had reached a considerable age before he could understand Latin or speak it, and that he had taught it himself without anybody to teach him. He lives like a philosopher and is interested only in his observations; he despises all the things of this world and also its great men and he will rather greet a poor man than one of worldly position.

Drebbel behaves like a simple and ignorant person. When he is asked whether he can make this, that or the other thing, he says he cannot. He only shows his real self to persons he considers intelligent or to those who desire to become so. For three or four years he has been smoking tobacco, a thing which he used to hate. He has become so much the slave of this habit, that he spends whole days and nights smoking and declares, that they who do not smoke have no sense. When he meets any one who is a hard smoker he respects and likes him very much and in such a case he is able to explain his secrets, whereas otherwise he is very uncomfortable.' [3]

The habit of smoking was introduced into England by Sir *Walter Raleigh.*

The celebrated painter *Peter Paul Rubens* (1577-1640) met *Drebbel* in 1629 in London after the latter's dismissal from the British Marine Service.

`I have only met the very famous philosopher *Drebbel* in the street and I have only exchanged two or three words with him casually. He lives in the country in a place that is rather far from London [perhaps Bromley or Stratford-Bow]; I never remember having seen a man of more extraordinary personal appearance than he. There is something in that badly dressed man and in his coarse clothes that fills one with surprise and that would make any other man ridiculous.' [4]

These data together with what was said inthe previous paragraph enable us to form a fairly definite picture of his personal character and appearance.

The portraits we have of him also reveal his appearance (see fig. 1 and 3). The first from is a woodcut by *C h r.van Sichem.* [5]

§ 3 - Drebbel's religion

To any one reading the quotations included in the previous paragraph with care it is clear, that *Drebbel* must have been an anabaptist. There is another passage in the work of *de Peiresc* which can but strengthen this impression:

`He lives according to the laws of Nature and believes in nothing. He would not consider himself insulted by the action or word of another in connection with anything that might be done to him. If any one abuses him, he answers not a word, unless they are right and are decent folk, and he does not excite himself in the very least. He carries no sword, neither in the country nor in town and he would not defend himself, were he attacked, although he is powerful and strongly built.' [1]

Were not the anabaptists required, amongst other things, to disregard human authority, to refrain from carrying a sword, to observe the principle of defencelessness (condemnation of all violence), of simplicity of appearance and dress?

That *Drebbel* was an atheist, as *de Peiresc* declares, is untrue. All *Drebbel*'s work shows plainly, that he was a be-

lieving Christian. What *de Peiresc* means is that he did not believe in the holy sacraments of the Roman Catholic Church, of which church *de Peiresc* was himself a member. In the introduction to *Drebbel*'s little book 'On the Nature of the Elements' we find: `What shall we do in gratitude? Shall we offer myrrhe and incense, or have ourselves circumcised, or shave off our beards and hair? Shall we take a higher chair and preach in white or black garments? Or shall we, who are ignorant without God, root out the ignorant with the sword? Or shall we shout praises unto God? Or write large books and make a great name? Ah, Brothers, is not all this vanity?' [2]

In his Dedication of the *Perpetuum Mobile* to *James I*, he also writes about war.

`Pondering how most kings allow themselves to be misled by blind desire, seeking by bloody war to extend their kingdoms, unmindful of the fact that it is impossible to do this without greater loss and the miserable ruin of their true subjects, who are forced to risk their lives, their possessions and their blood.' [3]

In this passage also the simplicity and the rejection of violence characteristic of the anabaptists find expression. *Hugo de Groot*, the famous Dutch jurist, writes in a letter to his brother, *Willem*, in 1622, when speaking of the inventors of the telescope: 'They say that there were two at the same time, both originally from Alkmaar and both anabaptists, if I don't fail.' [4]

And the next letter makes it clear that it was really Drebbel and *Jacob Metius* whom he meant.

It becomes still more reasonable to conclude that Drebbel was an anabaptist, when we study him amid his friends in Alkmaar. These were also almost all anabaptists, as we shall see.

§ 4 - Ancestry, wife and children

As already mentioned at the beginning of the first chapter, we know little about *Drebbel´*s ancestry.

From the archives in Alkmaar we learn only the following: His grandfather was called *Jan Pieterszoon Dremmel* and died in 1546, his father *Jacob Janszoon Dremmel* was

deceased in 1591; both lived in Alkmaar. This *Jacob* had another son, *Pieter Jacobszoon* (d. 1601) besides *Cornelis*.

About *Drebbel*'s wife *Sophia Jans Goltzius* and her relatives we are better informed.

She may also have belonged to the anabaptist community. Her brother, the engraver and painter, *Hendrick Goltzius*, who lived in Haarlem, was a protestant. The following details may be given regarding the *Goltzius* family, several members of which settled in Alkmaar. Besides her brother *Hendrick*, *Sophia* had another brother, *Jacob* (1574-1631) and a sister, *Catherina*. Round about 1600 *Jacob Goltzius* was living in Haarlem; in 1603 he settled at Alkmaar, where he established himself as a brewer, as we saw in Chapter l (p. 4), and there it was that *Drebbel* stood surety for him. On December 1st he obtained the rights of citizenship in that town. He was also a painter on glass. One of his children, *Cornelis Jacob* (probably named after *Drebbel*) was married in 1647, and again as a widower in 1656, by the burgomaster — a fact which points to his being a dissenter, i. e. not a Calvinist. His sister *Catherine*, too, lived in Alkmaar, where she was married to a tailor *Michiel Hendriks*. An uncle of these *Goltzius'*, a brother of their father *Jan*, and also named *Jacob*, was given the freedom of the city of Alkmaar in 1599, as was also a *certain Johan Goltzius* (originally from Kayserweert, like the rest of the family) in 1591. Of the four children of *Jan Goltzius* (married to *Anna Fullings* in Bracht, near Venlo) — *Jacob, Hendrick, Catherine and Sophia* — the youngest, *Sophia*, became *Drebbel*'s wife. [1]

Sophia Goltzius died in London before *Drebbel* himself. Her name does not appear in her husband's will of 1633, although in a deed concerning the estate of her brother *Hendrick*, who died in 1617, she is mentioned as his last heiress.[2] She was still living when *de Peiresc* wrote his essay on *Drebbel* in about 1627. From her union with Drebbel two sons and two daughters were born, besides several other children who died in infancy.

The eldest daughter, *Anna* (named after her grandmother *Anna Fullings*), married *Abraham Kuffler* in 1623 and

died at Utrecht in 1651. *Catherina* — so named after her aunt *Catherine Goltzius* — married *Dr Johannes Silbertus Kuffler* and was still living at the end of the 17th century, as is clear from her repeated visits to *Constantyn Huygens*, junior, in London during the years 1689-1694.[3]

We hear very little about the two sons, named *Jan* and *Jacob* after their two grandfathers, *Jan Goltzius* and *Jacob Drebbel*. In 1662 *Jacob*, assisted by his brother-in-law, *Dr Johannes Silbertus Kuffler*, tried to sell the English government an invention of *Drebbel* 's for sinking ships from a distance. [4]

§ 5 - Drebbel's friends in Alkmaar

At the beginning of the 17th century Alkmaar was the most important town in the northern part of North Holland. At that time there were among its citizens many men, who had made a great name for themselves by their remarkable knowledge of science, theoretical and applied, especially in connection with hydraulics and navigation.

Most of these were, like *Drebbel*, anabaptists. This was the reason, in part, why their interests were not limited by dogmatic considerations, as was the case with the strict Calvinists, but could develop freely along the lines of art, science or applied science. Undoubtedly *Drebbel* associated with many of them in his youth and during the first years of his marriage, when he lived at Alkmaar. We will mention the names of a few of them. From the Alkmaar chronicler we learn:

`In his youth (while living in Alkmaar) *Drebbel* was on an intimate and brotherly footing with the sharp-witted *Gerrit Pieterszoon Schagen* and when he made a journey to England (before he went to Germany), he would have liked to have taken this said *Schagen* with him (as being of the same age and position), but as *Schagen* was not inclined to travel, he undertook his journey alone.'

The words on a brotherly footing are again an indication that both *Drebbel* and *Schagen* were anabaptists.

This *Gerrit Pieterzoon Schagen* (1573-1616) is later described by *van der Woude* as a universal genius. His know-

ledge of languages, particularly, was very great. His writings were, alas, all burned at Edam.

A letter in his handwriting, dated December, 1607, once more brings out very clearly his baptist views. This letter, in which he commends *Drebbel* and his *Perpetuum mobile* with expressions of great praise, was addressed to *Adriaen Anthoniszoon*

Adriaen Anthoniszoon (1527-1607) was greatly interested in the mathematical sciences, he was burgomaster of Alkmaar fora considerable time and it is to him that we owe the ratio of the circumference of a circle to its radius, the number π. His sons, usually called the brothers *Metius*, must also have known *Drebbel*. The elder, *Adriaen Metius* (1571—1635) first studied at the Universities of Franeker and Leyden and later devoted himself, together with his friend, the well known cartographer, *Willem Jansz. Blaeu*, more especially to the study of astronomy, under the famous *Tycho Brahe* (1546--1601). In 1597 he was appointed professor at Franeker where he excelled not only in astronomy but also in arithmetic and surveying; he made a map of Friesland by trigonometry; furthermore he was a doctor of medicine and a passionate alchemist.

His brother *Jacob* (1591-1628), of a very reserved and shy nature, was a self-taught man. He devoted himself to the grinding of lenses and burning-mirrors at Alkmaar. By many he is regarded as one of the discoverers of the telescope. While living in London *Drebbel* evinced some interest in this son of the Burgomaster of Alkmaar, *Jacob Metius*, who like *Drebbel* was an anabaptist.3

When *Jacob Metius* was given 100 pounds by the States General on the occasion of his trying to obtain a patent for his telescope and thereby became known as an inventor, *Drebbel* inquired with much interest of his Alkmaar friend, *Ysbrandt van Rietwijck*, as to the nature of this invention.

A few further particulars regarding this invention may be of interest and are given here. It was but natural that *Adriaen Metius* at Franeker should survey the heavens with his brother *Jacob*'s telescope and by its means he was able to observe the following phenomena.

In the first place the sunspots, especially in the morning and in the evening, and it seemed to him that these spots came up on the eastern border and after ten days disappeared over the western edge of the sun; secondly, the mountains on the moon, thirdly the phases of Venus, fourthly the moons of Jupiter and, finally, the milky way, which resolved itself into a great host of stars, all of which goes to prove that *Metius'* telescope must have been very good for those days. [4]

As is clearly shown by what follows, all the above had already been achieved by the *Metius* brothers by 1608, that is before *Galilei* published his observations concerning the moons of Jupiter in the *Nuncios Siderius* (Star-messenger) in March, 1610. In May, 1610, *Gloriosi*, the successor of *Galilei*, wrote to *Terrenzio* at Rome:

`Gallileo's *Nuntius*, regarding which you ask my opinion sets forth a number of things which are not new and of which the real inventor is not accorded recognition. I think it is not unknown to you, that the inventor of the telescope was a certain Dutchman and it is already two years ago that rumours of this telescope came to the ears of all.'

'I think it more fitting, however, that our admiration and surprise should be confined to the four planets circling round the star Jupiter, each with his own motion; it is said that two of these were discovered by certain others by the helpful action of the telescope.'

`The very illustrious *Fuggerus* informed me that he had heard, that the Dutch, among whom the discovery of the telescope had been made, had also observed them. The suggestion coming to him by chance from these people, *Gallileo*, in order to increase his fame and his fortune thereby, desired, since he could not be the first to observe them, to be regarded as the first to have described them.' [5]

From all this it is clear, that Jupiter's moons were discovered by *Adriaen Metius* by the aid of his brother's telescope as early as 1608, but that public attention was directed to them only by the publication of Galilei's *Nuncius Siderius* in 1610. If we ask ourselves why the *Metius* brothers did not immediately give publicity to the observations made with their

telescope, the answer is probably to be found in the fact, that their observations did not tally with the teaching of *Aristotle*. Just about that time, in 1609, *Professor van Veen* was asked by the rigidly Calvinistic University of Franeker to resign his chair, because he and his pupils, *Stellingwerf* and his bosom friend *David van Goorle*, had openly opposed the Aristotelian teachings, and *Adriaen Metius'* salary had been reduced by 50 guilders a year, because *he* had also taken part in the struggle. It seems quite likely, therefore, that it was these incidents which withheld Metius from publishing his observations, which after all were contrary to Aristotle's teaching. It is a well recognised fact that *Galilei'*s publications in 1610 produced tragic results at his trial in 1636. [6]

Frederik de Houtman (about 1540-1627) was a pupil of *Adriaen Metius* in astronomy, and he and his brother *Cornelis* were among the first Dutchmen to visit the East Indies in 1596. During his imprisonment at Atjeh in 1602 he made astronomical observations of the southern hemisphere, which he was the first to describe. On his return to Holland, he published the results of his study while in the same volume he included the first Malayan Dictionary. [6]

De Houtman was a connection of *Drebbel's*; he married *Vrouwtje Cornelis*, the daughter of *Cornelis Nanninghsz*, a lumber merchant, and *Griet Mathysdaughter* and at the death of his mother-in-law in 1597, when her estate was to be divided, he represented his wife and when the agreement was signed in the 'Jongen Schutter', *Cornelis Drebbel* appeared as guardian and nearest blood-relation of the two other children, together with their uncle, *Clae s Nannighsz*. [7]

When *Willem Ysbrandtsz Bontekoe* in 1619 meets *de Houtman* in the Straits of Sunda, he tells us, that the latter was in possession of a telescope for nautical observations. Bearing in mind *de Houtman'*s relation to *Drebbel* and *Metius*, we cannot wonder that he was the first Dutch seaman to use such an instrument.

Drebbel's celebrated contemporary, *Jan Adriaenszoon Leeghwater* (1575-1650), was also an anabaptist. He was a millwright and engineer of de Rijp, a village near Alkmaar.

It Is thanks to his genius that North Holland, which at the time — about 1575 — was half water, was almost entirely reclaimed. Even outside his own country he was known as an expert on this subject and in 1628 he was sent to Bordeaux. The result was that, three famous men went to La Rochelle during that year: *Drebbel* had come by sea with the British fleet, *Rene Descartes*, who became the celebrated *Cartesius*, was there with the French army, while *Leeghwater* was paying a visit to the owner of the marshes round Bordeaux, which he was reclaiming, that gentleman also being in the army besieging La Rochelle. It is doubtful whether *Descartes* met *Leeghwater* at La Rochelle, but it is true that *Descartes* studied mathematics and astronomy at Franeker during the next year, 1629, as a pupil of *Adriaen Metius*.

In 1629 *Leeghwater's* works on hydraulics were a real assistance in the taking of den Bosch, which was besieged by *Frederik Hendrik*, Stadtholder of Holland. Furthermore, he also reclaimed marshlands near Metz and in North-Western Germany (Holstein) .

There were other fields besides hydraulics in which *Leeghwater* had made a name for himself. He was known as a good watchmaker and as an architect. It was he who introduced oil- mills into Holland while in 1605 he obtained a patent for a method of remaining under water. [8] (See Chapter VI, p. 64). One of his partners in this project was *Pieter Pieterszoon* (1574-1651), a man born in Alkmaar and later on a pastor in the anabaptist community at de Rijp and Oostzaan; he was also an engineer.

So we see that *Drebbel* was not a unique phenomenon but only one of a circle of gifted men (most of them anabaptists), each of whom contributed in his own field to the development of theoretical or applied science.

§ 6 - Friends in London

In England *Drebbel* came in touch with men of all sorts. Among the scientists with whom he was acquainted we might mention Lord *Thomas Chaloner* (1561-1615), tutor to Prince *Henry* and a man who was active in the field of chemistry; the famous *Francis Bacon* (1561-1626) and the mathematician

Henry Briggs (1556--1630) (see Chap. 1, p. 13). Then there were medical men, who were busily making alchemical experiments, such as *Robert Fludd* (1574-1637), *Raphael Thorius*, *Joachim Morsius* (1593--1642), the translator and editor of *Drebbel's* works, and others. Both *Thorius* and *Morsius* had a doctor's degree from the University of Leyden. *Morsius*, a German, returned to his native land after visiting London in 1619.

Salomon de Caus, too, must have known *Drebbel*. He was a Belgian by birth, who, like Drebbel, had entered the service of *Henry*, Prince of Wales, as an inventor. All these (being of the same age as *Drebbe1*) lived in the same world, in the same period, at a time when research in the natural sciences, although still mixed with much medieval mysticism and mystery, was gradually beginning to steer its own course. All these men, *Drebbel* included, exercised a strong influence upon each other.

Drebbel met many statesmen in London, and we learn that *Willem Boree1*, one of the Dutch ambassadors in London, was acquainted with him (see Chap. V p. 54). [1] *Balthasar Gerbier d'Ouvilly* (1592-1667), statesman, painter and adventurer, also met *Drebbel* in London, when a young man. *Gerbier*, a native of Antwerp, of ter having been in the service of Prince *Maurits of Orange* in 1614, came in touch some years later with *George Villiers*. Duke of Buckingham, through the kind offices of *Noel de Caron*, the Dutch ambassador in London. [2] As the person responsible for the arrangement of the Duke's entertainments he must certainly have worked together with *Drebbe1*. In 1620 there was published in the Hague an elegy written by *Gerbier* in 1618 on the death of the engraver, *Hendrick Goltzius*, *Drebbel's* brother-in-law. [3] *Gerbier* did not at first succeed in finding a publisher for this little work and perhaps it was through *Constantyn Huygens*, who knew *Caron* very well, that he at last came in contact with the publisher *Aert van Meurs*, for *Huygens'* poems were also published by him. In this elegy of *Gerbier*'s *Drebbel* receives very high praise, which would seem to indicate an intimate relation between *Gerbier*, *Goltzius* and *Drebbel*.

The friendship between *Cornelis Drebbel* and *Constantyn Huygens* (1596-1687), poet and statesman, is of greater importance to us, however. This *Huygens*, who later became the father of the famous physicist, *Christiaan* (1629-1695), visited London in 1621 as a young secretary at the legation. During his first stay there, from January 23rd to April 30th, he met *Drebbel* only casually.

`I saw Drebbel also for a short time. In appearance he is a Dutch farmer, but his learned talk is reminiscent of the sages of Samos and Sicily. I wished to profit by your company for a longer time, great grey-beard, but the brevity of the time stood in my way, and against my will you are postponed for a another year.' [4]

When he returned to England on the 5th of December that same year, he saw a great deal of *Drebbel*.

`We possessed *Drebbel* for a whole year, and he possessed me too, his possessor, and a not unfavourable one, unless I mistake me; this he proved to me during many lessons, being more affectionate to me than to any of his friends.'[5]

Huygens' parents were a little troubled by their son's close association with that 'magician'. He wrote them the following by way of calming their anxiety:

`I laugh to scorn that which you were pleased to write me in your last letter warning me against *Drebbel's* magic and your muttered accusation of him as being a sorcerer, whereas there is nothing to be found in his way of life which would cause me difficulty, were I to try to disentangle myself from my association with him. Old *de Gheyn* (a painter) will be pleased to know that I will bring with me the instrument, by means of which he shows the fine brown paintings, which is truly a masterpiece of the magician's art.' [6] This last refers to a camera obscura also mentioned in other letters. *Huygens* bought a telescope from *Drebbel* for forty guilders (see Chap. V, p. 49).7 In an autobiography by *Constantyn Huygens*, written about 1631 and dealing chiefly with his youth, we find an important passage about *Drebbel* and his discoveries, a passage which we shall quote repeatedly in the following chapters. 8 This passage begins as follows, *Huygens* having compared *Drebbel* to Fran-

cis Bacon a few pages back: 'On the subject of *Drebbel*, whom I have spoken of in the same breath with *Bacon*, I will be more brief. When this moon was named with the sun, I paid special attention to physics, in connection with which this Dutchman from the North, an inhabitant of Alkmaar, has proved very valuable, to which fact I can testify as an eye-wittess, since I know him thoroughly, because of my intimate contact with him, and I am well known to him too. Some have laughed at King James, saying that this everlasting inventor has never achieved anything the cost of which has been covered by its usefulness, but even if this were to be granted (but it cannot be granted, however, without doing the man injustice), it is obvious, that by the aid of penetrating knowledge he has contributed remarkable mechanical instruments, which some people have despised, but most have more admired than understood.'

§ 7 - The Kuff lers, his sons-in-law

In England *Drebbel* met the *Kuffler* brothers. As they played such an important part in the working out and making known of *Drebbel's* inventions, we give here a short sketch of their life history. [1]

Abraham and his brother *Jacob Kuffler* came to England about 1620. They were the sons of *Jacob Kuffler* and *Margaretha van Redinghoven*, who had moved from Holland to Cologne for religious reasons. *De Peiresc* gives us the following reasons for their going to England: `He, *Abraham*, went to England with his brother, whom you knew and who died at Rome. He realised that they were four brothers and had only very slender means of subsistance, and having studied philosophy and medicine well, he made a book, which he took to England, thinking that the King, who was a cultured man, when he should see that remarkable book, would consent to its being printed under his signature. With this expectation, they collected what they could of their possessions, so as to be able to equip themselves in such a manner that they would be well received and rewarded. But when they came to England, they found that the King did not trouble himself in the least about the book. But as they had heard *Drebbel* spoken

of, they went to see him. After the youngest, who was well educated, had talked with him and had realised that they could learn much from him, if they could gain his favour, they decided both to try to win the hand of his daughter, and that he whom she should love most, should marry her. For they believed that by means of this marriage-tie they would get to know his secrets. The plan succeeded; the girl preferred the one who was not learned (this was *Abraham*), because he was handsomer in appearance; he proposed to her and married her, he and his brother helping *Drebbel* with all possible zeal and energy so that he might be in duty bound to give them instruction.'[2]

Then, in 1622 *Jacob* was sent to the Continent to carry out propaganda for *Drebbel's* microscope, but he very soon died of' plague at Rome in November of that year (see chap. V, p. 57).

His brother *Abraham*, who had remained in England and who had married *Anne Drebbel* in 1623, sent for his two remaining brothers, *Johannes Sibertus* (1591-1677) and *Gilles* or *Aegidus* (1596-1658), to come to England. *Johannes Sibertus* had studied at Padua, where lie obtained the degree of Doctor of Medicine in 1618. After some time (in 1627), he married *Catherina*, *Drebbel's* second daughter. *Gilles* had been apprenticed to an uncle, *Abraham Kuffler*, a woollen draper in Amsterdam.

These three brothers, then, *Abraham*, *Johannes Sibertus* and *Gilles*, became closely associated with *Drebbel* and helped him in the construction of his instruments while they also made many journeys to the Continent in order to make *Drebbel's* inventions known to the public. After *Drebbel's* death the three *Kuffler* brothers formed a company to run a dye works at Stratford-Bow on the Lea near London. They left England during *Cromwell's* time, probably for patriotic reasons, and settled in Holland. Here too they devoted themselves especially to dyeing, first at Katwijk on the Rhine and later at Amsterdam and Arnhem (see Chap. VII, p. 78). Still later they returned again to England.

Gilles Kuffler married *Magdalena van Gheel* at Delft in Holland in 1639 and when his two brothers later went back and settled again in England he remained in Holland, where he

had begun a dyeworks of his own at Zeist in 1649. He died in 1661.

After the death of *Abraham Kuffler* in 1657, Dr *Johannes Sibertus* to whom the title of physician in ordinary to the Duke of York had been given, succeeded his brother as head of the dye works at Stratford-Bow. He died at a great age in 1677 in London. It was this *Johannes Sibertus* in particular who made *Drebbel's* ideas more widely known after the latter's death, and it was he, who was most diligent in trying to commercialize his inventions. He and also his wife *Catherina Drebbel* (Mrs *Kuffler*) were acquainted, as we shall see in succeeding chapters, with many members of the Royal Society of London. Hence these latter also came in touch with *Drebbel's* inventions, such as those dealing with the diving boat, automatically registering ovens and scarlet dyes.

CHAPTER III
DREBBEL AS ENGRAVER AND AUTHOR
OUR SOURCES OF INFORMATION REGARDING DREBBEL's INVENTIONS

§ 1 - Drebbel as an engraver

As we have already mentioned in Chapter I, *Drebbel* was an engraver by profession when living in Holland at Haarlem and Alkmaar as a pupil of his brother-in-law, *Hendrick Goltzius* and, as was quite usual in those days, he published his engravings himself.

These engravings, though rare and few in number, are excellent, especially a map of the city of Alkmaar engraved in 1597, which is a masterpiece. The copper plate of this engraving is preserved to this day in the Municipal Archives of Alkmaar. Other engravings, too, which are still left to us all show clearly how expert *Drebbel* was in handling the burin or engraver's chisel. Those still extant are:

1. The Seven Liberal Arts (*Septem Artes Liberales*), after *Hendrick Goltzius*. The three most interesting of these are shown in our illustrations, namely: *Grammar, Music and Astronomy*. (See fig. 5, 6, 7). In the right hand lower corner of the representations of the two last named we see clearly *Drebbel's* monograms, probably the same kind of monograms with which he later hall-marked his instruments.

2. *Juno,* after *Karel van der Mander,* an artist known especially on account of his 'Book of Painters', in which he discussed many painters, ancient and modern (1604). Like *Drebbel* he was an anabaptist.

3. *The Judgement of Solomon*, after *Karel van der Mander*.

4. *Esther and Ahasverus*, after the same artist.

5. One of a series of five engravings, after *H. Goltzius*, representing *The five senses*, which apparead in 1596. The four others, *Sight, Hearing, Smell* and *Taste*, were cut by *Nic. Clock*; only the last, Feeling, was done by *Drebbel*.[2]

§ 2 - As a writer

A number of short works written by *Drebbel* have been preserved. *'A short Treatise on the .Nature of the Elements and how they bring about wind, rain, lightening, thunder - and why they are useful'* was first published in 1604 and has certainly been more read than any other of his works. [1]

This little book, which was reprinted times without number, some times together with other of his writings, (then again with a biographical sketch based largely on *Cornelis van der Woude* (d. 1645), has been translated into Latin, German and French from the original Dutch. It consists of an Introduction followed by eleven chapters. In the first of these *Drebbel* gives a sketch of the nature of the four elements — fire, air, water and earth. (See the symbolical representation on the title page of an edition that appeared in 1688 (figure 10). His descriptions reveal him as completely representative of his contemporaries and as sharing with these the current views.

Drebbel then proceeds to point out the enormous expansion of air when it is heated. Water, too, expands a hundred or a thousand fold, when it is changed into `air' by heating, and then, when it cools again, it re-becomes water by a process of `coarsening'. We read in chapter IV:

`For whereas warmth makes air and water subtle, thin and large, cold as the opposite of warmth makes them coarse, smaller and compressed.

So winds draw together again that were forced out by warmth, as may be clearly seen if we hang an empty glass retort with its mouth in a vessel of water and the convex side towards a hot fire, as shown in the figure. (See fig. 2). You will see that as soon as the air in the glass begins to get warm, winds come

bubbling out. of the mouth of the retort, in the form of bubbles passing through the water; and this will continue as long as the air continues to grow warmer. But when you withdraw the retort from the fire, and the air begins to cool, then the air comes back into the retort and gets coarse and dense, so that in consequence a great part of the glass becomes filled with water, whereas previously the air, which had been warmed, was made to expand and grow thin by the heat of the fire. For if it were possible to make a glass very hot without breaking it, it would, on being allowed to cool, become almost entirely filled with water. For which reason a stone retort is more convenient; but for seeing the process of filling up, a glass one is better. For by as much as water is coarser and heavier than air, by so much does it expand more and grow larger when heated. Yes, many thousand times more. As we see in baking an apple, the air comes out without our noticing any diminution in dampness. So, again, if we seal an iron pot hermetically and then leaving a little hole in it, heat the pot and introduce a drop of water into it through the hole, the water will immediately be expanded and will issue forth from the hole with much noise as a rapid current of air.' [2]

Phenomena of this kind, which *Drebbel*, as we shall see in chapter IV, often applied in connection with such things as the *perpetuum mobile*, ovens with regulators etc., are brought forward in his final chapters to explain the cause of rain, wind, thunder and lightning.

In *Constantyn Huygens'* autobiography we have a contemporary's opinion of this little book. `Often have I found fault with his little book about the elements, because lie has dared to spoil that work by using studiedly ambiguous words (disgusting folly, this, on the part of a chemist), which was for the rest an exceedingly good treatise, showing forth a judgment which was by no means common- place.' [3]

In most of the editions *Drebbel's* dedication of the *perpetuum mobile* to *James I* is included. This dedication first appeared in a booklet dated 1607 entitled 'Marvellous Discovery of Eternal Motion.'[4] It is preceeded by an eulogy in praise of *Drebbel* by his friend *G. P. Schagen* addressed to *Adriaen Antonis-*

zoon, the, father of the *Metius* brothers. This little work also includes a treatise on the power of water and fire.

Another treatise by *Drebbel*, *De Quinta Essentia*, seems to have appeared in print for the first time in 1621, in Latin, thanks to the effort of *Joachim Morsius* (see Chap. II p. 26).[5] The latter informs us in a preface, that he received the MS. from *Ysbrandt van Rietwyck*, who like *Schagen* was an intimate friend of *Drebbel's*. *Morsius* was also in possession of several other pieces of writing by *Drebbel*, but it has not been possible to trace them.

In *De Quinta Essentia Drebbel* discusses in alchemistic terms, how the essence extracted from metals, minerals, plants and animals may be prepared and then used as medicine. From the directions he gives together with philosophical reflections on the subject, we gather, that by essence of metals he meant salts, such as for instance acetates, and by the essence of plants, alcoholic extracts and by the essence of animals, a kind of watery meat extract or bouillon.

A few letters and petitions of *Drebbel*‘s are still extant, the most important of these being the following:

In the collection of *Huygens* MSS. we find a letter, which he wrote from Westminster to his Alkmaar friend, *Ysbrandt van Rietwyck*, in about 1608.[6] In this letter *Drebbel* relates, after enquiring about the telescope invented by *Metius*, details concerning achievements with his magic lantern — a subject to which we shall return in chapter V.

There are also two letters to *James* I, which must have been written after *Drebbel* returned from Prague to London in 1613. 7 In these he begs *James* I to take him into his service, now that Prince *Henry* is dead, and to give him an allowance to enable him to provide for himself and his family.

And finally there is a petition written by him, in which he asks to be allowed to work a silver mine. [8]

§ 3 - Sources of information regarding Drebbel’s inventions

We will say a word here concerning our sources of information with regard to *Drebbel*’s inventions. We find numerous, though generally very short, informative references to these in the writings

of the most varying kinds of authors. We shall quote these in the following chapters whenever need arises. It is necessary to bear in mind the spirit of the times in which these passages were written and not to forget that these 17th century writers are not always accurate in their data, and that they are sometimes not sufficiently critical in their attitude, when judjed by present- day standards.

His contemporaries, *Constantyn Huygens* and *de Peiresc*, have left extensive treatises on *Drebbel*, in which they have tried to sum him up. It is in *Huygens*' autobiography (see Chap. II p. 27) particularly that we find detailed information, which furnishes us material wherewith to fill out other more fragmentary data. [1]

Nicolas Claude Fabri de Peiresc (1580-1634) was a many sided French savant living in Paris and Aix, who possessed a very large and complete library and corresponded energetically with many men of learning in his own and other lands. Many details concerning *Drebbel* are recounted, not only in these letters but also in two treatises preserved among his MSS. in the Bibliotheque de Carpentras. One of these was written in 1622 and deals with *Drebbel's* microscopes, the other is more concerned with *Drebbel* himself and his inventions in general. [2]

De Peiresc never met *Drebbel* personally but obtained his data from the *Kufflers*, who paid him repeated visits. This fact must be born in mind in the reading of *De Peiresc's* MS., nor must it be forgotten that *De Peiresc* was a good catholic and *Drebbel* a free-thinking anabaptist.

Then, finally, these is a MS. on folio paper, divided into five parts, separately paged, and dated 1690 that has been preserved at Cambridge. [3] It contains many well executed pen and ink diagrams and is called: 'A very Good Collection of Approved Receipts of Chymical Operations, collected by *Augustus Kuffler'*; a later hand has added 'And *Charles Ferrers* Phylchimist, Anno Domini 1666.' *Augustus Kuffler* was *Drebbel*'s grandson and the son of Dr *Johannes Sibertus* and *Drebbel*'s daughter, *Catharine*. *Augustus* was born in 1644. The first part is headed by the sub-title *Opera Chymica Petri*

Stali. This part cannot be as old as some, of the rest and its contents cannot be ascribed to *Drebbel*, for *'Petrus Sthael* of Straszburgh in Royal Prussia was introduced by *Boyle* in Oxford as the first regular teacher of practical chemistry in 1659.' [4]

Part II is called: 'A Collection of approved Medicines in Phisik for most Diseases hapninge to Human Bodies.' It is a book of recipes from which we obtain little that is of interest for us.

Part III contains: 'Directions to make and distell good approved Water or Soveraigne cordially.'

Part IV is: 'A collection of Brewing, Baking, makings of Cider and Meade, ordering and preserving all sorts of wines, cooking, etc.'

Perhaps these recipes date from *Drebbel*'s latter years, when he was obliged to keep an ale-house in order to make a living.

Part V comprises: 'A collection for the understandings of severall Ingenious matters and Performances, Delightfull and Pleasant As the Meltinge of Oares or Mines, the Dyinge and Strainінge of Colours, Distroyinge and Catchinge of Ratts and Mice, Catching of Doves and Lapwings and Crowes and Fish Training, Shootinge and Trapping of Foxes and Wolfes, how to teach a Setting Dogg understanding Tricks upond Cards and other Ingenious performances.'

It is in this last part especially, that we find detailed discussions which must refer to *Drebbel's* inventions, although his name is not once mentioned. Among a great deal of matter which is of little value, we find directions for the making of *Drebbel's* automatically regulated ovens, incubators, and scarlet dye, all of which we shall discuss more in detail in the succeeding chapters. Further, it seems clear, that the copyist did not copy completely all there was to be found in the MS., for occasionally he refers the reader to the original. It is therefore not surprising, that numerous inventions of *Drebbel's* are not dealt with in the manuscript. The publication of certain parts of this MS. would assuredly be very much worth while and would make a real contribution to the history of iatrochemistry, pharmacy, medicine and even the culinary art.

CHAPTER IV
MECHANICAL INSTRUMENTS

§ 1 - Perpetuum mobile

In this chapter we shall first give an account of an instrument made by *Drebbel*— a kind of air-thermometer, which depended for action on a certain volume of gas that varied according to temperature and pressure — and then sketch very briefly what *Drebbel* has to his credit in the field of hydraulics. It is a remarkable fact, that other instrument makers of that day spoke much of plans for constructing complicated machines, but that it was undoubtedly Drebbel who carried his plans to fruition, from which it is evident, that he must have been a very skilful and clever craftsman.[1]

Drebbel's great fame among his contemporaries is due in the first instance to the *perpetuum mobile* which he constructed. It is well to remember, when studying the history and construction of this instrument in general outline, that the standard required of such an instrument at the end of the sixteenth and the beginning of the seventeenth centuries was very different from what we should expect at present. Its nature was not really clearly defined and the world was content with a mobile per se.

The largest specimens of this instrument *Drebbel* constructed for *James* I, King of England and *Rudolf* II, Emperor of Germany; he made a simpler form in great numbers. *De Peiresc* mentions eighteen different kinds all constructed on the same basic principle.

A great deal of interest was aroused by the large instrument made for the King of England. *Ben Johnson* refers to it in his ‘Silent Women', when lie makes *Morose* say (1609):

> 'My very house turns round with the tumult! I dwell in a Windmill! The Perpetuall Motion in here not at Eltham.'

While in an epigram he says:

> `See you yond Motion? Not the old Fading,
> Nor Captayne Pod, not yet the Eltham thing,
> But one more rare …’

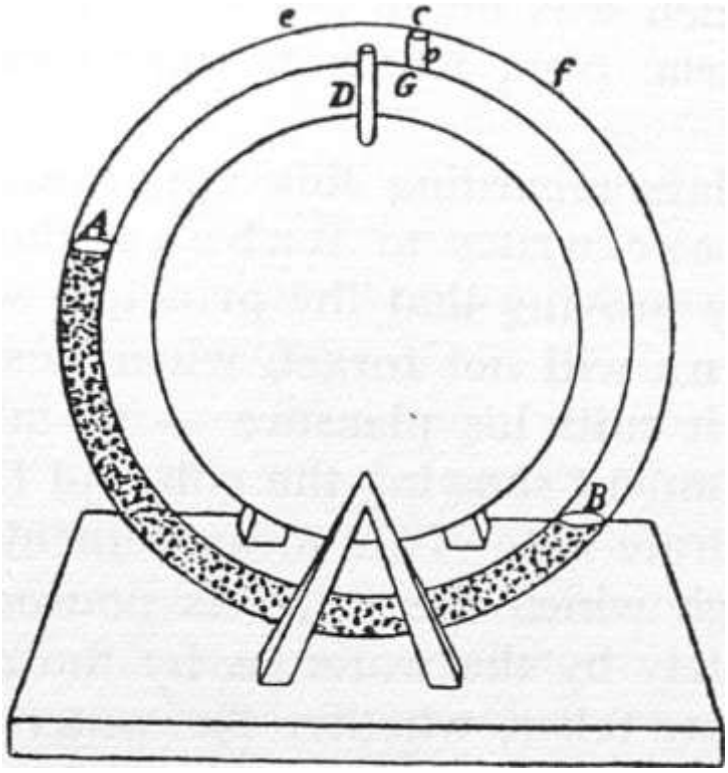
And, again, in 1621 *Henry Farley* writes in 'St. Paul's Church, her Bill for Parliament':

> `To see a strange out-landish Fowle,
> A quaint Baboon, an Ape, an Owle,
> A dancing Beare, a Gyants Bone,
> A foolish Ingin move alone …’

It is mentioned by many men of learning and writers through-out Europe. To one of these, *Antonini*, we are indebted for an enlightening description of the principle involved. He wrote from Brussels to *G. Galilei* on February 1st, 1612, amongst other things: 'Many days ago I learned that the King of England possesses a *perpetuum mobile* in which a certain liquid moves in a glass tube, now rising and then falling in such a manner as to resemble (so it is reported) the ebb and flow of the sea. While pondering over this, the thought came to me, that this was said in order to keep the real cause secret, and that the truth of the matter is, that this motion is due to a change in the air and is caused by heat and cold. My conclusion is based on considerations concerning the size of the vat known to your self and for this reason I tried my best to make a similar *perpetuum mobile* myself, and I did this, not according to the indications coming from England, which were a round channel in the form of a ring, but with a straight tube, as you will see from the profile drawing I am sending you.' [2]

After this follows a description of an instrument such as *Antonini* intended to construct. In a later letter dated February 11 of the same year *Antonini* gives further definite details: 'Now I send you a drawing of the

perpetuum mobile, which is in the possession of the King. The inner circle represents a hollow metal sphere, which is connected by a little tube, D, with the, glass tube eab. in which is the liquid which may be seen rising now on one side and then on the other. The part



of the glass tube marked ef is covered with metal-leaf; but I picture it to myself as I have drawn it, with a dividing wall at eG and an opening at O, so that the air may enter, as the liquid, B, descends and may find a way out, when it rises. That the cause of this movement is to be found in the expansion and condensation of the air enclosed in the metal sphere, will, I think, be sufficiently clear also to yourself, so that in case you should learn any particulars concerning this, you might believe them. [3]

Chr. Wren, mathematician, physicist and architect, too, gives us a description. In connection with a visit paid on June 12, 1663, by *de Monconys*, a Frenchman, to this famous member of the Royal Society, we read: 'On the 12th I went to see M. *Renes*, who explained to me the working of a thermometer with a hollow space, round which is a glass tube, in which tube is a hole connected with the space, and another hole connected with the outer air, giving entrance to the latter. When water is put into the tube, this causes the hollow space, which is suspended from its

middle, to revolve, so that the air, as it expands in the hollow space, emerges by way of the hole in the tube and presses the water to one side, which water, in moving to another place, moves like a wheel. This might be *Drebbel's* ebb and flow instrument or his perpetual motion.' [4]

There was most probably an instrument in Brussels, too — the one, perhaps, which was made by *Drebbel* for the Archduke *Albert* of Austria, from whom he had received a present of a microscope.

A few particulars regarding this apparatus have come down to us. *De Peiresc* writes to *Rubens*, the painter, on June 29th, 1623, hereby proving that the principle was known to him: `Monsieur *Rubens* will not forget, when passing through Brussels, to go — if it suits his pleasure — to take another look at *Drebbel's* instrument showing the ebb and flow of the sea, and to take very accurate note of its measurements, especially of the little hole, through which the water is poured and of the space taken up completely by the water as by the air; and further he should ask the care-taker, whether the water has to be renewed often or not, or whether a little of the water should be replaced by fresh ; where the instrument should be placed, in a dry or a damp place and whether this difference of place would do any damage.' [5]

Constantyn Huygens also understood, by about 1630 the principle on which *Drebbel's* instrument showing perpetual motion depended. He writes as follows in his autobiography:

`The *perpetuum mobile*, which I know only from the drawing of it is so cleverly constructed, that no one, as far as I am aware, has been able to discover the hidden causes at work — not even after it was broken. In a glass spiral is a liquid, which reproduces the ebb and flow of the sea repeatedly (a thing I cannot believe), which certainly is brought about by self-initiated motion back and forth and which enthrals experienced persons as much as inexperienced ones by its extraordinary continuance. I suppose it is something of the same sort as that, which now no longer astonishes us, where in a similar glass the enclosed liquid enables us to judge of the temperature of the day by the instability or

mobility of the liquid. It is quite certain that the water is forced to rise to fill the empty space, when the air is pressed together by the surrounding cold and that the water is pressed down again and is chased away, as if by the ebbing of the tide, when the air expands by warmth.

However this may be, if I am not mistaken, this invention was the first thing that bound *Drebbel* to the Emperor *Rudolf* II, a king, who is much interested in such things. Growing very intimate with him, *Drebbel* has often entertained him, while he looked on, with a number of ever changing instruments and machines. Being very soon called away by the King of England, *Drebbel* succumbed to the offer of [monetary] advancement and exchanged his former master (I do not know whether he was then already dead) for another, who was a person, who, as I have already said, judged less fairly in these elegant matters, which he pretended were more pleasing generally than profitable, according to an imputation which was not entirely untrue nor yet entirely true. This cleverest of all mortals did, however, make certain things which would be of priceless value, should they be applied to the uses of war.'[6]

For all that *Antonini* and *Huygens* were not the only persons among his contemporaries who understood, that the motion was caused by the daily changes in the temperature (and pressure) of the surrounding air. *Cabeo*, *de Peiresc*, *Mersenne* and others showed that they understood perfectly, that it was a kind of air-thermometer. [7]

The really remarkable part of all this was that *Drebbel* was able to change the irregular motion up and down into a more or less regular, rotary motion. That he did this is evidenced by the patent he took out in 1598, for in this patent, which was valid for eighteen years, we read of a 'watch or time-piece, which may be used for fifty, sixty, yea, one hundred years without being wound up or having anything done to it, as long as the wheels and other works are not worn out.' [8]

It is also clear from the otherwise rather obscure description given by *de Peiresc*, that the working of the thermoscope involved also the setting in motion of a time-piece. [9]

How this was constructed, we read in a little book, written by Ty*mme* in 1612 and entitled, 'A Dialogue Philosophicall', wherein nature's secret Closet is opened and the cause of all Motion in Nature skewed out of matter and form. Together with the wittie invention of an artificiall perpetuall motion (by *Cornelis Drebbel*).'

After remarking that he 'did at sundry times pry into the practise of this Gentleman, with whom I was very familiar', he tells the reader that 'two pointers on each side of the Globe doe proportion and show forth the times of the dayes, moneths and yeares, like a perpetuall Almanacke.'

'It setteth forth these particulars of Celestiall motion. First the houers of the rising and the setting of the Sunne, from day to day continually. Secondly hereby is to be seene, what Signe the Moon is in every twenty four houres. Thirdly, in what degree the Sunne is distant from the Moone. Fourthly, how many degree the Sunne and Moone are distant from us every houre of the day and night. Fifthly, in what Signe of the Zodiacke the Sunne in every moneth.' (See fig. 8).

According to *de Peiresc*, *Kuffler* added to this in 1624, that to the *perpetuum* was attached an instrument by which it could now and then be set or regulated: '*Kuffler* informs me, that the above mentioned *Drebbel* has made one of his perpetual motion machines for the Prince of Wales and that he has added another special point, namely this: The instrument must be placed against a wall, through which a hole must be made and that wall must be on the side where the sun shines and in the little hole a small instrument must be placed, made of wood like that on which bread is kneaded, and this must be so placed, that the sun shines on it at least once a month. A big lever is attached to the end of the instrument and he says, that whenever the sun shines on the instrument, the pointer stands exactly at twelve, so that, if it should happen to point to three o'clock, it would of itself move back to twelve.' [10]

§ 2 - Ovens of different kinds

We know from various sources, that *Drebbel* invented very cleverly constructed ovens and furnaces. *De Peiresc* mentions

‘… also the admirable invention of furnaces, where, for instance, the fire can be kept at the desired temperature — more or less intense.' [1]

It was not until some time after *Drebbel*'s death that the construction of these instruments became more widely known. The attention of the Royal Society was directed to them at a meeting, in October, 1662: 'Sir *Robert Moray* offered to the consideration of the society a way to compare the effect of heat and cold in rarefaction and condensation of air, with that of force of weight. Upon which Dr. *Goddard* suggested *Drebbel*’s method of governing a furnace by a thermometer of quicksilver.' [2]

Also *Chr. Wren* shows an interest in these furnaces.

De Monconys, after he had visited *Wren* writes in his diary on June 11th 1663: 'He also told me his thoughts about making a furnace like that of Mr *Kuffler*'s, to wit, one with a vat before the register, which was half in the furnace and half outside it and full of quicksilver, which last rose whenever the air in the retort, which is on the ashes, pushed it up and closed the register; for the little wall of the furnace is likeso a diaphragm, which divides the vat of quicksilver in two.' [3]

From this description we learn, that the regulation of temperature in this furnace was based on the same principle as that on which *Drebbel's perpetuum mobile* must have been constructed. When the fire began to burn quicker, the ashes got warmer, the air in the retort expanded and pushed the quicksilver further up into the neck of the retort, whereby a damper, to which a spring was attached closed down on the surface of the quicksilver, so that as a result less air was admitted than before and the temperature of the fire and the ashes were once more reduced.

A form of construction reminiscent of the plan on which present-day thermo-regulators in a thermostat, are made, was used by *Drebbel* in his incubators. The following data are taken from a MS. by *Drebbel*'s grandson, *Augustus Kuffler*, which is now to be found in Cambridge. This contains a detailed description accompanied by pictures, which greatly add to its clearness.[4]

In these furnaces it was not, as in the case of the apparatuses previously mentioned, the expansion and condensation of a certain quantity of air in an enclosure which regulated the supply of air to the fuel, but alcohol was used for this purpose (nowadays toluene is used). When this alcohol, which was in a vessel inside the incubator, expanded, a tube of quicksilver was caused to move, whereby a lid in the incubator was raised slightly and consequently cold air was admitted. It was possible to hatch eggs in these incubators.

Cornelis van der Wonde also mentions them: 'He was able, by means of a strange and amusing device, to hatch duck and chicken eggs all the years round, yes, even in the middle of winter, without using ducks or chickens for this, and everything went so punctually, that the young were born at the proper time, just as if they had been hatched by ducks and hens.' [5]

These incubators are also mentioned in the Royal Society on February 18th, 1668. 'Mr *Henshaw* upon occasion mentions the way of hatching chickens by balneums formally used in the Minories by Dr. *Keffler*'s brother; the particulars of which he was desired to bring in writing, which he promised to do.' [6]

De Monconys also describes ovens for baking bread in which the heat was made to circulate by means of smoke gases.[7] This kind of oven is also mentioned in *Evelyn's* Diary, in August 1666: 'I went to Dr *Keffler*, who married ye daughter of ye famous chemist *Drebbel*, inventor of ye died scarlet. I went to see his iron ovens made portable (formally) for the Prince of Orange's Army.' [8]

Further we read, that *Drebbel* invented an instrument for distilling sea water. This also *De Monconys* mentions: 'He possesses the secret of distilling a great quantity of sea water by means of an easily portable furnace and using very little coal; this water is then soft and good to drink. Such a furnace can distil more than 145 pounds in 24 hours and it is possible to run two or three of the sort at the same time.' [9]

Later his son-in-law, Dr *Johannes Sibertus Kuffler* tried to commercialize this invention. *Robert Hooke* wrote a letter to *Boyle* in 1663, from which we learn something about this matter: 'Dr *Kuffler*'s wife has been here to

enquire of me about an engine for distilling water, of which I told her I would acquaint you, when I next wrote.' [10]

In another subsequent letter we read further: 'Mrs *Kuffler* is very earnest to know when you will give order about the engine, and seems to be a little angry, and wonders you should be worse than your word, and such kind of speeches; though I had given her the reason, why you could not do it before you went hence.' [11]

From the above letter it is evident, that *Robert Hooke* knew Mrs *Kuffler* (*Drebbel*'s daughter) and was therefore probably, as was *Boyle*, conversant with all *Drebbel*'s inventions, as in fact we shall see in chapter VI.

§ 3 - Automatic musical instruments

The playing of the clavichord, a problem which was occupying *Drebbel* about 1609, involved the expansion of a certain volume of air by warming (af ter the manner of the air-thermometer). *Wurmoser van Vendenheim*. says: 'At Eltham we also saw the spinets which play themselves.'

Van Meteren also mentions this instrument, and *Drebbel* speaks of it in his two letters written to *James* I about 1613 in which he promises to make still more beautiful specimens, if the King of England will take him into his service.[2] The description which he then gives of these instruments, agrees entirely with the models illustrated by *Sal. de Caus* in a work on the subject of apparatuses of this kind which appeared in 1615. [3]

§ 4 - Drebbel as a hydraulic engineer

Although *Drebbel* did not become as famous as his contemporary countryman *Jan Adriaenszoon Leeghwater*, yet he too proved himself possessed of experience and knowledge in the field of hydraulics. As early as 1598 he obtained a patent 'to lead fresh water in great quantities through leaden Pipes and to raise it, like a fountain, from low down upwards to the height of 30, 40, 50 or more feet; in different ways and on the spot were it may be desired, to make it flow and

leap without ceasing.' [1] In order to obtain this result probably he must have placed a number of pumps one behind the other in such a way, that each successive pump raised the water, coming from the previous one to a greater height, as was also the case in the model described by *Sal. de Caus*. [2]

In praise of his work *Constantyn Huygens* writes: 'No one has made a cleverer contribution than *Drebbel* to the art of pumping up dead, as we call it, or left-over water from pools and of drawing it away — and no one ever will.'[3]

Cornelis van der Woude agrees with this, for he says:

`With certain instruments he was able to raise or pump up an unbelievable amount of water at once out of a well or river.' [4] And finally, further proof that he made practical use of his knowledge on the subject is to be found in his construction of a fountain at Middelburg and also in the appearence of his name as a partner in a project whereby certain lands round Cambridge were to be drained (See Chap. I p. 13).

The fountain at Middelburg was probably worked by the tides. When the sea water rose, the air in a closed vessel was compressed and this was then utilised to force fresh water from another container.

CHAPTER V
OPTICAL INSTRUMENTS

§ 1 - Drebbel as a glass grinder

In this chapter we shall outline *Drebbel*'s work in connection with optical instruments.

In *Drebbel*'s day it was necessary for a man who wished to accomplish anything in the field of optics to know all about glass, glass blowing and glass grinding, for it was difficult to obtain any lenses other than the simple ones used for spectacles. Doubtless *Drebbel* obtained a part of his knowledge of the subject from a lens grinder in Alkmaar, perhaps in company with the *Metius* brothers (see Chap. II, p. 22). [1] But it is probably his stay in Middelburg, where he erected a fountain in about the year 1600, to which he owes most of his information concerning these matters. There was a very important glass factory in that city in those days, at the head of which was *Govert van der Haghen*.[2]

Judged by comtemporary standards, the work done at this factory in glass blowing and grinding — in both of which the Italians were particularly expert — was extremely good. *Zacharias Janssen* and *Hans Lippershey*, glass grinders who lived in Middelburg, were probably both connected with these works. [3]

Amsterdam also had its glass-factory, but the workers in Middelburg seem to have been cleverer, and repeated efforts were made to persuade the latter to come to Amsterdam.

The fact that *Drebbel* visited *Janssen*, the glass grinder

in 1620 at Middelburg, shows clearly that he had connections there. He himself also made glass, for we read in de *Peiresc*: '… but that he is working to find out the composition of glass that will be a substitute for rock-crystal.' [4] And a further proof is furnished by a letter, written by *Constantyn Huygens*, dated January 30, 1622: 'I spoke about the telescopes even with *Drebbel* himself; he laughs at the idea that any one should think that the best are made in England; provided that the material is good — besides, rock-crystal can be used — and the knowledge of optics is good, all countries will be on an equal footing, as I have always maintained.' [5]

Drebbel must also have been a clever glass blower, as is proved by the fact that he was able to make the complicated set of glass tubes, which went to form his perpetuum mobile. Furthermore, he is the first of whom it is recorded, that he was the possessor of a glass grinding machine. *De Peiresc* tells us, on the authority of the *Kufflers*, that: 'He was to construct a mill (for grinding the necessary lenses — convex or concave) like the one he has in his house near London, a machine, which makes these lenses according to the required measurement, and makes them all so exactly like one another, without any divergence whatever, that he can make all the lenses equally well with the same instruments, and always get the same results, and no mistakes are ever made. And that is very easy, for one has only to put the glass on the machine and let a small boy run the mill. Then one can go out walking and need only look at the machine once every three or four hours, and nothing ever goes wrong. He does not polish his lenses with scouring sand, as our workmen do, but with tin.' [6]

Later the *Kufflers* were also versed in the art of glass grinding and concerning the son of *Joh. Sibertus Hartlib* wrote in 1685:

`He doth now make exactly the stopples of glass to stop bottles withal instead of corks, which I suppose may prove a very special kind of accommodation for preserving wine and all other kinds of liqors.' [7]

It is very probable that *Constantyn Huygens* also learned the art of glass grinding with a machine from *Drebbel* in

1622, while he was in close contact with the latter, and then later taught it to his son *Christiaan*, the celebrated natural philosopher. As we saw in chapter IV, *Hooke* was well acquainted with *Drebbel*'s daughter and her husband. It is probable, therefore, that he also gained his knowledge of this machine in the same way. [8]

There is no doubt that *Drebbel* made a great number of telescopes. *Constantyn Huygens* bought them for himself and for relatives; he writes about this to his father when complaining of lack of funds: 'I am already in debt to *Burlamachi* for 240 guilders. *Drebbel*'s telescope has used up 40 guilders, I am bankrupt to the amount of 60 guilders.' [9]

Drebbel made other optical instruments too. Amongst other things *van der Woude* recounts: 'He could make a flat sheet of glass, without any ground edge, in which one could see one's face seven times, that is, a single face showed as seven faces in this glass.' [10]

This is based on fact. There is still a little looking glass of the kind descri- bed, belonging to the collection in the possession of the Natural Philosophy Society at Alkmaar and which was shown to me in 1931. The peculiar effect was produced by grinding a number of circular depressions in the back of a piece of plate glass and then covering this back side with silver. By this means it is brought about that one sees oneself reflected as many times as there are depressions in the back of the glass, while the front remains a plane surface.

The fact that *Drebbel* could produce looking glasses of this kind indicates what admirable work he did and how high was the standard of his achievment in his art.

De Peiresc describes lenses of this sort also.[11]

§ 2 - Magic lantern and camera obscura

Drebbel himself tells us in a letter written in about 1608 to his Alkmaar friend, *Ysbrandt van Rietwyck*, what he was able to achieve with his camera magica or magic lantern. He says that he could make himself appear under all sorts of guises by its means:

`I take my stand in a room and have obviously no one with me.

In the first place I make my dress and appearence different before the eyes of all those who are in the room. Now I am dressed in black velvet, and in a moment, as quick as thought, I am in green velvet, in red velvet, ringing the changes on all the colours in the world in succession.'

And again: 'Besides, I change myself into a real tree, with leave fluttering as if in the breeze, and this without any one's noticing; and not only into a tree, but into anything that I may wish. After that I change myself into the shape of any creature, as I may myself desire, now into a lion, then a bear and then, again, a horse, a cow, a sheep, a calf, a pig and so forth.' [1]

We have no detailed information regarding the construction of this contrivance, with which, no doubt, he often entertained *James* I and his court. Probably it was more or less like those with which, until quite recently, transformations of the sort described were performed at country fairs.

Thanks to *Constantyn Huygens* we have more information concerning another contrivance, which was closely related to the magic lantern, namely, the camera obscura. When *Huygens* visited England as a young man in 1622, he already wrote home full of enthusiasm about this camera. In a letter dated March 17th, we read the following: *'Old de Gheyn* will be glad to hear, that I shall bring with me the contrivance by means of which he [*Drebbel*] shows such beautiful brown pictures, which are really masterpieces of the magician's art.' [2]

A little later, on April 13th, 1622, he adds: 'I have that other instrument of *Drebbel*'s with me, which really produces marvellous results in the shape of pictures reflected in a dark room. It is impossible to express the beauty in words. The art of painting is dead, for this is life itself, or something higher, if we could find a word for it. For both shape and outline, as well as movements are depicted by it so naturally and in such an amusing way. The *de Gheyns* will be marvellously entertained by it, but our cousin *Carel* will be furious about it.' [3]

From his autobiography we learn that *Huygens* did indeed take the instrument home with him to the Hague.

Huygens writes of the painters of his day, and in speaking of the remarkable Torrentius, he says:

‘I saw him once in my father's house, when, surrounded by several men of no mean standing or little knowledge, he approached me (my name has always been held in good repute by the great philosopher, they say, even before I knew him personally), as if to see the optical instrument, by means of which the shapes of things outside are reproduced in an enclosed space on a white surface. Having just returned from England and from *Drebbel*, I was working this very accurate instrument, also to the great amusement of painters. Then *Torrentius*, who made a display everywhere of his modesty and friendliness of disposition, asked whether the little people he saw on the plate where really alive outside the room, feigning great admiration the while and looking at the changing images with the greatest attention. When I had agreed with him and, as usual, was busily absorbed in trying to amuse my friends by showing a great variety of objects, I began to think over the simple question put by *Torrentius*, who was now gone, and his pretended ignorance in a matter which now-a-days is familiar to every one, and I was not without suspicion that that veneer of cleverness was his particular invention, as he wished to make sure, that no one should discover that he knew nothing. And, as the two *de Gheyns* did agree with me, I was bold enough to maintain further, that it was especially by this same means that the wily fellow had achieved that in his pictures which in the opinion and judgment of the narrow world was to be ascribed to inspiration. This suspicion has been supported up to the present time by the striking likeness which the paintings of Torrentius show to these shadows, as also by that 'convincing quality, ascribed to his art when compared with the objects themselves which it represents, and concerning which all beholders agree with one another. And I cannot but wonder by what negligence on the part of our painters it happens, that so pleasant and useful an aid to them in their work should so far have been neglected by them or be unknown to them.'[4]

Perhaps, then, *Torrentius*, — a very remarkable picture by him hangs in the Rijksmuseum at Amsterdam — possessed a camera obscura.

A few pages further on, *Constantyn Huygens* proceeds

as follows: 'This other was not one of the devices — by which princes entertain themselves — of which he was the inventor. He elaborated it — for was it not an earlier discovery? I refer to that which I mentioned, when I spoke about *Torrentius*. It was a lightly constructed instrument, whereby that which was held outside it was lighted by a powerful sun and had its form reflected inside an entirely closed chamber. His predecessors made use of a little hole. It used to be thought that *Drebbel* was the first to employ a round lens, but even this he owed to his predecessors' zeal, unless indeed one were to maintain that a man, who is ignorant of an invention preceeding his own, becomes quite naturally, as it were, the inventor himself of the new thing. That this happens — and not so rarely — is a fact recognized by those who weigh the praise meted out down the ages, in all fairness and with the honesty due such a matter. This is certain, that to *Drebbel* should be ascribed the white bord's being parallel with the wall, as also the movement backwards and forwards and the easy turning in all directions. This apparatus, which produces a very pleasant and very useful show, is perfect, if my friend *Drebbel* will finally set the images, which are inverted by the rays issuing from the forms, right side up and justify the reputation he has long claimed for himself. I know this is not an experiment difficult to achieve, but I, who always try to find the easiest way, not considering the troublesome of much value, would rather wait to receive that which is still lacking from that hand, than accept the results offered by others.' [5]

From this passage it is again clear, that *Drebbel* (and with him almost all inventors) rely on, and elaborate, ideas and contructions of their predecessors and contemporaries.

The camera obscura represents an evolution begun by *Leonardo da Vinci* and *Don Panuptio*, continued *by Della Porta, Drebbel*, *Kepler*, *Hooke* and *Marshall*, and which finally led step by step to the construction of our modern photographic apparatus. *Drebbel*'s contemporary, *Kepler*, also used a camera obscura, and the later improvements introduced by *Hooke* and *Marshall* were based on *Drebbel's* construction of the camera. [6]

§ 3 - Invention and construction of microscopes

It is extremely difficult to be absolutely certain as to who made the first telescope and similarly it is almost impossible to come to a definite conclusion, based on such data as we have at our disposal at present, as to whether or not *Drebbel* was the first to construct a composite microscope consisting of two convex lenses. But in any case it is certain that many people ascribe this invention to *Cornelis Drebbel* and that he did a great deal to make this instrument generally known all over Western and Southern Europe. [1]

Microscopes constructed on the principle of the Dutch telescope, i. e., microscopes composed of a concave and a convex lens, came into use very soon after the discovery of the telescope. They were known to *Galilei* as early as 1614 and also the *Chorez* microscope in Paris was supplied with both a convex and a concave lens, as is shown in an illustration.[2]

We shall give the first hearing to those who ascribe the invention of the microscope to *Drebbel*, after which we shall mention such objections to this thesis as are known to us.

Christiaan Huygens, whose father, as we have seen more than once, was often in touch with *Drebbel*, when writing about a microscope with two convex lenses, says: 'That there were microscopes of this sort to be seen in London, in 1621, at the house of *Drebbel*, a native of our country, has often been told me by those who were there at the time. These same persons maintained that he was held to have been their inventor.' [3]

His father subscribes to this opinion in his autobiography, in which he recounts some further details about *Drebbel*s microscope. He says: 'Produced not only by the hand of this same man, but also by his marvellous ingenuity is this perspicillum, if I may so call it, supplied with two lenses, the lower of which, that is nearest to the object, hardly approaches the middle of the nail of one's little finger in thickness. Even if he should prove to have achieved nothing else in his whole life, this wonderful glass gives him a right to an immortal name.[4]

Another contemporary of his, the painter *Rubens*, writes in 1629 to *de Peiresc*, after meeting *Drebbel* : 'They assure me,

in sooth, that for many years he has made nothing but that optical instrument, the tube of which stands up straight, and that objects placed under this are exceedingly much enlarged …' [5]

De Peiresc, too, speaks in his treatise in 1622 of *Cornelis Drebbel*: Inventor Dioptrae. [6]

We shall return to *de Peiresc* later in connection with the propaganda made for the microscopes. First, however, we will sum up the facts adduced to disprove the above pronouncements of *Drebbel*'s contemporaries. *Fontane*, an Italian, declares that he himself had constructed a microscope as early as 1618, composed of two convex lenses. He did not, however, make this statement until 1646. He quotes the testimony of *Sirsalis*, but this witness can speak of nothing previous to the year 1625. [7] *Drebbel*'s new microscopes had by that time already been introduced into Italy, as we shall see later.

Besides, it would seem strange that the Italians should not have been able to work *Drebbel*'s instruments when these came from Paris, if there had been similar instruments in Italy before them, and yet such was the case.

Another fact militating against the assertion that *Drebbel* was the inventor of the microscope is to be found in a letter from *Willem Boreel*, written in 1655 to *Pierre Borel* in Paris. We read:

`When I was ambassador in England, in the year 1619, *Cornelis Drebbel*, a Dutchman from Alkmaar, familiar with many of Nature's Secrets, who was employed as a mathematician in the service of *James* I and was a friend of mine, showed me the instrument which the Archduke [Albert] had given him as a present, namely, a microscope by that same *Zacharias*. It was not equiped, like the ones one sees now, with an insignificant little tube, but with one about a foot and a half long, the tube itself being of gilded brass, two fingers in diameter. It was supported by three brass legs which rested on a round ebony disc. On this disc could be placed little particles of dust or other tiny objects, which could then be looked at from above, their forms being then magnified to an almost miraculous degree.'[8]

How *Sacharias Janssen's* microscope was constructed, we are not told. Its outer appearance was rather different from

*Drebbel´*s, of which, thanks to *de Peiresc* have a description which completes the one given by *Huygens*.

His microscope is about as long as a 'par,' or the length of a travelling quill-case, about the thickness of a wrist in diameter. It is made of gilt brass and is built up of three pieces, so that it may be possible to lengthen it more or less, according to the distance at which the tiny objects are placed. At one end he has made a small funnel, painted black, with a little hole in it about the size of a small nail to look through; a fairly small sphere, convex on both sides, has been placed at about two fingers' distance from the little hole. On the other side there is a smaller tube, about a third of the first in diameter and about the length of a little finger, at the extremity of which is fixed another lens, flat on one side. This flat side is turned towards the convex lens, the round side being turned towards the object and covered with brass in such a way, that only a little hole is to be seen which is so small that a thick needle could fill it up. *Jacob Kuffler* says, that it is neither regularly convex nor concave, and that it is not simply ordinary glass, but that, in order to make it clearer, he throws a certain other substance on it, when it is melted and on the point of congealing, and that this makes it clearer. I accept this; as far as one can see it must be half a small glass bulb, about the size of a small cherry, for the flat side is easily distinguishable from the inside of the tube when the instrument is dismantled, and from outside it was easy to see the rotundity of a little half-bulb covered with a sheath of gilded brass.

‘This instrument was placed in a gilded brass ring, which was supported by three little legs, which in turn rested on a small flat tray like the lid of quill-case, and between this flat plate and the lens was a small round plate, which was black and could revolve. On this he placed the objects, turning them backwards and forwards so as to bring them to the point where they would be exactly within the line of vision. He chose a place where the sun shone on the object without being in the way of the microscope. Furthermore, the object is seen reversed, so that if the little creatures appear to the naked eye to be walking to the right, seen through the glass they will seem to be going to the left ; one

observes the results of the magnifying, while the images are reversed.

If one shortens the tube, by the length of three, four or six fingers' breadth, and more than the half its own length, the object is not blurred, but always remains sharp, so that we see it more and more clearly the shorter we make the tube, although for all that the size diminishes, just as hand-writing diminishes in size, when we look at it through a magnifying glass, in proportion as we bring the glass nearer down to it, which fact strengthens me in the opinion that it is simply two magnifying glasses on top of one another.' [9]

So runs the first complete and very accurate description of a microscope that we possess. It is clear that it would be difficult to assert, that *Zacharias Janssen* already owned a real microscope with two convex lenses. Considering the claim established for *Drebbel* as the inventor, it seems probable that this was not the case.

We will now try to find out, how the above mentioned microscope came into the hands of *de Peiresc* and how these instruments came into more general use. [10]

In the spring of 1622 *Drebbel* sent *Jacob Kuffler*, the brother of his son-in-law, *Abraham*, to demonstrate and sell the new microscopes on the Continent. On May 22nd *Jacob* gave a demonstration in Paris in the apartments of *Maria de Medici*, the Queen-Mother, who was much interested in optical instruments. [11] *De Peiresc* was present on this occasion, and was immediately seized with great enthusiasm for the new invention. So great was his enthusiasm, that when on the 2nd of June he himself came into possession of a microscope, he wrote to his brother begging him to keep this fact secret, as otherwise he might have to part with the instrument to some highly placed persons in case any such should ask him for it. [12] On the 7th of June he sent *Jacob Kuffler* on his way, provided with letters of introduction from himself — to his brother at Aix in Southern France in the first instance.

De Peiresc asked his brother, if it could possibly be managed, by the help of the *Duke of Guise* to introduce *Kuffler* to the *Grandduke of Tuscany*.

Subsequently *Jacob Kuffler* travelled to Italy, where he had an introduction to *Hyronymus Aleandro*, in which *de Peiresc* had begged to have *Kuffler* introduced to Cardinal *Di Santa Susanna* and Cardinal *Barbarini,* later Pope *Urbanus* VIII. From this letter we learn further that, besides the King of England, the Dutch Stadtholder, *Maurits* and the Duke of Anjou were in possession of microscopes by *Drebbel*. [13]

But *Jacob Kuffler* died of plague at Rome in November, 1622, without having been able to display the new microscope.

On August 14th *de Peiresc* sent two of his instruments, which he had received from *Kuffler*, to Rome. [14] At first, however, the Romans were not able to make them work properly, although *de Peiresc* sent directions. [15] But finally, after *Galilei* had come to Rome in May, 1624, bringing his old style, microscope with one concave and one convex lens, success was achieved in making *Drebbel*'s microscope function properly.

In the autumn *Galilei* sent microscopes to various friends in Italy. According to a description by *Galilei* himself in a letter to *Cesi* dated September 23, 1624, these new instruments correspond exactly with the ones sent to Rome by *de Peiresc*. [16] In this way *Drebbel's* instruments were introduced into Italy.

The name microscope, which is still in use, we owe to *Giovanni Faber* as appears from the following passage (1625): `A short time ago, at my house, we saw and stood astounded, almost to the point of regarding it as a miracle before, a glass of most marvellous clearness and most cleverly constructed by two Germans skilful in this art; these artists had brought it and given it to me as a gift; it was suggested that it should be called microscope to correspond with telescope and to indicate the seeing of the tiniest things.' [17]

The Germans referred to, were *Abraham* and *Gilles Kuffler*, who were travelling in Italy at the time and demonstrating the microscope there.

In England, too, *Drebbel* supplied microscopes to many prominent persons besides *James* I. This fact is no doubt one of the contributory causes of the rapid increase in the number of microscopes constructed in England, thanks largely, later, to the work of *Hooke*.

If we inspect *Hooke*'s own microscope we find that it shows a strong resemblance to *Drebbel*'s instrument. There is a model set up in London, at the Science Museum in South Kensington. This resemblance between the two instruments is not to be wondered at, when we remember that, (as we saw above, p. 44), Hooke was intimately acquainted with the *Kufflers* and also with *Drebbel*'s daughter. Not that we wish to belittle the value of *Hooke*'s work on this account, but he no doubt sought the support of his predecessor, *Drebbel*, in the construction of his microscope, just as *Drebbel* himself was dependent on earlier lens grinders.

CHAPTER VI

THE SUBMARINE AND OXYGEN

§ 1 - Drebbel's construction of a submarine

Drebbel owed his fame among his contemporaries to his *perpetuum mobile*, but also largely to his successful experiments with his submarine. When in his later years he was obliged to keep an ale-house in order to make a living, the strange stories that were current about his submarine brought people to take a look at him. (See Chap. I, p. 12).

We gather from a journal kept by *Beeckman*, a native of Middelburg, that *Drebbel* must have been working on this submarine in 1620, and there is a hint in *Gerbier*'s elegy in memory of *Hendrick Goltzius* which suggests that this was also the case as early as 1618. [1] In December 1622 *de Peiresc* enquires from Paris of *Camden* and *Selden* in London regarding the inventions of 'Sieur *Cornelis Drebbel*', including amongst other things a boat, which runs under water. [2] The answers he received from these two learned gentlemen have been lost, more's the pity.

In his treatise on *Drebbel de Peiresc* further tells us on the authority of the *Kufflers*, that he is supposed to have invented this boat at the age of seventeen, and that it could carry nine persons. [3]

In 1624 *Abraham Kuffler* goes to Italy via Paris and it is to this fact that we owe the details, written by *Faber*, a German savant living in Italy (1625).

`Persons who have sailed under the sea in that ship, invented by the remarkable genius of the Dutchman, *Cornelis Dreb-*

bel and constructed in London, England — where it may be seen even today — have sworn to me solemnly, that while a storm was raging on the surface, deep down in the sea they experienced not the slightest difficulty. The ship carries 24 people, eight of whom row, while the rest remain in their little cubicles; for 24 hours they suffer from no lack of air and live contentedly on that which is locked in the little vessel; after this period of time has elapsed, they go up to the surf ace of the sea, and when the cover of the boat has been unbolted and left open for a short time, they take in fresh air, upon which they are able, after putting the lid on the ship again, to dive down as deep into the water as the captain wishes to do — even to the depth of fifty fathoms, should he so desire. And what will surprise you still more — they steer by the compass and know where they are and they move the ship with the greatest ease by means of oars. But what almost passes belief is this: that that part of the ship where the rowers sit has no bottom, so that the water is visible all the time to these rowers, who are nevertheless not in the very least afraid, as sitting on their seats a little above the water, they never touch it with their feet.

But it is not my pleasure to set forth at the moment all that I was told just lately by the son-in-law of the constructor of this boat.'[4]

Constantyn Huygens writes in his autobiography (1631) :

`Worth all the rest put together is the little ship, in which he calmly dived under the water, while he kept the king and several thousand Londoners in the greatest suspense. The great majority of these already thought that the man who had very cleverly remained invisible to them - for three hours, as rumour has it - had perished, when he suddenly rose to the surface a considerable distance from where he had dived down, bringing with him the several companions of his dangerous adventure to witness to the fact that they had experienced no trouble or fear under the water, but had sat on the bottom, when they so desired, and had ascended when they wished to do so; that they had sailed whithersoever they had a mind, rising as much nearer the surface or again diving as much deeper as it pleased them to do, without even being deprived of light; yea, even that they had done in the belly of that whale all the things people are used

to do in the air, and this without any trouble. From all this it is not hard to imagine what would be the usefulness of this bold invention in time of war, if in this manner (a thing which I have repeatedly heard *Drebbel* assert) enemy ships lying safely at anchor could be secretly attacked and sunk unexpectedly by means of a battering ram — an instrument of which hideous use is made now- a-days in the capturing of the gates and bridges of towns.' [5]

In 1645 we find *Cornelis van der Woude* of Alkmaar telling the following story:

`He made a ship, with which one could row under water and sail from Westminster to Greenwich — a distance of two Dutch miles. Yes, even five or six miles, as far as one wished; and in the ship it is possible to see without a candle and to read the Bible or any other book; which ship was to be seen lying in the Thames — London's river — until a few years ago.' [6]

When writing of *Drebbel* in 1663, *de Monconys* says:

`He had also made a ship, which could dive down under water, if one wished, and which was propelled under water by means of oars. These oars were made fast to the outside of the ship by means of leather thongs, so that they could move. He could not dive deeper than twelve or fifteen feet, however; if he did, the heaviness of the water would make it difficult for him to rise to the surface again and he would be drowned.' [7]

A corroborative statement is found in the writing of *Papin*, who made a similar submarine in 1691: 'The oars would have to be attached by pieces of leather, as it is said they were in *Drebbel*'s boat.'[8]

From these data we may draw the conclusion that the submarine must have been fairly large and not entirely closed. We must not, therefore, picture it as a modern submarine but more as a sailing diving-bell. *Papin*, whom we mentioned above, was following *Drebbel*'s example, when he made a boat with gaps in the bottom.

It is comparatively easy to achieve the requirements necessary to assure stability in a submarine built in the form of a diving-bell. H. A. *Naber* proved this at Hoorn in 1922 in the case of his individual submarine constructed on the above principle. In

1931 he demonstrated it again at Hoorn before the present writer.

The theory explained a boat like this may be roughly outlined as follows (according to *Naber* in 1904).

In a diving-boat made in the form of a diving-bell, the pressure, and therefore also the volume, of the air depends on the depth of the boat under water. Let us suppose that the boat is floating under water; if it is then propelled downwards, the pressure on the enclosed air will increase and the volume diminish, with the result that the upward pressure grows less — by Archimedes' Principle — and the boat goes deeper and deeper. But if, on the other hand, the boat while floating under water is given an upwards impulse, the air pressure will decrease and so the volume, and with it the upwards pressure, will increase, the boat being thereby made to rise, until it floats above the water.

It follows, therefore, that by simply changing the direction say by means of a horizontal rudder — the boat may be made to sink or rise as desired. At a certain depth, which *Naber* calls the 'critical depth' it is possible to make the boat move forward, care being taken the while, that by slight adjustments of the direction it is enabled to maintain itself constantly in very nearly the same position of unstable equilibrium.

If it sinks too much below this 'critical depth', it will be impossible for the crew to give it an upwards impulse, as the apparent weight will then have become too great. (See *Monconys'* remark on page 61). [9]

Drebbel determined the depth to which his boat had descended by means of a quicksilver barometer, which could, of course, only be done in an open vessel without a bottom. Of this barometer Constantyn *Huygens* Jr writes as follows, in an entry made in his diary in London on October 18th, 1690, when Mrs *Kuffler* comes to him, as the secretary of the King and Stadtholder, *William III*. `Old Mistress *Kuffler* came to see me in the morning. She was still talking about aplace at court or elsewhere; I said I could not help her. She said that her father *Cornelis Drebbel* had a long tube of quicksilver in the boat in which he dived be under water.' [10]

For the sake of stability a submarine in the form of a diving-

bell rather elongated in shape, must be divided into several compart- ments. From Faber we learned that this was so in the case of *Drebbel*'s boats.

Drebbel was not the first man to talk of plans for making submarines, [11] but he is the first whom is recorded that he made successful experiments with such a boat and really produced one that was sea-worthy.

Diving-bells were known in ancient times, but it was only in the 16th century that they began to be more generally used.

In England *William Bourne* had already worked out plans for a submarine in 1578, which appear in his 'Inventions and Devises, very necessary for all Generalles and Captaines, or Leaders of Men as well by sea as by land.'

The Scottish mathematician and theologian, *John Napier* (1550-1617) was also interested in the problem of sailing under water. On the title page of 'Secret Inventions' a little work published by him in 1596, appears the following:

`These inventions besides devises of sayling under water with divers, other devises and strategems for harming of the enemyes by the Grace of God and worke of expert Craftsmen I hope to perform.' We do not know whether or not *Napier* ever really carried out his plans.

Henry Briggs, who was professor of mathematics at Gresham College, London, and later at Oxford, was an acquaintance of *Drebbel*'s, as we saw on p. 13, and he was also a friend of *Napier*, whom he visited in 1615 and 1616. He was to visit him again in 1617, but *Napier* died in April 4th of that year. *Henry Briggs* writes to *Bishop Usher* in 1617:

`*Napier*, Lord of Markinston has set my head and hands to work with his new and admirable logarithms. I hope to see him this summer (1617), if it please God, for I never saw a book which pleased me better and made me more wonder.'

`Logarithms by *Jo Nepar*, fear of Marchistoun, 'King of Numbers' were published in 1619 by the author's son, Robert, with commentary and notes by Henry Briggs.[12]

Hence it is not impossible that it was because of the interest taken by the celebrated Scotsman in the submarine, that *Briggs* came in touch with *Drebbel*.

The problem of remaining under water was being studied in and about Alkmaar too during the time that *Drebbel* still lived in Holland. On May 8th, 1605, *Pieter Pietersz., Jan Adriaensz. and Wilhelm Pietersz*., all three inhabitants of de Ryp, a village near Alkmaar, obtained a patent for a term of ten years on an invention, which made it possible to do a number of things under water:

'… setting forth how they, the petitioners, had invented and made trial, in the presence of His Royal Highness the Prince, of a certain aquatic art enabling them to walk, stand, sit under water, or lie down, eat, drink, read, write, sing and talk; further to repair bridges and sluices or to destroy these; to attach cables to ships that are sunk so that they may be hauled up from the bottom; to search for pearls and other valuables on the water-bottom, or further to carry secret missives and letters under water, and all this while able to draw breath even if one, two, five, six or more fathoms under the surface.' [13]

The best known of the three patentees is J*an Adriaensz. (Leeghwater)*, of whom mention has been made in chapter II, p. 24. From a 'Little Chronicle' written by *Leeghwater* we learn, how in April, 1605, he and his companions had given a demonstration in the Hague in the presence of Prince *Maurits* before they took out the above mentioned patent, and that their experiments were very successful. In September, 1606, they gave another demonstration of their art in Amsterdam, where again they were very successful; on this latter occasion *Leeghwater* remained under water for three quarters of an hour.

§ 2 - His method freshening the air in his boat

The great question that arises as we proceed with the investigation of the data concerning the early submarine, is whether or not *Drebbel* used oxygen in this connection, or in other words, whether *Drebbel* was the first of whom we have any knowledge to isolate oxygen and to be acquainted with the most im- portantof its characteristics. With a view to answering this question, we will begin by presenting the reader with the facts bearing on the subject.

In the first place there are in our possession several passages from the writings of contemporaries, all of which would lead us to believe that *Drebbel* used oxygen in his perpetuum mobile as the gas that filled the enclosed space. We cite these here for the sake of completeness. They point to the fact that *Drebbel* was able to isolate a certain *spiritus*. It would seem that the astronomer *Kepler* had heard something to this effect in 1607, for he writes about *Drebbel*:

'If he can create a new spirit, by means of which he can move and keep in motion his instrument without weights or propelling power, he will be Apollo in my opinion.' [1]

Tymme writes in 1612 in his little work on perpetual motion that the bulb of the *perpetuum mobile* was filled with 'a fierie spirit extracted out of a mineral matter.' [2] This expression suggests the preparation of oxygen from saltpetre.

Robert Fludd may have had this in mind when he said in 1638: 'Some fraudulent persons maintain that they have extracted a fluid or a spirit, hereby arousing still greater admiration.' [3]

A still clearer indication is to be found in *Drebbel*'s own `On the Nature of the Elements' (1604), in the fifth chapter:

`Very dry, subtle or warm air, which then very quickly penetrates the coarse, heavy clouds, expands them, makes them subtle and thin, and again changes them into the nature of air, whereby its volume is increased an hundredfold in a moment, which brings forth the terrific motion which, cracking and bursting, sets the air alight and moves it, until volume and density are equal, when there is rest. Thus is the body of the saltpetre broken up and decomposed by the power of the fire and so changed in the nature of the air, or as when a wet hand or cloth is waved about on a hot iron, or molten lead, which by expansion or enlargement due to heat cracks and bursts with a noise like thunder.' [4]

The submarine is also connected with the subjects of the followin quotations. *Digby* (1603-1665), who was perhaps an eye-witness of the submarine demonstration, writes in his ‘Discourse concerning the Vegetation of Plants', when he is discussing saltpetre and says that this mineral is perhaps present in the air in the form of a gas:

`*Cornelius Drebel*, having contracted a great quantity of

this into a narrow room, could recreate and revive his languishing guests in his straight house under water; when they had fed upon all the balsome that was in the air shut up with them: by opening a Phiol, that dilated itself with fresh Spirits into that stale depredated and exhausted Air.' [5]

The most detailed discussion is by *Robert Boyle* (1627- 1691), as is evident from the following quotation (1660) :

`But yet, on occasion of this opinion of *Paracelsus*, perhaps it will not be impertinent if, before I proceed, I acquaint your Lordship which a conceit of that deservedly famous Mechanican and Chymist, *Cornelius Drebell*, who, among other strange things that he performed, is affirmed, by more than a few credible persons, to have contrived, for the late learned King *James*, a vessel to go under water; of which trial was made in the Thames, with admired succes, the vessel carrying twelve rowers, besides passengers; one of which is yet alive, and related it to an excellent Mathematician, that informed me of it. Now that for which I mention the story is, that having had the curiosity and opportunity to make particular inquiries among the relations of *Drebell*, and especially of an ingenious Physician that married his daughter, concerning the ground upon which he conceived it feasible to make men unaccustomed to continue so long under water without suffocation, or (as the lately mentioned person that went in the vessel affirms) without uncon-venience; I was answered, that *Drebell* conceived, that it is not the whole body of the air, but a certain quintessence (as Chymists speak) or spirituous part of it, that makes it fit for respiration; which being spent, the remaining grosser body or carcase, if I may so call it, of the air, is unable to cherish the vital flame residing in the heart; so that for aught I could gather, besides the mechanical contrivance of his vessel, he had a chymical liquor, which he accounted the chief secret of his submarine navigation. For when, from time to time, he perceived that the finer and purer part of the air was consumed, or over-clogged by the respiration and steams of those that went in his ship, he would by unstopping a vessel full of his liquor, speedily restore the troubled air such a proportion of vital parts, as would make it again, for a good while, fit for respiration, whether by dissipating, or precipitating

the grosser exhalations, or by some other intelligible way, I must not now stay to examine; contenting myself to add, that having had the opportunity to do some service to those of his relations that were most intimate with him, and having made it my business to learn, what this strange liquor might be, they constantly affirmed me, that *Drebell* would never disclose the liquor to any, nor so much as tell the matter wherof he made it, to above one person, who himself assured me, what it was.

This account of *Drebell*'s performance I mention, not that I any farther assent to opinion that I have already intimated, but because the man of the invention being extraordinary, I suppose your Lordship will not be displeased to know the utmost I could learn about it, especially not having found it mentioned by any writer.' [6]

Further we find:

`Submarine navigation, at least for a short pace, has been successfully attempted by the excellent *Cornelius Drebel*, as *Mersenne* assures us; and as I have been informed both by *Drebel*'s son-in-law and by other judicious persons, that have had the account of trials from the very men, that went in the vessel under water for a good while together; who affirmed, that though there were many in the boat, yet they breathed very freely, and complained not of any inconvenience for want of fresh air and here also give me leave to take notice, that this inventive *Drebel* was no professed ship-whright, nor so much as bred a seaman.' [7]

Boyle also spoke on this subject at a meeting of the Royal Society of London on June the 26th 1667. We read:

`Mr *Boyle* related, that he knew a man, who by a way used by him would undertake to be three hours at a time under water without any prejudice.

This gave occasion to discourse, what quality it was, that made the air fit for respiration. Some thought it become unfit by being clogged and entangled by gross vapours. Mr *Hooke* was of opinion, that there is a kind of nitrous quality in the air, which makes refreshment necessary to life, which being spent or entangled, the air becomes unfit.' [8]

Thus we see, the famous *Robert Hooke* (1635--1703) agreed with *Drebbel*'s ideas concerning the composition of air. The

well known *O1denburg*, Secretary of the Royal Society, is also well informed concerning *Drebbel*.

In 1663 *de Monconys*, a Frenchman, visited London and in his 'Journal des Voyages' he narrates the following, when dealing with the subject of *O1denburg*:

`The latter confirmed everything that I had heard concerning *Drebbel*; amongst other things that he was able to extract a subtle spirit from the air, which caused the coarser particles in a coarser air, in which we can no longer breath, to fall down, thereby making it fit again for respiration.'

Together they visited *Johannes Sibertus Kuffler*, who lived at Stratford-Bow near London: 'He possessed the secret of keeping the air perfectly pure and of making it always fit for respiration. Hence knowing the secret or method of diving down deep into the water in a contrivance the shape of a bell, he can stay there as long as he wishes, which one would not be able to do without knowing his secret, because in the first place the air gets warmer or coarser or rather, as he thinks, gets used up; for he thinks there is a certain quintessence in the air, which alone we breathe in and which sustains life, and which if lacking, we die, which would happen if one stayed a long time in enclosed air; which he restores by means of the essence he prepared, and which he called the *'Quintessence of the air*.' ;When he had transfused the air with a drop of this, one breathed with as great pleasure and ease as one would on a lovely hill-side.'

After a description of *Drebbel*'s ovens, he proceeds thus about this discovery:

`This doctor, who was very pleasant and was rather good-looking although he had but one eye, was not willing to lay bare the secret, which, he declared, his father-in-law considered as important as the great Work [making gold], saying repeatedly that he would reveal it to him alone who should reveal to him the great Work.' [9]

In the minutes of the Royal Society we find the following dated May 6th, 1669:

`Mr *Daniel Coxe* mentioned, that *Cornelius Drebbel* pretended to have a certain liquor, to supply the want of fresh air in the boat, which he had made to go under water with; and

which boat was so framed, that it had no bottom according to the relation given of it in the notes made upon *Hernades*. (This is the quotation from *Faber* given on page 59).

`Sir *Robert Moray* mentioned, that Mr *Greatorix* had improved his engine for going under water with; and that by means thereof he could sink himself ten fathoms under water, and stay there with ease enough as long as he pleased, going up and down, stooping and working; but at a much greater depth he found an intolerable pressure.' [10]

This last was also experienced by *Naber* in his experiments, when he reached greater depths.

In his book, *Physica Vetus et Vera*, E. *Dickenson* (1624- 1707) shows clearly that a gas was being discussed:

`Furthermore I have heard very learned and honest men, who can be thoroughly trusted, that it is possible to prepare a certain kind of gas, by means of which the lack of fresh air can be compensated in such a way, that it becomes feasible to live for a long time in a small and entirely enclosed space. And they said that this was the experiment made in London in the river Thames by the famous Hollander, *Cornelis Drebbel*, on which occasion not a few men remained a long time under water in a covered boat; whenever their breathing became more difficult or uncomfortable, very soon free respiration was re-established by the opening of a bottle and allowing the gas in it to issue from it, when it seemed as if fresh air had been introduced into the enclosure.' [11]

In *Papin*'s correspondence we find a few particulars recorded concerning this renewing of air. As we have already mentioned, *Papin* himself made a submarine at the very end of the 17th century. In 1691 *Huygens*, writing to *Papin*, speaks of a funnel standing straight up and extending above the surface of the water and adds:

`*Drebbel*'s diving boat had no funnel of this kind, according to my father's account and he was present at the time when *Drebbel* himself dived down under the Thames without a trace of anything remaining above water, and came up after a fairly long time again and at a point far away from that at which he dived in. It was said that he had something by which he was

able to renew the air in his boat, which would be a very important discovery.' [12]

Leibnitz wrote to *Papin* in 1695:

'I will tell you, Sir, what I guess the famous *Drebbel*'s quintessence of air was. It was evidently spirits of wine, which he burned. For there is no fluid which more nearly corresponds in its nature to the nature of air. And perhaps the vapour it gives off, can be used to renew air spoiled by respiration. No one can pronounce a judgement in this matter better than you, but I imagine that this alone would not help for very long without the introduction of new air from outside, but perhaps this means may not be without its use. I understand from Mr *Boyle* and also from *Drebbel*'s daughter, whom I met with her husband, Mr *Kuffler*, at London, that *Drebbel*'s boat made a considerable distance under water. But they did not mention definitely whether he made use of the outer air.' [13]

Papin answered Leibnitz that it could not possibly have been spirits of wine, as this, he writes, like all burning flames would only serve to still further spoil the air. [14]

Anyone reading these numerous passages with an unprejudiced mind cannot but be convinced that oxygen was really known to *Drebbel*. And the fact that *Drebbel* was able to remain under water with his companions in the boat for several hours, without their experiencing any difficulty in breathing, as we saw above, would almost force us to believe, that he was able to prepare oxygen. To renew the air by means of a funnel standing up above the surface of the water, would be impossible in a bottomless boat, and besides, *Huygens* asserts quite definitely that there was no funnel.

The following sentence from *Drebbel'*s own treatise on the elements (1604) 'saltpetre broken up by the power of the fire and thus changed into the nature of the air' makes it fairly certain that he prepared oxygen by heating saltpetre - a method which according to Scheele, one of the later discoverers of oxygen is one of the best. [15]

Drebbel kept the secret of renewing the air in his diving boat by means of oxygen to himself, as we have already heard from

de Monconys. Only *Dr Johannes Sibertus Kuffler* knew the secret after his death and he made no further use of it, probably because he saw no commercial advantage in so doing. For years after this date the Royal Society was witness to the fact that experiments were made in connection with respiration and combustion, inspired by *Drebbel*'s work. *Robert Boyle* tried to discover the secret of extracting oxygen from saltpetre by making an exhaustive study of that mineral and even urged *Spinoza* to exert himself in the same direction, through *Oldenburg*, the Secretary of the Royal Society, but *Spinoza* did not succeed in explaining the fact that certain substances burned easily when mixed with saltpetre, although he discovered oxycellulose and nitrocellulose while carrying out his researches on the influence of nitric acid on paper. [16]

As we have already seen, *Hooke*'s and *Boyle's* views on respiration agreed with *Drebbel*'s. These, again, formed the basis whereon young *John Mayow's* acute intellect built up his splendid theory of respiration and combustion, by which he proved that the `*spiritus nitro-aereus*' necessary for these phenomena was probably contained in saltpetre (1668-1674). [17]

CHAPTER VII CHEMICAL DISCOVERIES

§ 1 - Drebbel as a maker of explosives

Credit must be given to *Drebbel* for making a contribution to the science of explosives and kindred subjects and their development. First of all, he made use of the knowledge of pyrotechnics, which he possessed as an alchemist, in connection with the many entertainments given at the court of *James* I and *Prince Henry*. We read of one of these, for instance, in a letter written by *John Chamberlain* to *Dudley of Carleton* and dated January 5, 1608. The writer says:

`Yesterday night there were to be shown certain rare fireworks by a Dane, two Dutchmen and Sir *Thomas Chaloner* in concert.' [1]

But when *Drebbel* was taken into the service of the British Admiralty in 1626, he used his knowledge more for the purposes of war. (See Chap. I, p. 10). In the 'Orders of Buckingham's Expedition' we find entered on January 26, 1626 'for the making of dyvers, watermines, water petards, fforged cases to be shot with fireworks, and boats to goe under water;' and later, on June 29, 1626; '360 fforged iron cases with fireworks, 50 watermines, 290 water petards and two boats to conduct them under water, for H. M. special service to go with the fleet.'

All this was evidently for use on the Expedition to the isle of Rhé and la Rochelle. Further, *Constantyn Huygens* tells us (1630): 'For this Daedalus also knows how to direct the powers of gunpowder in such a way that it can no more be held in check by water than

by air. He was to show proof of this when he accompanied the British fleet in the year 1628 to the French coast and was to demollish the royal sea-castles by which the Ruppellani were shut in - a thing he claimed he could easily do. But he did not even make a beginning of an effort in this direction, to say nothing of producing any result. Some say that it was on this account that on his return *Drebbel* accused the promotors or leaders of this affair of fear and cowardice unworthy of the most warlike of all Peoples, but not unheard of by some fateful mischance or other in those days of fighting against the French. How powerful a destroyer of fleets he was, he demonstrated not long ago, though he himself was not present, when he entrusted to one of his sons-in-law (perhaps by way of fatherly gift) his invention of a machine, by which a large ship could be destroyed in a moment, to the great astonishment of the persons commissioned by the States of this Republic to investigate the matter. The drama enacted was the more horrifying because of the fact, that the man who lead and carried out the action, sitting on the very boat at the prow of which was fixed, the apparatus from which the shot was fired, remained safe and unhurt.' [2]

From this it is evident, that no successfull use was made of this instrument of war before la Rochelle, although its failure was not to be ascribed to any fault of *Drebbel*'s. Nor were the cautious Hollanders willing to make use of it at the time, although the demonstration of its possibilities by one of the *Kufflers* appears to have been so satisfactory.

We have also a French account of these weapons before la Rochelle. *Carles Bernard* wrote in 1628 in the Mercure Francois:

`During the night between Sunday (Oct. 1st.) and Monday, the English shot ten or twelve floating petards for the purpose of setting fire to the royal French fleet. The body of these petards is of white iron filled with gun-powder and floats on a piece willow wood, through which a spring is made, which when it encountered the bows of one of the royal ships, took effect, which consisted simply in this, that it threw water into the ship with much power; all the others were captured as they floated on the water and did no harm.'

Pierre Mervault recounts the same in his diary, as does also the famous painter, *Rubens*, [3] but we must not forget that these uncomplimentary accounts of *Drebbel*'s work come from persons who belonged to the enemies of England. Furthermore it is a well known fact, that after *Buckingham* had been murdered by *Felton*, on August 23rd, 1628, before the last expedition started on its way, his successor, the *Earl of Lindsey* could not make his men fight, when they got to la Rochelle and hence the failure was certainly not due to *Drebbel*. [4]

Probably these petards had a sort of cap filled with *aurum fulminans* or some such substance; fulminate of gold had been already described by *Basilus Valentinus* and in a MS. by *Augustus Kuffler*, *Drebbel*'s grandson, preserved at Cambridge we find a description of the same directions, which we reproduce here in order to give the reader an idea of the way a recipe of that kind was given in those days.

Aurum Fulminans

Re refined Aurum, 1 ounce, or leafe aurum put in a little retort or boltshead put so much aquam regis upon it as will dissolve itt which will bee som ounces IV. By Digestion in 3° gradu then put gutttatim Liquoris salis tartiari so much as precipitates the aurum the signe is the Liquor as was yellowish will become muddie and Inribidd when the precipitation is made sett itt in 2° gradu lett is stand soe long till the Liquor comes clear and transparent. Decant this clear Liquor which is a little saltish put fire or distilled water upon the Remaine aubout 6 Inches abouve the matter shake itt and sett itt in 2° gradu to Digest 4 hours then Decant the Liquor repeate this Dulfication by Digestion and Decantation so long till the water bee noe more saltish then Put a Little water in to wash out the Pulvis then filter itt per Chartam put the Charta with the Pulvis in a crusible put it in Primo gradu other wise itt will Fulminate and fly to pieces. Lett itt stand soe long till itt is Dry. Collect the Pulvish put it in a violl for use which is aurum fulminans. [5]

Aurum Fulminans counterfeit

Re Salis tartrari salis nitri at Equall parts of sulfuris half as

much as of either the former. Rubb them to Powder and Put Same in a Fire shovell hold them over the fire and as soone as it is melted it fulminates and strong as that of Gold.

Pepy's 'Diary' gives the following on March 14, 1662:

'In the afternoon came the German Dr *Kuffler* to discourse with us about his engine to blow up ships. We doubted not the matter of fact, it being tried in *Cromwell'*s time but the safety of carrying them in ships; but he do tell us, that when he comes to tell the King his secret (for none but the Kings, successively, and their heirs must know it) it will appear to be of no danger at all. We concluded nothing, but shall discourse with the *Duke of York* to-morrow about it.'[6]

At about this period *Joh. Sibertus Kuffler* and *Jacob Drebbel* sent in a petition 'for a trial of their father *Cornelius Drebble*'s secret of sinking and destroying ships in a moment, and they ask for a reward of £ 1000 if it should succeed. The secret was left them by will, to preserve for the English crown before any other power.' [7]

Most likely nothing further was done about the matter at the time. Towards the end of the 17th century we hear of renewed efforts being made, however. In 1689 a son of *Johannes Sibertus Kuffler*'s comes to visit *Constantyn Huygens* (the son) in London and this invention is again discussed. *Huygens* wrote in his diary: 'Before I went out, *Kuffler* came in to see me - the son of the man from whom papa (of blessed memory) got a telescope in a wooden tube (which was, however ground by his brother). He said he had an invention of his father's by which a ship could be very quickly sunk by means of a sort of petard, which made a hole about 15 or 16 feet square in the ship; that the Protector, *Cromwel1*, had promised him a great sum for this, but just then came to die.`[8]

Then, again, in March, 1694, one of *Drebbel*'s daughters who must have been very old by that time — comes to talk with *Huygens* on this same subject. We read: 'In the morning old Mistress *Kuffler* came. She wanted to ask for a subsidy from the King and to offer him her father's invention for sinking ships.' [9]

§ 2 His discovery of using tin salt in dyening with cochineal

Drebbel certainly brought about a great improvement in the dyeing of cloth an intense scarlet, by the introduction of tin salt as mordant in cochineal dyeing. Cochineal, especially that imported from America, was much used in *Drebbel*'s day in preparing red dye. There were several mordants known, of course, by which the colour could be fixed upon the fibre; *Drebbel*'s contribution was that he added pewter in the form of tin salts to the number of the available mordants. The remarkable thing about this particular mordant is that it makes the red much more intense, than others, such as alum or tartar.

In the Science Museum, South Kensington, London, there are now two specimens of silk dyed with cochineal, one done with alum and the other with tin salt. The fine colour of the one where tin was used strikes one immediately. It seems to have been forgotten, that is was *Drebbel* who discovered this process and made use of it with his sons-in-law, the *Kufflers* in Stratford-Bow on the Lea near London.

Three passages may be quoted recounting particulars concerning this invention, the most interesting of which is one from the writings of *Beckmann*:

`The tincture of cochineal alone yields a purple colour, not very pleasant, which may be heightened to the most beautiful scarlet by a solution of tin in *aqua regia* or muriatic acid. M. *Kuhlenkamp* at Bremen, one of the most learned dyers of Germany, and who has studied with great care every new improvement of his art, gave me the history of this scarlet dye, as I have already related in my Introduction to Technology.

The well-known *Cornelius Drebbel*, who was born at Alkmaar and died at London in 1634, having placed in his window an extract of cochineal, made with boiling, water, for the purpose of filling a thermometer, some *aqua regia* dropped into it from a phial, broken by accident, which stood above it, and converted the purple dye into a most beautiful dark red. After some conjectures and experiments, he discovered that the tin by which the window-frame was divided into squares had been dissolved by the aqua regia, and was the cause of this change. He communicated his observation to *Kuffelar*, an ingenious

dyer at Leyden, who was afterwards his son-in-law. The latter brought the discovery to perfection and employed it some years alone in his dye-house, which, gave rise to the name of *Kuffelar's* -colour.'[1]

Boyle's account of the discovery agrees with the above, in this we read:

'For the most famous *Cornelius Drebel*, who was the inventor of the true scarlet dye, was a mechanican, and a chemist, not a dyer; and as an ingenious man, that married his daughter, related to me, was so far from having been versed in that profession, when some, merchants put him upon the advancement of certain way of dyeing a fine red or rather crimson, that had been a while before casually lighted on in Holland, and proved very gainful to the finders, that he did not know so much as the common way of dyeing the ordinary reds, though the merchants having once taught him, that by the help of a sagacious conjecture (to be told you in one of the following essays) he soon invented the true scarlet dye, which has since been so much esteemed.' [2]

Fredericus Hoffmann's account of the discovery is of somewhat later date (1702).

`If we observe the art of dyeing, we note that this has been enriched by the most beautiful discoveries resulting from the beneficence of chemical science; for the discovery of scarlet dye is ascribed to *Drebbel*, the famous chemist from Holland, who made a solution of cochineal in *aqua fortis*, and in order to prevent this from eating away the fibre of the cloth, he added water and pewter filings to mitigate the acidity.' [3]

That it really was *Drebbel* who made this discovery was corroborated as early as 1627 by his contemporary, *de Peiresc*: `*Drebbel* has shown them a way of making the scarlet dye, and this is more beautiful and at a better price than the colours now usually made. *Kuffler* showed me specimens of it which were remarkable fine.' [4]

Drebbel is also mentioned in the *Rawlinson* MS. and in *Evelyn*'s 'Diary' as the inventor of 'died scarlet'. [5]

Before returning to the subject of the discovery itself, we will first enquire how a knowledge of *Drebbel*'s method of dyeing

scarlet cloth was spread over Europe. *Drebbel* himself does not seem to have done much in this line on a large scale, although the family records of the *Kufflers* show, that the dye-works date back as far as 1607. After his death, however, in 1635, the *Kufflers* formed a company for commercializing the discovery. This they probably did in Bow. In 1642 they settled in Holland — most likely for political reasons — their first place of residence being the Hague.

Very soon after their removal to Holland they began to devote themselves to dyeing. A deed drawn up in Leyden shows that in 1647 a certain Jacob *Kuffler* with a certain *Gys* as his partner, were dyeing scarlet cloth by a new method at Katwyk near Leyden. Scarlet dyeing with cochineal had already been introduced into Leyden itself in 1620 by *van der Heyden*. Probably the promotors of the new process chose Katwyk on the Rhine above Leyden, because their method, as we have already seen, demanded the use of very clear water. [6]

From another Leyden deed it is clear, that *Gilles Kuffler* had settled in Amsterdam between the years 1649 and 1651, probably at the house of his uncle, *Abraham Kuffler*, a clothmerchant of that city[7]. According to the deed, *Gilles* had not always been well versed in the art of scarlet dyeing. [8]

Johannes Sibertus, his brother *Gilles*, a cousin *Johannes Kuffler* and another cousin *Abraham Velthuysen* formed a company at Hulckensteyn, a country place near Arnhem, with a view to establishing a dye-works there in their joint names, but very soon a violent quarrel arose between them, which was however amicably settled in 1654. [9]

In 1656 *Dr Johannes Kuffler* left Holland again and returned to England, where he took over the management of the dye-works in Stratford-Bow after the death of his brother *Abraham*. After that the process must have gradually become more widely known in England, Holland and the other countries.

In France there was already a good method of dyeing cloth scarlet with cochineal. A passage in the writings of *Rabelais* indicates that at the end of the fifteenth and the beginning of the sixteenth centuries this art was already cultivated by *Jean Gobelin* and his son *Philibert* on the banks of the little

river Bièvre in Paris. We read: `and it was by this little stream, which now flows through Saint Victor, that *Gobelin* did his scarlet dyeing.' [10]

The *Gobelins* themselves became rich and gave up dyeing, but their place was taken by two Belgian families, the *Comans* and the *de la Planches*. In 1629 the two families parted company, but the *Comans* kept up their activities at the dyeworks in the Maisons des *Gobelins* until 1654. Then a few years later *Jean Gluck*, or *G1ug*, imported a new method of dyeing scarlet from Amsterdam. This *Gluck*, who was an anabaptist, must have been initiated into the secrets of the art by *Gilles Kuffler*, then living in Amsterdam. [11] About 1660 *Jean Gluck* bought the dye-works in the 'Maisons des Gobelins', where at the time *Cheneviz*, a dyer and former partner of *Etienne Gobelin* was still living. Here he established his works in which the Dutch method was to be employed. In 'L'instruction generale pour la teinture des laines, etc.,' (1669-1671), drawn up by order of *Colbert*, we find mention made of the old procede de l'écarlatte de France (§ 16) and of the rouge écarlatte in the preparation of which tin was used as mordant (§ 22).

Furthermore, Gluck obtained letters-patent from the king in 1677 permitting him to establish works at Lyons, where during twenty years he should be allowed to do all the bleaching and dyeing of scarlet cloth and linen wares according to the Dutch method, to the exclusion of all other persons or workmen, without, however, preventing other workmen in the city of Lyons from preparing or making materials of other colours, even the *escarlatte en graine* (the old French method) or other dyes already in use and established in the above named City. [12]

The dye-works in the 'Maison des Gobelins' remained in the hands of the *Gluck* family and in active working until the beginning of the nineteenth century. From the directions given in *'Le teinturier parfait'* (1708) we see, that the method by which cloth was dyed the Dutch scarlet was the same as that, as we shall see later, used by the *Kuffler*s in England. [13]

The process also soon became known in Germany. *Joh. Kuncke1*(1638-1702), the famous German alchemist, writes in '*Ars*

vitraria experimentalis', when he is discussing the different ways of dyeing red: ‘It is possible to obtain this colour in another way namely with pewter and strong water and in pewter vats produce a much greater degree of brightness.’[14]

In a little book written in 1709 and entitled *'Curieuse and volkommene Kunst Faerber'* we read in connection with the Dutch method of dyeing scarlet: 'Any one wishing to dye scarlet must above all make a special point of obtaining a heavy kettle made of pure unadulterated pewter (large or small, according to the amount he wishes to dye) and to be sure to keep this clean always.' [15]

As may be gathered from the writings of *Savary* (1750), *Kasteleyn* (1791), *Dumas* (1830) and *Laboulaye* (1861), these prescriptions for scarlet dye were able to hold their own until the introduction of synthetic dyes. [16]

Having now recounted how the knowledge of scarlet dyeing by means of cochineal spread through Holland, England, France and Germany, we will proceed to tell the reader something about the process itself, without, however entering into technical details.

During *Drebbel*'s life-time and some time after his death, the secret of how the scarlet colour was produced at Bow never leaked out.

On April 30, 1662, Sir *William Petty* gave a lecture before the Royal Society of London entitled: *'An Apparatus to the History of the Common Practises of Dying*,' from which it is evident, that pewter was purposely used as mordant in the works at Stratford-Bow. *Petty* discusses the different metals used in dyeing and says of pewter: 'They also use Pewter for Bow-dye, Scarlet, viz. they dissolve Bars of Pewter in the *aqua fortis* they use; and make also their Dying-kettles or Furnace of this Mettal.'

Of saltpetre he says: 'The next Mineral Salt is Salt-Peter, not used by ancient Dyers, and but by few of the modern. And that not till the wonderful use of the *aqua fortis* (whereof Salt-Peter is an ingredient) was observed in Bow-scarlet.'

And finally he remarks about cochineal: 'Cochineel is of several sorts, viz., Silvester and Mestequa: This also is used with Branliquor in Pewter-Furnaces, and with *aqua fortis*, in order to the Scarlet dye.'

Speaking of the vessels or tubs, he observes 'In some cases the matter of the Vessel wherein the Liquors are heated, and the Tinctures prepared, must be regarded; as the Kettles must be Pewter for Bow-dye.' [17]

Now *Boyle* relates in 1667:

'A most famous master in this art (this was perhaps *Kuffler*, Auth.) assured me, that neither he, nor others can strike the lovely colour, called bow-dye, unless their materials be boiled in 'vessels of a particular metal.'

Some pages further *Boyle* continues: 'Thus in dying scarlet, tho' you should see every ingredient that is used about it; tho I should particularly inform you of the weight of each; and tho' you should be present at the kindling of the fire, and at the increasing and remitting of it, whenever the degree of heat is to be altered; and tho', in a word, you bour the least doubt of your comprehending the whole art: yet if I should not tell you, that the vessels, which immediately contain the thinging ingredients, are to be made of, or lined with tin; you would never be able, by a due observation of the other circumstances, to bring the tincture of cocheneal to give a perfect scarlet.' [18]

These papers also elucidate to us the directions given in the latter part of the MS. in Cambridge containing prescriptions by *Drebbel* and *Kuffler* for the making of scarlet dye. In this MS. we find first of all directions for the scarlet dye. We learn that the colouring matter is cochineal, and besides the usual mordants — alum and tartar — mention is made of a 'Secrett" which may also be used as mordant. Then follows the prescription for preparing this secret:

To make the Secrett.

`Put your Emitt in A Larg flat firre Tubb and put your water on itt and Putt somuch Common-water to itt thatt itt Beginns to worke when the water Lookes yellow itt is good and the Powder grayish of yellowish if itt spoiles by standings put some fresh Strong water to itt that itt may worke anew and it many times recovers the whole Tubb. You may varie your Colours by adding Allum to make Browner Tartarum to make brighter and yellower

and by diminishing and Augmentinge quantity of Colour, ‚etc.'

Petty's treatise makes it obvious that the word pewter is purposely omitted from the above directions, with a view to preserving secrecy and the non-commital word 'emitt' is used in its stead. As *Petty* tells us, they dissolved pewter in nitric acid and if it would not all dissolve, more 'strong water' was added. In a later set of directions, appearing in this same MS. and dealing with `staining scarlet', we find that this should be done in a pewter pottinger, which also shows that the properties of pewter as a mordant were known.

Other dyers, too, remarked that pewter had an influence on scarlet dye. *Jan Hennebo* of Leyden witnessed to this fact on April 3, 1648, when he declared that in his experiments he had noticed, that scarlet dyed in pewter vessels was much brighter and more beautiful than that done in brass ones. Yet one feels much less sure in his case than in *Drebbel*'s that he purposely used pewter as a mordant. [20]

`How few secrets have there been, though never so gainful, that have been long conceal'd from the whole World by their Authors? Were not all the least Arts of life at first private? Were not Watches, or Locks, or Guns, or Printing, or lately the Bowdye, devis'd by particular men, but soon made common. If neither chance, nor friendship, nor Treachery of servants, have brought such things out; yet we see ostentation alone, to be every day powerful enough to do it. This desire of glory, and to be counted Authors, prevails on all, even on many of the dark and reserv'd Chymists themselves.' [21]

CHAPTER VIII

A SUMMARY

§ 1 Chronological Table

We give here a short outline of the main events in *Drebbel*'s life and in addition note a few facts bearing on these.

1568-1648	Eighty years war between the Netherlands and Spain.
1572	*Cornelis Drebbel*, son of *Jacob Drebbel*, born at Alkmaar.
1584	*Prince William of Orange* murdered at Delft; his son, *Maurits* becomes Stadtholder of Holland.
1585	After Antwerp had been taken by the Spaniards, some of the inhabitants of this city settled in Middelburg, with the result that a flourishing glass-industry grew up there. This explains why such men as *Sacharias Janssen*, *Hans Lippershey*, *Cornelis Drebbel*, *Jacob Metius*, *Beeckman*, and *René des Cartes* were able to learn this trade in Middelburg.
1591	*Drebbel*'s father dies at Alkmaar.
1595	*Drebbel* marries *Sophia Goltzius*, youngest sister of the famous artist, *Hendrick Goltzius*, who lived at Haarlem and who was *Drebbel*'s instructor in the art of engraving and in alchemy.
1597	*Drebbel*, an inhabitant of Alkmaar, made a fine map, of this town.
	Adriaen Metius, (the son of *Adriaen Antoniszoon*, burgomaster of Alkmaar, mathematician and expert in the contruction of fortifications) was appointed professor of mathematics and astronomy at the University of Franeker.

1598	*Drebbel* takes out a patent for a certain sort pump and time-piece.
1599	*Cornelis* and *Frederik de Houtman* visit the Indies. The first Dutchmen to do this.
1600-1601	*Drebbel* works in Middelburg, where he constructs fountain amongst other things.
1602	*Drebbel*, as a citizen of Alkmaar, takes out a patent for the building of chimneys.
1603-1625	*James I*, King of England.
1603	*Drebbel* living at Haarlem. On his return from the Indies, *Frederik de Houtman* a relation of *Drebbel*'s, publishes a book on the Malay language, in which he includes a description ofthe constellations to be seen in the Southern hemisphere. (He had studied astronomy under *Adriaen Metius*).
1604	*Drebbel*'s booklet 'On the Nature of the Elements' appears.
1605	*Jan Adriaenszoon Leeghwater*, together with *Pieter* and *Wilhelm Pietersz.*, take out a patent for his diving apparatus, after having demonstrated this in the Hague to *Prince Maurits* in April of that year.
1606	About this time *Drebbel* moves to England. Here he constructs his Perpetuum mobile for *King James* and enters the special service of *Henry*, Prince of Wales.
1608	At the end of September *Hans Lippershey* shows his telescope to *Prince Maurits* in the Hague and also to *Frederik Hendrik* and the Spanish Commander, *Spinola*, who was in Holland in connection with negotiations concerning an armistice. On October 2nd, he asks for a patent. *Jacob Metius* also tries to get a patent, and on October 17th, fl. 300 are given him for use in the completion of his invention. *Drebbel* makes inquiries of his friend *Ysbrandt van Rietwyck* concerning this invention.
1609-1621	Twelve years' Truce between the Netherlands and Spain. Quarrels about the teachings of Aristotle at the University of Franekerl as a result of which *Adriaen Metius*' salary was reduced by fl. 50.

1610 *Drebbel* goes to the court of *Rudolf II* in Prague in October. *Galilei* copies the Dutch telescope and demonstrates it before important personages, in Venice. A letter from *Gloriosi* proves that *Galilei* was the first to describe Jupiter's moons, but not the first to observe them. The writings of *Adriaen Metius* lead us to conclude that he himself had, by the aid of his brother's telescope, already observed sun-spots, mountains on the moon, moons round Jupiter and phases of Venus, before the publication of *Galilei*'s Nuncius Siderius.

1611 *Matthew* takes Prague. According to *de Peiresc*, *Drebbel* was taken prisoner but later released.

1612 Death of *Rudolf II* on January 20th. *Drebbel* wishes to leave Prague, but he is prevented. *Matthew* becomes Emperor of Germany.

1613 *Drebbel* is given money to make his journey and leaves for England.

1617 *Hendrick Goltzius* dies at Haarlem. From a deed connected with his estate we learn that *Drebbel* was living in London.

1618-1648 Thirty years' war in Germany.

1618 *Balthasar Gerbier* writes his elegy on *Hendrick Goltzius*, from which we learn that *Drebbel* was at the time already occupied with experiments with his divingboat.

1619 *Frederik V*, Count Palatine, becomes king of Bohemia (Nov. 3) after the capitulation of Prague. According to *Cornelis van der Woude*, *Drebbel* was taken prisoner on this occasion. According to other writers, *Boreel, Gerbier, Morsius*, he was living in London.

1620 *Cornelis Drebbel* and *Adriaen Metius* visit the glass grinder, *Sacharias Janssen* at Middelburg. About this time *Drebbel* meets *Abraham* and *Jacob Kuffler*. *Frederik V* disappears from Prague and takes refuge in the Hague.

1622 Constantyn *Huygens* sees a great deal of *Drebbel* in London, buys telescopes and a camera obscura from him. *Jacob Kuffler* goes to Paris and then to Rome in order

to demonstrate *Drebbel*'s microscopes. After his death in the latter city, *Abraham* sends for his two other brothers, *Johannes Sibertus* and *Gilles*, to come to England.

1623 *Abraham* marries *Drebbel*'s daughter *Anna*.

1625 Death of *James I*. *Charles I* becomes King. Death of *Prince Maurits*. *Frederik Hendrik* becomes Stadtholder of Holland.

1626 *Drebbel*, in service of the British Navy, settles in the Minories, London.

1627 *Johannes Sibertus Kuffler* marries *Drebbel*'s daughter, *Catherina*. La Rochelle besieged by French Government troops. First effort of the English under Buckingham to relieve this city. *Abraham Kuffler* also present on that occasion.

1628 *Leeghwater* and *Descartes* took part in the siege of la Rochelle, while *Drebbel* was in the last English expedition, which was not successful. *Drebbel* dismissed from the service of the Admiralty.

1629 During the siege of 's Hertogenbosch *Leeghwater* renders valuable services to the Stadtholder, *Frederik Hendrik*, in matters of hydraulic engineering. *Descartes* studies mathematics and astronomy at Franeker under *Adriaen Metius*.

1631 *Drebbel* associated with the mathematician *Henry Briggs* in plans for the draining of lands around Cambridge.

1633 Death of *Drebbel* in the Parish of Trinity, London.

§ 2 Discoveries and Inventions

If, in conclusion, we take a bird's-eye view of *Drebbel*'s most important discoveries and improvements, the following facts stand out as worthy of particular attention:

At the age of twenty-five, *Cornelis Jacobszoon Drebbel* was already an engraver of unusual merit, who had received his training from *Hendrick Goltzius*. At about the same time he began his career in the field of applied science by making investigations into the question of the variation in the volume of air brought about by

temperature and pressure. In the course of his life as an Inventor he constructed many instruments on the basis of the results of his researches in this field and the insight he gained by this work; in his little book on the elements (Published in 1604) an important place is given to the subject of gases and liquids in connection with his explanations of such natural phenomena as rain, wind, thunder and lightening.

As early as 1598 he took out patents for a certain kind of pump and a clock which did not need winding, which depended on the variation in the volume of air. In 1600 he made practical application of his knowledge in Middelburg, in connection with a fountain he contructed there, and again in 1610 he built a structure of a similar nature for *Rudolf* II in Prague.

It was on this same principle of the change brought about in the volume of air by the action of temperature and pressure, that he made his perpetuum mobile for *James I* at Eltham, in about 1605, when he was in England.

While *Adriaen Metius*, a fellow townsman of *Drebbel*'s in Alkmaar, was trying to explain the cause of the primary motion among stars - the primum mobile - *Drebbel* produced perpetual motion, the *perpetuum mobile* as counterpart.

This *perpetuum mobile* in its simplest form consisted of a glass bulb filled with air or a fierie spirit, connected with a glass spiral, in which there was a small quantity of liquid. Owing to the change in temperature, the air expands by day and decreases in volume again during the night, with the result that the liquid in the spiral may be seen moving backward and forward with a motion like the ebb and flow of the tide — the principle on which the airthermometer is based.

Drebbel used this same principle in his *self-registering ovens* and his *incubators* for the hatching of chickens. His successors in these researches members of the Royal Society like *Hooke, Boyle, Wren, Renshaw and Goddard,* were very much interested in these instruments, details concerning which they obtained especially from his son-in-law, Dr *Johannes Sibertus Kuffler*.

It seems quite certain that *Drebbel* was an expert in the manufacturing, blowing and grinding of glass, for in making his optical instruments he melted a certain kind of glass, of which

he alone knew the constituents. The glass spirals, which he blew for the *perpetuum mobile*, were most difficult to make and he invented a most ingenious machine by means of which he ground his lenses.

Constantyn Huygens became well acquainted with the art of grinding glass, especially during his visit to London in 1622, when, as a friend of *Drebbel*, he was in constant touch with him. In that same year he bought one of *Drebbel*'s telescopes for forty guilders. These facts may be partly responsible for his son *Christiaan's* skill in making telescopes at a later date with one of which he was able to discover Saturn's rings (1655).

Even *Drebbel*'s grandson, *Augustus Kuffler*, was still a practised glass grinder in 1685, as is proved by his making glass stoppers for bottles, although he was a physician.

Constantyn Huygens aroused much admiration and interest in *Drebbel*'s camera obscura, when he returned with one of these instruments to the Hague and showed it to the painters, *De Gheyn* and *Torrentius*.

The latter may have made use of a similar apparatus in the painting of his much admired still-life pictures.

Drebbel is credited with the invention of the microscope with two convex lenses. In 1622 these microscopes were demonstrated in Paris by *Jacob Kuffler*, in the presence of the Queen Mother, *Maria de Medici* and the French savant, *de Peiresc*. Subsequently they were taken on to Italy, where *Galilei* was one of the persons who became acquainted with them. He made some of his own on the same model.

Later, *Robert Hooke* and *Christopher Wren* made improved forms of Camera Obscura and microscopes by means of their own grinding machines, thereby building on the foundation laid by *Drebbel*, for they, like *Boyle* and *Constantyn Huygens* Junior, came into personal contact with *Drebbel*'s daughter, *Catharina*, and with his son-in-law, Dr *Johannes Sibertus Kuffler* and were therefore thoroughly well informed as to the details of *Drebbel*'s inventions.

Great was the fame reaped by *Drebbel* on account of his *sub-marine* or *diving-boat.* This boat, which had no bottom, was built on the principle of the diving bell. He measured the depth he

had reached under water by means of a quicksilver barometer, steered by means of a compass, and went a great distance down the Thames to the great astonishment of James I and his court and many Londoners who were present.

Inside the boat he renewed the air, by use of a gas, made from saltpetre, 'broken up by the power of the fire and so changed in the nature of the air'. He knew that air is made up of two component parts, the *quintessence* (oxygen), fit for respiration, and the *carcass* (nitrogen), unfit for respiration.

Later *Drebbel*'s views were the subject of much discussion among members of the Royal Society, *R. Boyle, R. Hooke, John Mayow,* yes, even *Spinoza* (the latter at the request of the Secretary of the Royal Society) tried to elucidate the method by which *Drebbel* had been able to extract air in the form of spirit from saltpetre, vitrum. Research into the problem of Spiritus-nitroaereus, has occupied the minds of chemists in England ever since the days of *Drebbel*'s experiments with his diving-boat.

Soon after his arrival at the English court, *Drebbel* helped to display rare fire-works. Later he devoted himself to making *aurum fulminans, fulminate of gold,* which he made use of before La Rochelle as a detonator in his petards and torpedoes (1628).

Finally, *Drebbel* was the first to use tin salt as a mordant in dyeing with cochineal. This method was applied by the *Kuffler* brothers, *Drebbel*'s sons-in-law, in their dyeworks at Stratford-Bow. Later the process became known all over Europe and was generally conceeded to be the finest for scarlet dyeing.

A number of recipes — chemical, pharmaceutical and culinary — have been preserved at Cambridge in a MS. of *Augustus Kuffler*, *Drebbel*'s grandson. The publication of parts of this document would certainly be worth while.

Attention should be, called to *Drebbel*'s monogram and autograph, which might perhaps serve as means of identifying further drawings or instruments of his, still extant perhaps in English collections.

The reason why *Drebbel* did not make all his discoveries public is to be found, perhaps, in the fact that they constituted his means of subsistence. After his dismissal from service in the British Navy in 1629, he was very poor. He was not able, like *Robert*

Boyle and *Christiaan Huygens*, who were both great landowners to give immediate publicity to an invention. And so the interesting and thrilling life of *Cornelis Drebbel*, ‘that great singular learned mechanic,‘ as *Boyle* called him, was not lived in vain. May the device [1] which guided him in his work, also inspire the rising generation of our men of science:

`USE THY GIFTS RIGHTLY.'