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Caravaggio and the Alchemy of Painting

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In December 2005 I felt a need to gather together in a bilingual presentation what I had previously written on Caravaggio and optics[1] (Fig. 1) in order to update the areas of Italian research on Painted Optics[2] that had been misunderstood largely due to inaccurate translations. David Hockney deserves great credit for his 2001 publication *Secret Knowledge*[3] and for the subsequent debate on the Internet amongst artists and scientists, like Charles Falco and Michael J. Gorman[4], on the possible use of camera obscura by painters.

My research has always been developed along two parallel tracks:
Art-Historical and Optical-Geometrical.

There was an underworld of 'hidden scientists', active in a field opposed by the Church, that of lenses, accused of cheating because "disturbing the images during their difficult path, towards the eye, they alter any information of the external world"[5].

In the past University Professors maintained an absolute opposition towards

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[1] R. Lapucci, *Caravaggio e l'ottica/Caravaggio and Optics*, Firenze, Servizi Editoriali, 2005.

[2] Among the first Italian studies on the camera obscura and the image projections must be remembered R. Longhi, *Caravaggio*, Roma, 1952; V. Ronchi, *Storia della tecnica ottica*, Firenze, 1970; Luigi Spezzaferro, *La cultura del Cardinal Del Monte e il primo tempo del Caravaggio*, in 'Storia dell'arte', III, 9-10, gennaio-giugno 1971, pp. 57-92; A. Parronchi, *La 'camera ombrosa' del Caravaggio*, in 'Michelangelo', V, 1976, 18, pp. 33-47; C. Ragghianti, *Tra Leonardo e Caravaggio. Nuove indagini di linguaggio formale: specchi, illuminazioni, camere ottiche*, Laboratorio di studi sulla forma, Università Internazionale dell'arte, 1973/74; M. Gregori, *Giovan Battista Moroni*, Bergamo, Bolis, 1979 plus other important essays by: Ferdinando Bologna, Marco Bona Castellotti.

[3] D. Hockney, *Secret Knowledge: rediscovering the lost techniques of the Old Masters*, London, Thames and Hudson Ltd, 2001.

[4] D. Hockney, ivi, 2001; C. Falco, D. Graves, *Questions of Optical Evidence*, s.d., in http:/www.artandoptics.com; M.J. Gorman, *Art, Optics and History: New Light on the Hockney thesis*, in "Leonardo", 36, 24, 2003, pp. 295-301; D. Stork, *Caravaggio's Supper at Emmaus (1601-02): problems in re focusing, problems in the studio, problems with illumination*, 2002, in webexhibits.org; S. Grundy, *On the other hand: a positive look at Caravaggio and the camera obscura*, 2004, in webexhibits.org.

[5] V. Ronchi, 1970, p. 102.

those 'small glossy glass disks'[6] which, on the contrary were used with great satisfaction. However, as this topic was close to heresy, it was rejected and employed only in fields considered less important, such as the collection of scientific specimens, dream interpretation, magic and theatre scenography[7].

Analyzing the evolution of the projection systems one could say that the basic phenomenon of light passing through the window and projecting images was already known by Alhazen and his followers in the Medieval period; also Leonardo quotes it several times in his Treatise (in relation to the formation of images in the retina); he knows the principle of the stenopeic hole (Fig. 2); the use of a first convex lens will be suggested by Girolamo Cardano (1550) and by Daniele Barbaro (1568); the correct positioning of the image upside-down will be reached by Giovan Battista Della Porta through the use of a biconvex lens; the left-right flipping will be obtained only with a second biconvex lens, added by Kepler[8].

The optical systems, thanks to the use of lenses and mirrors, formed reduced images of the world with the same reproduction of light (shading and colour); they were used to astonish the spectator with magical tricks, called 'Deceptiones'[9].

The Lombard-Venetian entourage was particularly sensitive to these studies immediately related to artistic shows (theatre, painting).

In Venice Monsignor Daniele Barbaro and Fra Gerolamo Fracastoro were active in this field[10].

In Milan Girolamo Cardano, doctor of the Borromeo family, was a mathematician, astrologist, dream interpreter, practiced card player and cardsharp[11]. In Pavia he had a laboratory where he created devices experimenting on the "effetto ottenuto sistemando lenti in una o in un'altra posizione; del piombo come fondente nella lavorazione del vetro, delle proprietà dei prismi di cristallo; della sostanza dei colori; dell'impiego del calore"[12].

He was also a friend of Galeazzo Rossi, a very able blacksmith, who was able to forge a sword that could bend like lead but was able to cut iron as if it was wood, or to make armour resistant to bullets. Many times he was brought to trial by the Inquisition and then released; finally he decided to abandon the Spanish territories and went to live in Bologna in 1562[13].

However, the strongest personality in this field was just one of these amateur scientists, not an academic scholar, Giovan Battista Della Porta (Fig. 3), who wrote a fundamental text, *Magiae Naturalis; sive De miraculis rerum naturalium*,

[6] V. Ronchi, 1970, p. 105.

[7] R. Lapucci, *Caravaggio e i "quadretti nello specchio ritratti"*, in Paragone, XLV, 1994, 529-531-533, pp. 160-170.

[8] M. Kemp, *The Science of Art. Optical themes in western art from Brunelleschi to Seurat*, New Haven and London, 1990, pp. 188-191.

[9] A chapter on "Deceptiones" is present in *Turrius, sive de Intellectione*, 1540 ca., by Gerolamo Fracastoro, wholly transcribed in Italian by V. Ronchi, 1970, p. 103.

[10] R. Lapucci, 1994, pp. 161-162.

[11] J. Hammond, *The Camera Obscura. A Chronicle*, Bristol, 1981, p. 15.

[12] M. Milani, *Gerolamo Cardano. Mistero e scienza nel Cinquecento*, Milano, 1990, p. 98.

[13] M. Milani, 1990, p. 98.

libri IIII, Neapoli, 1558; *Della Magia Naturale*, II edition, Venice, 1579.

The book did not aim to be a scientific text but only to justify some marvellous phenomena that, anyway, occurred in nature. Chapter XVII of this Treatise is titled: "How someone who cannot paint, can draw the outline of a man or of any other thing, provided that he can match the colours"[14]. Here the author teaches an expedient to reproduce faithfully a figure through the use of a concave mirror and a biconvex lens[15].

In the Lombard-Venetian entourage of the XVI century the first projections were probably executed only with lenses or only with mirrors. The contours of the shapes were projected like Chinese shadows. Paolo Pino (1548) describes artworks by Giorgione reflected by mirrors several times in the same painting (Saint George)[16]. At that time it was being debated whether painting, as well as sculpture, could have a 3-D rendering. These artworks aimed at showing the two (front and back) or three (side view) sides of a personage, such as:

- Savoldo, *Gaston de Foix,* Louvre (Fig. 4), shortening and counter shortening, mix of direct and reflected light, angle bone structures, projections and contractions[17].
- Giovanni Bellini, *Young woman at the mirror,* Wien, Kunsthistorisches Museum (Fig. 5), Signed and dated "JOANNES BELLINUS FACIEBAT MDXV" (1515).
- Lorenzo Lotto, *Triple portrait of a jeweller*, Wien, Kunsthistorisches Museum (Fig. 6).

The direct dependence of Caravaggio's art on Giorgione's has to be read again today in the sentence attributed by Giovanni Baglione[18] to Federico Zuccari when commenting on the *Calling of St. Matthew* at San Luigi dei francesi: "I do not see anything else than Giorgione's thought".

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[14] G.B. Della Porta, *Della Magia Naturale*, 1558, consulted edition, Napoli, 1611, p. 639.

[15] At the beginning I hypothesized that his system also made use of a stenopeic hole, while today I think that the opening described by Della Porta (large one finger and deep one finger) was rather acting as a diaphragm.

[16] P. Pino, *Dialogo di pittura*, 1548, in P. Barocchi, *Trattati d'arte del Cinquecento. Fra Manierismo e Controriforma*, Bari, 1960 (vol. I: Varchi, Pino, Dolce, Sorte), p. 131: "... se la memoria mia conserva il ragionamento vostro, chiuderò la bocca a questi che vorranno diffendere la scultura, come per un altro modo furno confusi da Georgione di Castel Franco, nostro pittor celeberrimo e non manco degli antichi degno d'onore. Costui, a perpetua confusione degli scultori, dipinse in un quadro un San Georgio armato, in piedi, appostato sopra un tronco di lancia, con li piedi nelle estreme sponde d'una fonte limpida e chiara, nella quale transverberava tutta la figura in scuro sino alla cima del capo; poscia avea finto uno specchio appostato a un tronco, nel qual rifletteva tutta la figura integra in schena et un fianco. Vi finse un altro specchio dall'altra parte, nel qual si vedeva tutto l'altro lato del San Georgio, volendo sostentare ch'uno pittore può far vedere integralmente una figura a un sguardo solo, che non può così far uno scultore".

[17] C. Ragghianti, 1973/74, p. 6.

[18] G. Baglione, *Le vite de' pittori, scultori, et architetti*, Roma, 1642, ed. cured by V. Mariani, 1935, p. 137 "Che rumore è questo? E guardando il tutto diligentemente, soggiunse. Io non ci vedo altro, che il pensiero di Giorgione, nella tavola del Santo, quando Christo il chiamò all'apostolato; e sogghignando, e maravigliandosi di tanto rumore, voltò le spalle et andossene con Dio".

In fact, in the *Three philosophers, 1504-09,* (Fig. 7) Wien, Kunsthistorisches Museum there are some elements that can raise new interpretations.

Marcantonio Michiel refers to this subject as three men: "due riti e uno sentado che contempla gli raggi solari"[19] ("two standing and one sitting who contemplates the sun's rays"), but what is in his hand? An astrolabe? Is he projecting rays into a cave? The young man seated has been identified with the Anti-Christ death carrier, whose arrival had been predicted by the astrologists in 1504.

The central figure (as visible in X-ray analysis) has dark skin (Is he Arab? Maybe Alhazen?). The old man on the right side has a paper in his hands showing the phases of the moon. Giorgione paints "without drawing"[20].

To better understand how these projections could take place we can use two charts executed by Susan Grundy, showing a Projection with a biconvex lens (Fig. 8) and a Projection with a concave mirror (Fig. 9).

Multiple hypothesis can be proposed on the basis of a Della Porta text which proposed a combined use of a concave mirror and of a biconvex lens.

One is represented by this axis-symmetrical scheme (Fig .10) proposed by Gorman in 2003[21]. In my opinion, even if it is correct for the calculations of the focal distances and for the path of the rays, however it uses too big a lens and too small a mirror in respect to what was available at Della Porta's time. Moving the object closer or farther from the lenses, or from the mirrors, permits one to reduce or enlarge the dimensions of the projected shape.

What made me think that Caravaggio had used the Della Porta system (Fig. 11)? Maybe he had met him in the Lombard-Venetian entourage before his transfer to Rome or at the Del Monte house[22] or through Giovan Battista Marino and the Crescenzi family[23].

Della Porta succeeded, by using biconvex lenses and concave mirrors, to reverse the upside down image into the right way up, but not from left to right[24].

Caravaggio did not use any preliminary drawing: was he painting while images were projected?

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[19] MARCANTONIO MICHIEL, venetian, art lover, contemporary of Giorgione; he left several notes on Venetian artists. His intention was to write a Treatise but Vasari did it first and he abandoned this idea. For a complete biography see: *Marcantonio Michiel*, Series: Le voci del Museo, edited by C. DE BENEDICTIS, Edifir, Florence, 2000.

[20] In *Titian biography*, Giorgio Vasari (1568, Milano, 1964, edited by G. PREVITALI, P. DALLA PERGOLA, L. GRASSI, from the text of the Giuntina edition, vol. VII, pp. 303-348) mentions him as a pupil of Giorgione; this latter Master after 1507 "...usando nondimeno di cacciarsi avanti le cose vive e naturali, e di contraffarle quanto sapeva meglio con I colori, e macchiarle con le tinte crude e dolci, secondo che il vivo mostrava, senza far disegno, tenendo per fermo che il dipingere solo con i colori stessi senz'altro studio di disegnare in carta fusse il vero e il migliore modo di fare e il vero disegno..." (p. 308).

[21] M.J. GORMAN, 2003, p. 298.

[22] L. SPEZZAFERRO, 1971, p. 77 nota 106.

[23] A. PARRONCHI, 1976, p. 42.

[24] For this one will have to wait for Johannes Kepler and his system with two biconvex lenses, published in his *Dioptrice*, Augsburg, David Franck, 1611 as in the human's eye crystalline.

He repeated the same models twice in a single composition: was he multi-projecting different views of the same model on a single canvas? (Fig. 12).

During the Del Monte period he had too many left-handed models (Figs. 13, 14): was he unable to reverse the projected image left to right with the system he used at this time? This seems confirmed by the fact that the same personages present here (Mario Minniti and Fillide Levasti) are reproduced using the right hand in other artworks.

The use of projections through systems associating mirrors and lenses developed thanks to new discoveries related to the invention of the telescope, which Della Porta also wanted to achieve. However, the use of low quality lenses (badly polished and forged) resulted in an increase in the contrasts (stronger chiaroscuro shading), distortion or aberration in the anatomical foreshortening (Bellori criticizes Caravaggio who does not know how to put the right fore-shortened pose in his figures because he lacks drawing skills); the use of a 'camera obscura', of a source coming from above and of torches (other scholars refer to candles)[25]; all aspects often mentioned by the biographical sources on Merisi[26].

An evident effect of distortion due to projection can be noticed in the *Boy with a basket of fruit,* Rome, Borghese Gallery (Fig. 15) where Susan Grundy observed an unusual elongation of the head and neck, due to the projection. With photo editing software she corrected the distorsion, inclining the painting towards the spectator in its upper part (squeezed 90%). A similar effect is in the glass vase in the *Boy bitten by a Lizard*, Florence, Longhi Foundation (Fig. 16).

Literary sources describe the artist's camera obscura. In the painter's room "a uniform light coming from above without reflections, as it could be in a room from a window with the walls painted in black; thus having the pale and dark colours very pale and very dark, this gives relief to the painting but in an unnatural way, never previously done or thought of in any other century or by any other

[25] D.G. Stork, 2002, p. 7 (here he mentions the use of hundreds of candles, which I personally do not believe).

[26] Concerning the increase in the contrasts it is useful to quote two sentences by G.P. Bellori, *Le Vite de' Pittori, Scultori et Architetti moderni*, Roma, 1672, ed. 1976, p. 204 (English translation in H. Hibbard, *Caravaggio*, Harper & Row, New York, 1983, p. 363): "For this gentleman he painted the Concert of Youths portrayed from life in half-figures; a woman in a blouse playing a lute with the music sheets in front of her; a kneeling St. Catherine leaning on the wheel. The last two paintings are also in the same rooms but have a darker color, as Michele had already begun to darken the darks"; "the coloration ... was not as sweet and delicate as before, but became boldly dark and black, which he used abundantly to give relief to the forms" (Bellori, p. 204, in Hibbard, p. 364).

For the distorsions or aberrations, see always G.P. Bellori, 1672, p. 205: "he did not know how to come out of the cellar and that, lacking invenzione and disegno, without decorum of art, he painted all his figures with a single source of light and on one plane without any diminution" (in Hibbard, p. 364) and p. 213: "Now began the imitation of common and vulgar things, seeking out filth and deformity"(Hibbard, p. 372) but also G.P. Bellori, Postille autografe alle vite di G. Baglione, p. 138:" Who wanted to paint as well as Caravaggio, had to have the good Natural as Caravaggio. Second, I answer that if it is true that the Natural suffers for defects, because one man is too big, the other too small, one too straight, the other too crooked, however it is also true that Natural, good or bad, is always the Master of Art following Nature".

ancient artist"[27] or else: "he went on so much in his way of painting, that he never went out in the sunlight, (with) any of his figures, but he found a way to execute them in the dark air of a closed room, using a light from above which came down straight on the principal part of the body, leaving the rest in the shadow in order to confer power with a strong pale and dark, contrast"[28].

In the *Calling of St. Matthew*, Rome, San Luigi dei francesi, light does not come from the window but from the "hole in the ceiling". This use can be traced back to seeing the gnomons installed in Florence by Ignazio Danti, first in the Church of Santa Maria Novella and later in San Petronio at Bologna, where he lived from 1575 to 1578[29]. Gnomon is a Stylus whose shadow, projected on to an horizontal or vertical plane, indicates the direction or the height of the sun. The ancients used it as a watch, or to determine latitude[30]. It was usually installed on the facade and traced the path of the sun on the floor of the Church (Figs. 17, 18).

Sunlight, the source of light used by Caravaggio when composing his paintings, did not remain in a fixed position, but moved continuously during the day. In the *Beheading of St. John*, Valletta, Co-Cathedral (Fig. 19) each personage acts as a protagonist at different times during the day[31]. This imposes the necessity of "re-focusing" as David G. Stork[32] (Fig. 20) noticed; every hour the light situation in the room changes and the artist needs to re position the lenses and the mirror (Fig. 21); however this provoked the dimensional variation of the new area subject to projection.

This kind of variation can be observed in the *Martyrdom of Saint Matthew*, Rome, San Luigi dei Francesi (left leg and foot of Saint Matthew) (Fig. 22) or in the *Boy bitten by a lizard*, Florence, Longhi Foundation (Fig. 23) where the boy is executed in two different settings of light and size:

The right side of the face is bigger, wider, longer, darker; the left side of the face: smaller and brighter, slightly rotated towards the spectator.

Hockney suggested[33] that to avoid re-focusing, Caravaggio sometimes projected separated portions of reality and then he recomposed them together as in a patchwork (Fig. 24).

He projects from the model and quickly traces some sketches of figures that often he reuses at a later time for other projections. There are several examples

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[27] G. Mancini, *Considerazioni sulla pittura*, (ca. 1617-21), ed. Marucchi, Roma, 1956, p. 108.

[28] G.P. Bellori, 1672, p. 217.

[29] M. Kemp, 1990, pp. 78-79.

[30] AAVV, *La nuova Enciclopedia delle scienze*, Garzanti, Cernusco sul Naviglio, 1998, p. 714.

[31] There are several light sources in this painting: Salome and the old servant are highlighted by a side light positioned on the left and almost parallel to them. The jailer from a light source that was above him that was more dirtect and diagonal. The executioner by an almost perpendicular light slightly advanced towards the spectator in respect to the vertical plane of the artwork. Finally the Baptist seems projected at two different times (torso and legs separately); maybe in the centre the two portions did not join (smaller dimensions of the legs) therefore the artist covered them with the red mantle hiding the hips.

[32] D.G. Stork, 2002.

[33] D. Hockney, 2001, p. 114.

(Figs. 25, 26) which allow us to hypothesize this use, sometimes they are flipped left to right (Fig. 27).

Accurate investigation is needed for the light sources. Lomazzo distinguished between primary (external entering the painting towards its background) and secondary sources (luminous bodies which project light vice versa, or better from inside the painting outwards versus the spectator) thus forming two directions of light rays, one bringing you towards the background of the artwork and one pushing you outside again from there, as noticeable in the lantern of the Dublin, *Capture of Christ* (Fig. 28) or in the candle of the *Seven Acts of Mercy*, Naples (Fig. 29).

After the geometrical section, let's now examine briefly some documentary aspects of the scientist-artist link between the end of the XVI and beginning of the XVII century.

The connections between Caravaggio and the scientists of his time were much stronger than supposed in the past. As Leonardo, the artist was a scientist, or better he was a science divulger (like Super quark or National Geographic today); he had the task to explain via images the complex phenomena which rule the natural world. A very modern behaviour; today the visual culture clearly prevails over the oral or written one; it has a more direct and effective power in respect to expressing oneself in words.

Even if the artist's science often is not exact; in order to become easily comprehensible (and therefore usable by a vast public) sometimes it is simplified and is subject to some empirical decisions.

In 1545 Titian painted the *Portrait of Daniele Barbaro* (Fig. 30) (probably projected by lenses) and 4 years later (1549) he acted as a witness at an important baptism in Venice, of the baby future Cardinal Francesco Maria Del Monte, as a close friend of his father. Simone Peterzano, Caravaggio's teacher, is 'Titiani alumnus'[34].

However at the turn of the century in the scientific world the situation drastically changes: Leonardo's science is not a true one, Galileo's is, because it comes from scientific method. The attention moves from a still and stable world to one "all in motion". Consequently even light is not studied in a relationship to perspective but to motion. Nature is no longer only investigated by the senses but also by instruments and described via physical laws (Newton will define them *Principia*).

The Microcosmos is explored with a new analytical view (lenticular as imposed by the field of scientific illustration) as well as the Macrocosmos (with the telescope to observe the movement of the celestial bodies).

The interest in optics was particularly influenced by the ideas of the Bishop Sfrondati in Milan[35] and of the Council of Trent (1548-1563), which established

[34] L. Spezzaferro, p. 58, note 14; S. Grundy, 2004.

[35] S. Bandera, *Giulio e Antonio Campi in San Paolo Converso a Milano*, in Paragone Arte,

that Nature must be perceived through the senses and that among them sight has to be the main one.

That is the reason why in the second half of the XVI century there were so many new editions of ancient Treatises[36] on the subject, such as in 1563 Claudii Ptolomaei *Liber de analemmate*, Rome, and in 1571, Alhazen, *Catoptrica*, Milan; or in 1573 when Ignazio Danti translated into Italian, Euclides, *Optics*, published in Florence.

Observing the frontispiece of the book by Nicolò Tartaglia, *La Nova Scientia*, Venezia, 1550 (Fig. 31) one can notice that here some disciplines are considered fundamental to the New Science such as Music, Arithmetic, Astronomy, Geometry, Perspective. They prevail over the old science (Astrology, Necromancy, Sorcery...). On the back is Philosophy with an inscription: "Nemo huc geometrie expers ingrediat", close to the inscription: Plato and Aristoteles. Meaning that one cannot proceed from Philosophy to Science without Geometry. To introduce one to this new Science on the door there is Euclides. Tartaglia also published a dissertation on Euclides[37]. Galileo is the pupil of Ostilio Ricci, who was in turn a pupil of Tartaglia.

The crossed paths between Caravaggio and the scientists were many; they were all friends or correspondents of Galileo. Already in Milan, in the Peterzano workshop he often met Gian Paolo Lomazzo[38] the theorist of light, in contact with Cardano and Benedetti and Ottonario, Piemontese mathematicians[39], friends of Galileo and Guidubaldo Del Monte.

In Rome under the patronage of Cardinal Francesco Maria Del Monte, he was connected to Cardinal Federico Borromeo, Galileo and Tommaso Campanella; Francesco Maria, in his alchemic cabinet, produced mirrors and glass. Here he probably met his brother Guidubaldo. In the Urbe, Caravaggio also sold paintings to Vincenzo Giustiniani (friend of Del Monte and collector of mirrors) and to a "(specchiaro) mirror maker who lives at Magine di Ponte"[40].

In the Inventory of the artist's studio (written for the trial against Prudenzia Bruni, in 1605) a mirror shield and eleven pieces of glass (lenses) are cited; he also had to appear in court for having made a hole in the ceiling of his landlady[41]. However according to Fiora Bassani and Riccardo Bellini at this time he

n. 69, III serie, 2006, pp. 40-60.

[36] The information on these new editions of the ancient Treatises is provided by M. Kemp, 1990, p. 86, and note 106 at p. 349.

[37] N. Tartaglia, *Euclide Megarense Philosophe*, Venezia, 1543.

[38] Lomazzo, the theorist of Light divided it into three parts: Optics (sight perspective), sciography (chiaroscuro and shadows), specularia (reflections). For a complete series of Lomazzo writings, see P. Ciardi, *Giovan Paolo Lomazzo, Scritti sulle Arti*, I vol., Firenze, 1973; II vol., Firenze, 1974.

[39] G.B. Benedetti, *Diversarium speculationum mathematicorum*, Torino, 1585; in M. Kemp, 1990, p. 86 and note 109 at p. 349.

[40] F. Bassani, R. Bellini, *Caravaggio assassino. La carriera di un "valentuomo" fazioso nella Roma della Controriforma*, Roma, 1994, p. 38 and note 11.

[41] F. Bassani, R. Bellini, 1994, pp. 201-202.

had stopped experimenting with Della Porta's writings[42]; I agree and will soon publish more on this topic.

He also attended the house of Monsignor Paolo Gualdo, friend of the poet Marzio Milesi, and of Galileo, interested in science and suspected of heresy in 1611[43].

After the murder of Ranuccio Tomassoni, Merisi escaped with Andrea Ruffetti, a notary, graduate in *Legislation* whose house was always full of biologists, botanists, philosophers (links to the scientific illustration field)[44].

When he moved to Naples he met Giovan Battista Manso, Marchese di Villa, another friend of Della Porta, as Colantonio Stigliola, scientist of physical forces, the most Galilean of all the Neapolitan scientists, as was also Paolo Beni (defender of the *Sidereus Nuncius*). Most people in this group joined the Academy of the 'Svegliati' ('Awakened', including Tommaso Campanella)[45].

Also in Sicily his friends, such as Vincenzo Mirabella, were Galilean; this noble man from Syracuse, poet and scientist, was preparing a telescope and asked Galileo to send him "two crystals for the telescope"[46]. However it is the link with Guidubaldo Del Monte which has not sufficiently been investigated. Galileo had noticed the spots on the sun and the moon "in virtù di Perspettiva", some "in scorcio", some "in faccia", only thanks to the geometric projections on the curved surfaces (Fig. 32) that Guidubaldo Del Monte had explained in his *Perspectivae libri sex*, published at Pesaro in 1600; Galileo had a chance to see a first draft of this publication on the occasion of his visit to Del Monte in 1594[47].

It was a fundamental moment because Galileo could now find his fixed point and demonstrate that it is certainly the earth which rotates around the sun (classical theory of relativity, also called Galilean relativity). In 1588 while he was a pupil of Ostilio Ricci, Galileo sent Guidubaldo a theorem on the centre of gravity and he helped him to obtain the role of Professor of Mathematics at the University of Padua in 1592. In 1597 Guidubaldo asked Galileo to teach mathematics to his son.

The two scientists carried on research together (on the parabolic trajectories) and shared interest in Optics and Astronomy. As with Della Porta, Galileo also was studying the principle of compounded lenses and between 1592 and 1601 he was copying the *Theorica Speculi Concavi Spherici* by Ausonio which brought him to experiment on the concept of punctum inversionis, for concave mirrors and convex lenses (the point where the image is enlarged and is at the maximum level, greatly confused but still upright); it coincides with the focal point. A fundamental issue for the telescope theory.

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42 F. Bassani, R. Bellini, 1994, p. 205.

43 F. Bologna, *Caravaggio, l'ultimo tempo (1606-10)*, in Catalogue of the Exhibit: *Caravaggio. L'ultimo tempo 1606-10*, Napoli, 2004, p. 20.

44 F. Bologna, 2004, p. 20.

45 F. Bologna, 2004, p. 21-22.

46 F. Bologna, 2004, p. 33.

47 M. Kemp, 1990, p. 93.

Michael J. Gorman[48] also reports that Guidubaldo was a correspondent of Giacomo Contarini in Venice and that he himself: "supervised the final work on Della Porta's new camera obscura in Venice"[49].

In 1580 Della Porta in Murano had found, at the suggestion of Contarini, an artisan capable of executing a mirror just as he required it for his research, sponsored by Cardinal Luigi d'Este, which at that moment was related to a parabolic mirror and an occhiale (sometimes identified as a telescope)[50].

The Academies also played a key role in this development; they claimed: "contro l'egemonia delle lettere... l'universale scienza necessaria al pittore" ("against the humanistic hegemony ... the universal science as necessary for a painter")[51].

In the Accademia del Disegno at Florence, the geometry of Euclides was taught to artists[52]. On the 18th October 1613 Galileo was elected as a member of this Academy (letters with Cigoli on the comparison between painting and sculpture)[53].

Then the Accademia dei Lincei was founded in 1603 by Federigo Cesi, "nobiluomo dalla mente scientifica", a noble man with a scientific mind but not a University Professor; for his sharp sight, Cesi chose the Lynx, printed on the front page of two of Della Porta's writings (Vice-Prince of this Academy and one of the four founders, together with Francesco Stelluti, Luca Valerio e Johannes Faber). In 1611 Galileo also was made a member of this Academy and in 1613 Mirabella (Della Porta introduced him to Cesi who asked Galileo's opinion and in 1614 they accepted him)[54]. This Academy insisted on the necessity of favouring the direct observation of nature in respect to the study in books[55].

There were also the Associazione dei Secreti (Naples) and the Accademia degli Svegliati (Naples). Della Porta belonged to the first one; Giovan Battista Marino to the second one. The purpose of the former was to reveal the secrets of nature (it was suppressed in 1581 because it came into conflict with the Church).

Another artistic field that could develop optical devices was the one of scientific capture: organic specimens could not be kept for a long time, so artists needed to illustrate their forms very quickly. Ulisse Aldrovandi: "bisogna havere

[48] M.J. Gorman, 2003, p. 298.

[49] M.J. Gorman, 2003, p. 298.

[50] Della Porta's books were put on the *Indice* in 1594; it was prohibited for him to write on science or philosophy or to carry on scientific experiments. However in 1598, Cardinal d'Este interceeded, and saved him from the Inquisitors, and the damnation of his books was annulled, see M.J. Gorman, 2003, p. 298; for a complete biography of G.B. Della Porta, see on Internet the Wikipedia web site: http://it.Wikipedia.org/wiki/Giovan_Battista_Della_Porta.

[51] M. Kemp, 1990, p. 93 and note 126 at p. 349.

[52] M. Kemp, 1990, p. 93.

[53] "Intendesi per pittura quella facoltà che col chiaro e con lo scuro imita la natura", Galileo Galilei, *Letter to Cigoli*, 1612, in L. Spezzaferro, 1971, p. 89.

[54] F. Bologna, 2004, p. 33.

[55] D. Freedberg, *The eye of the lynx: Galileo, his friends and the beginnings of modern natural history*, Chicago, University Press, 2002.

la pianta fresca e circa cavata dall'hora dalla terra: perché le piante essiccate non si possono dipingere" ("one must have the fresh plant, just taken out from the ground; because the dessiccated plants cannot be painted"). Concave mirrors were used in the XVI century as microscopic enlargers; with one of them Giovanni Rucellai in 1523 could show the anatomy of a bee[56] (Fig. 33).

Optical devices were also used for topography[57] and for the theatre[58].

As already examined, Michelangelo Merisi shows frequent contact with mirror makers; in Rome: Caravaggio sells paintings to a "specchiaro che sta alla Magina di Ponte", but who were the mirror and lens manufacturers at that time? Two places in Italy were renowned for this work: Venice, with the Murano Island and Florence, with the Cristalleria Medicea[59]. The production of lenses occurred all over Italian territory, but Florence and Bruges were very famous for spectacle lenses (Fig. 34); therefore many convex and concave lenses were produced here in order to correct any visual defect. For the artist's projections however, not very sophisticated tools were needed: the bottom end of a drinking glass could have been enough.

Lenses were made cutting slices from a block of sodium-calcium-silica based glass (Fig. 35), of a poor quality. They contained bubbles of air and had a greenish colour due to the presence of iron; they were smoothed inside a metal container that had the desired curvature and then polished with abrasive dust that was always finer and finer. Many scientists, including Galileo, polished their lenses on their own. Until the XIX century the limit for a good lens was with a diameter of 10 cm.; over this size it lost luminosity and badly focused along the side edges; a similar size one can be observed in Bartolomeo Manfredi, *Allegory of the Seasons*, Dayton, Art Institute, ca. 1610 (Fig. 36) in the hand of the Spring female figure.

Also mirrors were often employed by the painters; famous is Parmigianino, *Self-portrait in a mirror*, oil on panel hemispheric, Wien (Fig. 37)[60]. Examples of

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[56] C. RAGGHIANTI, 1973/74, p. 9.

[57] The Maps of Florence by Bonsignori (1584), at bird's eye view, probably were executed with periscopes with optical systems set on the bell towers or roofs of houses.

[58] In Florence devices existed based on optical prisms which allowed the change of scenography in view. And also some illuminating instruments were based on hydraulic spring automatic systems derived from the Arab tradition which Ragghianti related to the Treatises written by Sebastiano Serlio, 1545 or by Nicolò Sabatini, 1638, who used a camera obscura, see C. RAGGHIANTI, 1973/74, p. 21.

[59] "Venice from the end of the XV century becomes the main centre of production for the glass mirrors invented as a replacement for the metal ones which were always in use since the time of Pliny and Archimedes and Euclide's fantastic applications", see RAGGHIANTI, 1973/74, p. 4; for Florence, see S. CIAPPI, A. LAGHI, M. MENDERA, D. STIAFFINI, *Il vetro in Toscana. Strutture prodotti immagini (sec. XIII-XX)*, Poggibonsi, 1995.

[60] Vasari tells us about the experiments of the young Parmigianino while he painted his self-portrait on a barber's mirror "specchio da barbieri, di que' mezzotondi" and explains: "E vedendo le bizzarrie che fa la rotondità dello specchio nel girare... fece una palla di legno al tornio, e dentro si mise con grande arte a contraffare tutto quello che vedeva nello specchio, e particolarmente se stesso, tanto simile al naturale, che non si potrebbe stimare né credere". "And noticing the strange things that the round part of the mirror produces in turning... he made a wooden sphere with the lathe, and inside he put himself to imitate everything he saw in the mirror, and particularly himself, so similar to Naturel, that it could not be extieemed or believed" (G. VASARI, Vita di Francesco Mazzuoli, called il Parmigianino, Milano, 1964, edition

"shield mirror" are present in Caravaggio's artworks, like the *Conversion of the Magdalene*, Detroit, Institute of Arts (Fig. 38) and the *Medusa*, Florence, Uffizi (Fig. 39); here we can notice the green coloration of the glass.

Another interesting optical aspect is that of depth of field. In Caravaggio's early artworks we notice a strong compression of space; the main personages are squeezed against the front plane in a stage set which has very little depth (30-50 cm.) (Fig. 40). Later on (the first artwork where we notice it is the *Supper at Emmaus*, London) (Fig. 41) the space of the stage is much wider (circa 2 meters from the left to the right hand of the pilgrim). Despite using the re-focusing system, the artist now can rely on a combination of lenses and mirrors which allows him to have more depth of field (which is inversely proportional to the focal distance; the shorter the focal distance, the wider the depth of field; therefore you must set the object further away from the lens). In other words a larger room was now available to the artist.

On the table of the same *Supper at Emmaus* (Fig. 42) each object casts a shadow that has a different direction in respect to the others; which means that each object has been executed (or rather, projected) separately from the others, in a different light condition (at different hours of the day). The chicken has a shadow which shows that the sun is almost in a perpendicular direction (lunch time), slightly on the right in respect to the viewer; the wine carafe has been executed later in the afternoon when the sun is in a low position (an elongated shadow on the table cloth); the basket of fruit casts an unreal shadow and the eye level is parallel to the basket, while for the other objects they are seen from above.

And moreover, concerning the eye level, in the Vatican *Deposition*, (Fig. 43) Christ and Niccodemus are observed from bottom up, the central figures at eye level, the top figures from above downwards. In the Florence, Pitti, *Sleeping Cupid* (Fig. 44) despite the two different planes as an eye level position, here there are also two separate sources of light, concordant to the viewpoint; one is positioned above on the left, on a plane which is slightly in front in respect to the vertical plane of the painting and hits the legs of the Cupid; the other one comes from the lower side toward the upper level and hits the belly button and the chin of the Cupid. The two portions of his body have been separately projected and later on recomposed.

Caravaggio seems to have used different projecting systems depending upon the space/room available.

At the beginning when he was on his own in Rome he did small sized portraits, very bi-dimensional; later on, in the Del Monte laboratory (maybe in the observatory tower with the moon phases recently discovered by Paolo Sapori and

cured by G. Previtali, P. Dalla Pergola, L. Grassi, from the text of the Giuntina edition, vol. V, pp. 7-33; this passage is at p. 17). This artwork was bought by 'Valerio Vicentino' (Valerio Belli, born in 1468 in Vicenza and dead in 1546; Vasari devotes also him a biography in vol. V, pp. 164-167) a crystal carver, and later it was purchased by the sculptor Alessandro Vittoria (Trent 1525-Venice 1608).

his colleagues) he moved to a larger size, with multiple figures and expressed more perspective depth; then at the brothers' Mattei house, he can finally compose with much more space around, as can be seen in the Odescalchi *Conversion of Saul* (Fig. 45), which seems to be executed in a transitional moment between Del Monte and Mattei[61].

In his late artworks the light characteristics are very different; he makes a wider use of stereotyped figures (tracing); there is a flatter perspective where depth is once more omitted and dark and empty backgrounds increase in size; he multi projects the same figure (often the torso is projected separately from the legs). But still the light sources vary for different personages or different objects represented. There is an intentional effect of "In Focus/Out of Focus"[62] to suggest the front or back planes (Figs. 46, 47).

Keeping in my mind Galileo's sentence "Eppur si muove" I recently proposed a new hypothesis: not all these so called repentances in Caravaggio's artworks were really compositive changes. Some were rather intentional effects of double or triple luminous contour, aimed at suggesting a dynamic movement. Always with the help of literary sources, for instance Leonardo[63] suggested, in order to evaluate the muscle structure, to use a small light (a torch) and move it several times around the figures, never keeping the source in a fixed position.

Lomazzo modified the mannerist appreciation of the snake-like shape that Vasari suggested as an artistic ideal into the flame shape, always rotating in a helicoidal torsion, but a shape of light. He told us that executing the figures as Leonardo suggested makes them seem as if they were "coming out of the surface, ... more than real... properly alive"[64].

Caravaggio seems to have planned to obtain a photo-kinematic effect[65] in some anatomic portions of figures, those which at the moment of making a violent dynamic gesture are all of sudden quickly blocked in order to arrest its violence (with a sort of progressive use of the brakes, as in a car ABS system) (Fig. 48). To this I linked the sentence of Marzio Milesi, his poet friend: "fingha pur le cose altri, adombri e lustri, Voi vive e vere l'arrecate" ("others can imitate things, then add shadows and highlights, You render them alive and real")[66].

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[61] R. Lapucci, *Sorpreso dalla luce: schemi ottico prospettici del Saulo Odescalchi Balbi*, in catalogue of the Exhibit: *Caravaggio a Milano*, Skira, Milan, 2008 pp. 117-121.

[62] For the on focus out of focus, see R. Lapucci, *The Technique of Caravaggio's Late Years (1606-10)*, in Catalogue of the Exhibit: *Caravaggio and the paintings of Realism in Malta*, edited by C. De Giorgio, K. Sciberras, Valletta, Midsea, 2007, p. 135.

[63] Leonardo da Vinci, *Trattato della pittura*, beginning of the XVI century, consulted edition is hat from the Vatican Urbinatis Codex n. 1280, edited by G. Milanesi, anastatic reprint, Rome, 1984, chapter 773, p. 244.

[64] G.P. Lomazzo, *Idea del Tempio della Pittura*, Milano, 1590, in P. Ciardi, 1974, II vol., chapter XXII, p. 305.

[65] R. Lapucci, *Caravaggio foto cinematico*, in *Caravaggio e l'ottica/Caravaggio and Optics*, 2005, pp. 33-50 (p. 40).

[66] M. Milesi, from the manuscript: *Monumenta Ingenii Aliquod*, poems published in G. Fulco, '*Ammirate l'altissimo pittore': Caravaggio nelle rime inedite di Marzio Milesi*, in Ricerche di Storia dell'Arte, 10, 1980, pp. 65-89; the poem quoted in the text is at c. 73r, entitled "Il me-

Along the same path will later proceed Lorenzo Bernini with his suggestion of breaking the contour lines because "le forme rese sommariamente finiscono per sembrare tutte in moto" ("Shapes rendered in a rough way end up looking as it all in movement")[67].

Everything goes back again to the link with science and the new conception of cosmology arising from Galileo's and Newton's theories: from the movement of the planets to: "Tutto si muove nell'universo" ("Everything moves in the Universe") and only ether is still.

Most artists tried to apply a dynamic rotation to their figures, see Michelangiolo, *Saint Matthew, Captives* (Fig. 49); a comparison can even be proposed between the *angel* in the *Saint Matthew* Contarelli (Fig. 50), and Leonardo's *Water swirls* (Fig. 51), with their concentric spiral movement.

In Caravaggio, *Bacchus*, Florence, Uffizi (Fig. 52) the first pulsation of the heart and the wine just poured produces a circular movement of the liquid in the wine chalice: life pulses and movement is transmitted.

The photo kinematic effect was probably amplified by the fluctuating light of the candles and of the torches which, at the time of Caravaggio, illuminated paintings (Fig. 53).

Among all the European realists Velàzquez is the one who fully understands this dynamic effect, rendering it with great ability in his horse's legs (Fig. 54) or in the wheel of his *Weavers* at the Prado (Fig. 55).

This movement could have been borrowed from theatrical devices; famous among them are Leonardo's machines for theatre (Fig. 56). The links with theatre have been recently investigated by Dario Fo[68], pointing out the use of red curtains: the scenario is going to close and the story is ending now (Figs. 57, 58). There is a dynamic passage, which one could call the 'transeunte'. If you look at the scene one minute later, it will be empty; the actors will have gone away.

Also the idea to build in the studio a sort of scenery with personages or puppets, derives from theatre; the use of puppets is attested for Tintoretto; Correggio had sculptors at his disposition who made clay or wooden dolls to be projected with mirrors on the ceilings to be frescoed.

An actor, called Scalafato, is present in Caravaggio's work (Figs. 59, 60); he was a person who was secured with a sling to repair boats in the shipyards, but he was employed also in the theatre for figures of Angels or of Spirits (Ariel in The Tempest).

Dario Fo also refers to a hole in the stage floor, under which there was an actor with a mirror, who sent up a simulacrum of the actor's image (very foggy and transparent), looking like a ghost (for Hamlet's father or Macbeth).

Important also, were the religious representations performed on the Church

desimo", in G. Fulco, pp. 87-88.

[67] R. Pierantoni, *Forma fluens. Il movimento e la sua rappresentazione nella scienza, nell'arte e nella tecnica*, Torino, 1986, p. 307.

[68] Dario Fo, *Caravaggio al tempo del Caravaggio*, Rai Sat Extra, 2003-04.

square or inside at Christmas or during Corpus Christi celebrations; these kinds of performances for the public entertainment were often sponsored by the Guilds or Corporations.

Very close references can be found for Caravaggio especially with Diego Sànchez de Badajoz, *Recopilaciòn en metro*, Sevilla, 1554[69] commissioned by the House of Feria at Zafra; this family (Suarez de Figueroa) was at the service of the King of Spain and of the Church, and maintained at the Court a group of religious poets writing moral topics. One of them was Diego, who wrote "farsas" precurring the auto sacramental genre. Later on these representations arrived in Naples, where they had a great popularity, reaching their maximum level in 1632 with Silvio Fiorillo's comedy: *La Lucilla constante con le ridicolose disfide e prodezze di Policinella*, dedicated to Don Juan de Figueroa, third Duke of Feria and Governor of Milano.

Religious dramas were on fashion in Spain during the reigns of Phillip III and IV. They explained topics from the Old and New Testament, by inserting them into the contemporary social and political contexts using the subjects of prefiguration and allegory.

The key figure of this dramaturgy was the symbolic shepherd, who introduced the scene acting as a bridge between the audience and the sacred subject; together he taught doctrine but was a rustic personage, as in many of Caravaggio's paintings (Figs. 61, 62).

The main topics of these poems were *The Farce of the Gipsy*, *The Good Fortune Teller*, *The Marriage*, *Card games* (Figs. 63, 64).

Another typical issue was the fight/link between the old and young woman, respectively corresponding to Satan and to an Angel (or to the good and bad conscience) (Figs. 65, 66, 67).

Caravaggio felt the need to make theatre on an immovable plane such as a painting surface.

Thus, through the dynamic effect of the gesture, painting became able to surpass sculpture, by becoming similar to theatre, the forerunner to cinema.

Was then Caravaggio a precursor of Futurism? In the sense that he tried to block more photograms on the same image in a way that will be later used by the futurists? (Figs. 68, 69).

A final consideration concerns a possible link between Caravaggio and the alchemy of photography. The lead white 'abbozzo' presence, executed to sketch the main lighted areas of each composition, seems to confirm the possibility that the artist for a while, kept seeing the projected image and quickly tried to block it during the short permanence of the simulacrum on the canvas.

This monochromatic underpainting would have afforded Caravaggio the opportunity to pose multiple figures together and capture their relationship in one

[69] A.E. Wiltrout, *A Patron and a Playwright in Renaissance Spain: The House of Feria and Diego Sànchez de Badajoz*, Thames Bok Ltd., London, 1987.

quick 'snapshot'.

Corrado Maltese together with Sebastiano Sciuti[70] found in this 'lead white' some impurities made of Barium sulphide (Barite), a very interesting material that they considered an adulterating product. Today it should be reconsidered in a new perspective because it is a fluorescent (glow in the dark) material, which (mixed with the lead white for the abbozzo) could have allowed Caravaggio to sketch his first draft in a dark environment.

Until his death in 1610 Caravaggio lived in the successful period of optics and does not see its decline. In fact in 1609 Galileo[71] succeeds in making the telescope (which he offers to the venetian Republic; from 1592 to 1610 he lives and teaches in Padua). In 1610 he discovered the 4 satellites of Jupiter and published *Medicea Sidera* and *Sidereus Nuncius*. At this point he received the first admonition from Cardinal Bellarmino who suggested that he talked about hypotheses and not theories. 1611 was his last happy year: he was received with honours by Pope Paolo V and became a member of the Lincei Academy. The publications of 1613 caused the first denunciation by the Inquisition in 1615. In 1616 the Church condemned the Copernican theory and gave the second warning to Galileo, impeding him from teaching. The main opposition came in 1632 when he was brought to trial and tried for heresy[72].

However in 1611 when the opposition to Galileo was beginning, the censor approved the Treatise *Opticorum libri sex*, by François d'Augulion, Rector of the Jesuit College at Antwerp, published in 1613 with 7 illustrations by Rubens (Fig. 70), engraved by Theodore Galle. The text followed the Medieval and Renaissance "approved" theories and never penetrated into the hostile territories of Kepler, Galileo and Descartes[73], but the images did, even if in an allegorical way.

Scientific Theory cannot speak anymore but Art does!

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[70] S. Sciuti, G.E. Gigante, S. Rinaldi, A. Culla, C. Falcucci, *Analisi non distruttive e riflettografie a infrarossi su alcuni dipinti del Caravaggio esposti in Palazzo Ruspoli*, in Acts of the Symposium: *Come dipingeva il Caravaggio* (Florence, 28/1/1992), Milan, Electa, 1996, p. 69.

[71] For a complete updated biography of Galileo, see G. Galilei, *Opere*, cured by F. Flora, Treccani, Series: I classici del pensiero italiano, Milano-Napoli, 2006, pp. XXI-XXXVI.

[72] On the 22nd of June 1633 Galileo is enclosed in the Convent of Santa Maria sopra Minerva "veementemente sospetto di eresia" ("vehemently suspected of heresy"); he could not speak and he had to abjure his ideas, see F. Flora, 2006, p. XXXIII.

[73] M. Kemp, 1990, pp. 101-102.

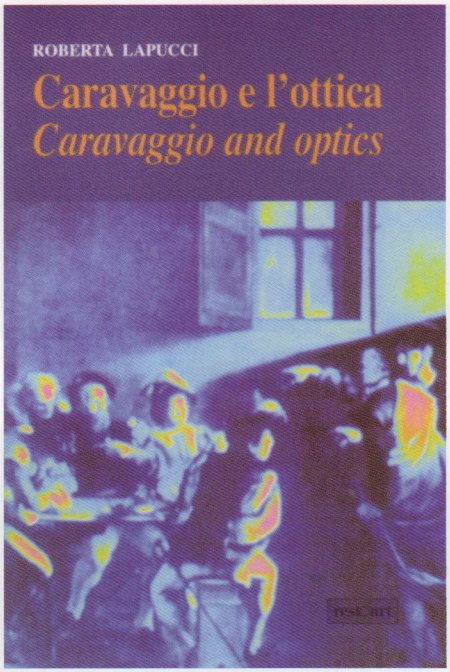

FIG. 1

R. Lapucci, Cover of the Volume: Caravaggio and Optics, Florence, 2005.

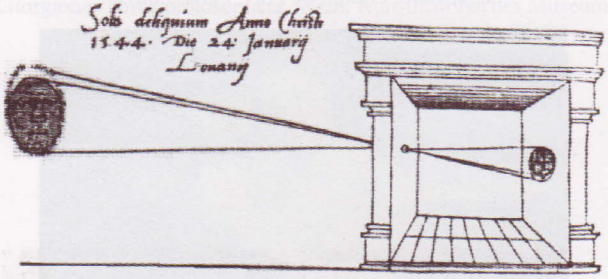

FIG. 2

Graphic for a stenopeic hole from Reinerus Gemma Frisisus,
De radio astronomico et geometrico liber, Antwverpiae, 1545.

FIG. 3

G.B. Della Porta, Engraved portrait from the frontispiece of *Ars Reminiscendi*, 1566.

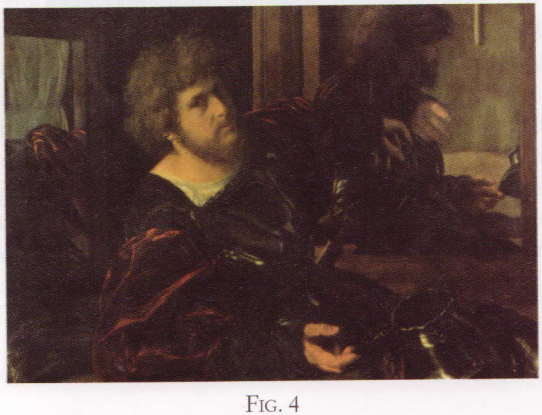

FIG. 4

G. Savoldo, Gaston de Foix, Paris, Louvre.

FIG. 5

G. Bellini, Young woman at the mirror, Wien, Kunsthistorisches Museum.

FIG. 6

L. Lotto, Triple portrait of a jeweller, Wien, Kunsthistorisches Museum.

FIG. 7

Giorgione, Three philosophers, Wien, Kunsthistorisches Museum.

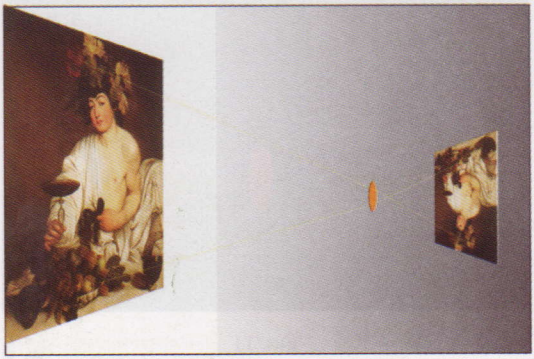

FIG. 8

S. Grundy, Graphic of the projection trough a biconvex lens.

FIG. 9

S. Grundy, Graphic of the projection trough a concave mirror.

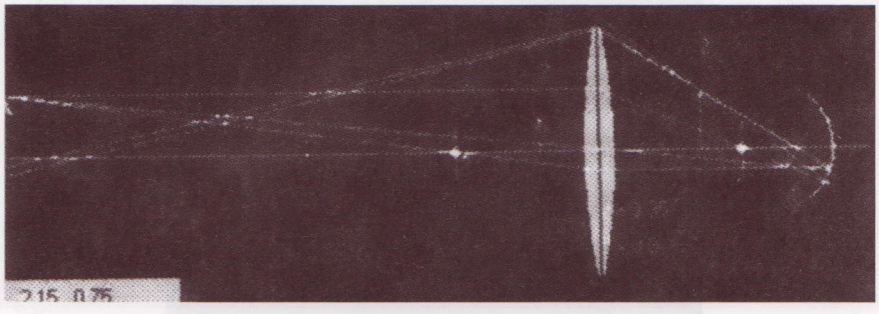

FIG. 10

M.J. Gorman, Axis symmetric Graphic of a composed projecting system, presumed from Della Porta's *Magiae Naturalis*.

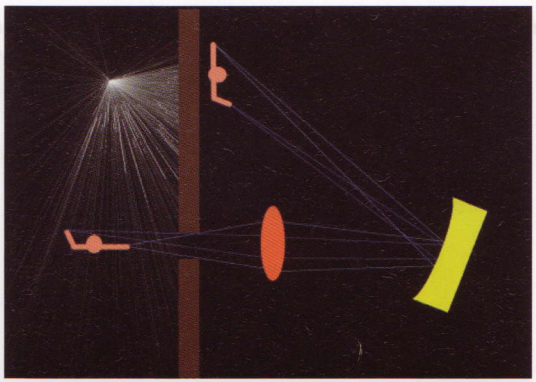

FIG. 11

R. Lapucci, Proposal for Caravaggio's projection with Della Porta's system.

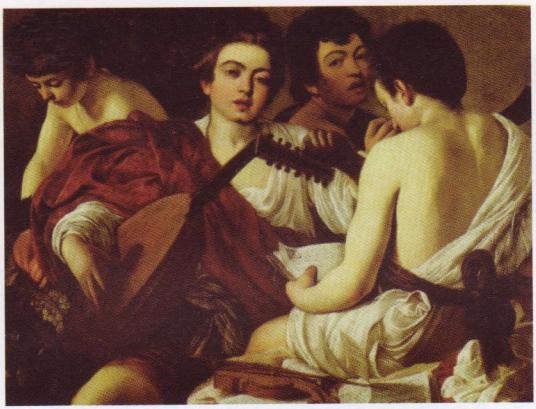

FIG. 12
Caravaggio, Concert of youths, New York, Metropolitan Museum.

FIG. 13
Caravaggio, Saint Catherine, Madrid, Thyssen Collection.

FIG. 14

Caravaggio, Bacchus, Florence, Uffizi.

FIG. 15

Detail from Boy with basket of fruit, Rome, Borghese Gallery
(a. as it is in the painting; b. as corrected by S. Grundy by squeezing 90%).

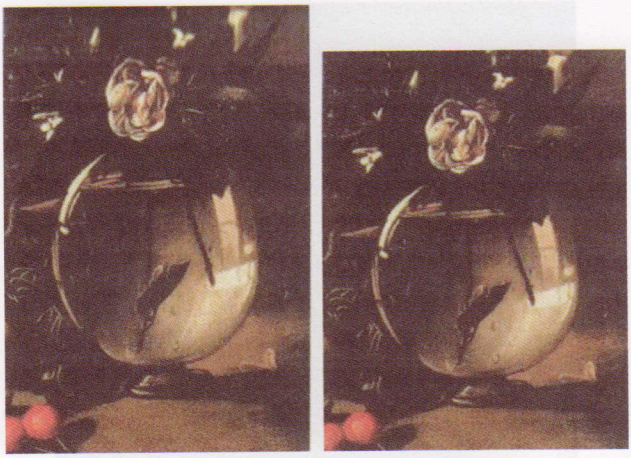

FIG. 16

Detail, glass vase, from Caravaggio, Boy bitten by a Lizard, Florence, Longhi Foundation (a. as it is in the painting; b. as corrected by S. Grundy by squeezing 90%).

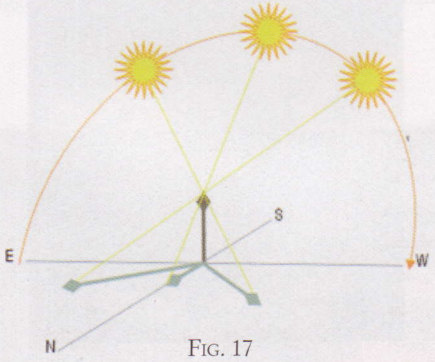

FIG. 17

Gnomon.

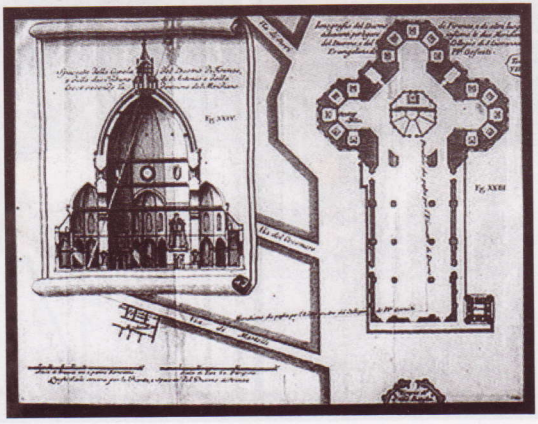

FIG. 18

The gnomon of Florence, Santa Maria del Fiore drawing from Opera Santa Maria del Fiore.

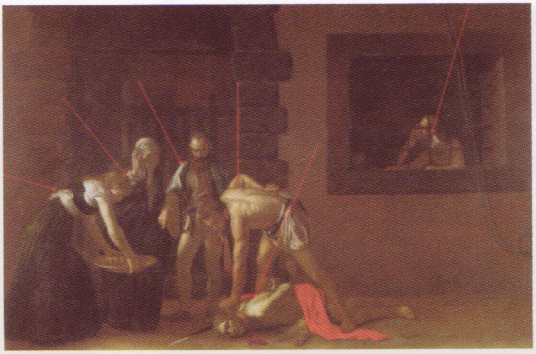

FIG. 19

R.Lapucci's graphic of the light sources in Caravaggio, Beheading of St. John, Valletta, Co-Cathedral.

FIG. 20

Detail from Caravaggio, Supper at Emmaus, London, National Gallery (re-focusing for the arm produces the deformation of the hand's size; the further is bigger than the closer).

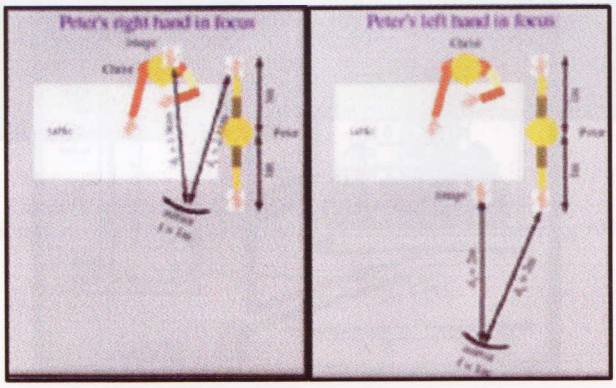

FIG. 21

D. Stork proposal for re focusing in the Supper at Emmaus, London, National Gallery.

FIG. 22

Detail from Caravaggio, Martyrdom of Saint Matthew, Rome, San Luigi dei francesi, Contarelli Chapel.

FIG. 23

Detail from Caravaggio, Boy bitten by a Lizard, Florence, Longhi Foundation.

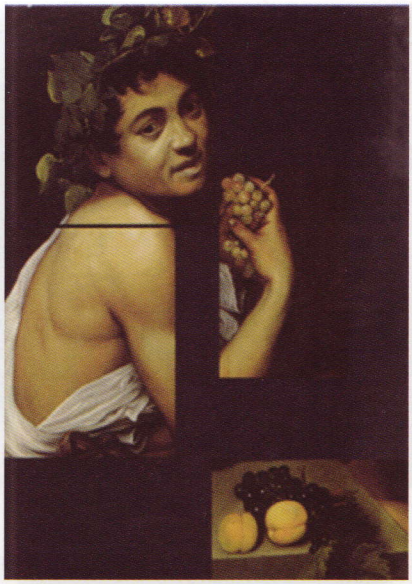

FIG. 24

D. Hockney's graphic for the patchwork composition through separate projections in Caravaggio's Bacchus, Rome, Borghese Gallery.

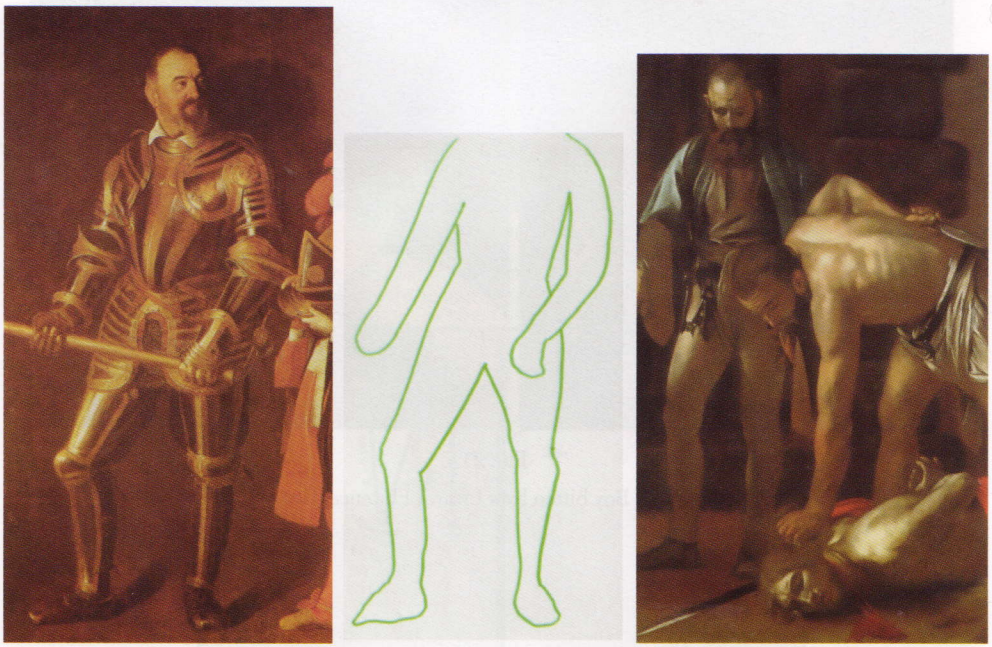

FIG. 25

R. Lapucci's graphic of similar shapes in two Caravaggio's paintings: the Portrait of Wignacourt, Paris, Louvre and the jailer of the Beheading of St. John, Valletta, Co- Cathedral.

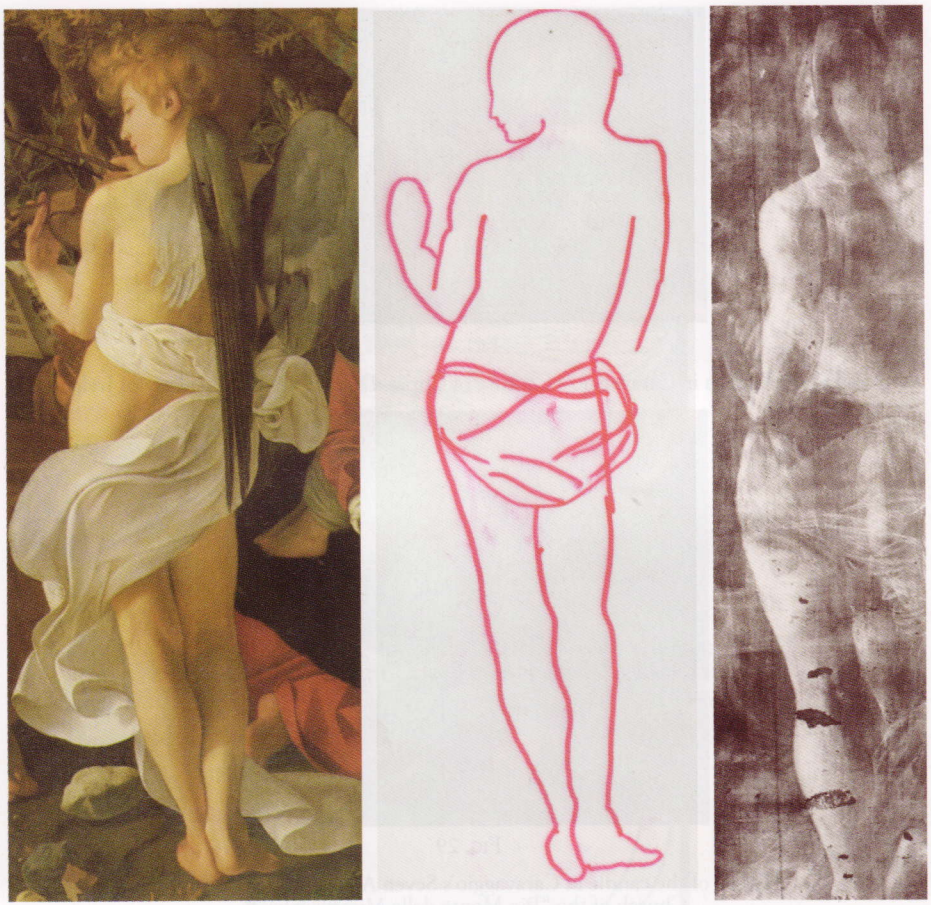

FIG. 26

R. Lapucci's graphic of similar shapes in two Caravaggio's paintings: the Angel in the Rest to the flight in Egypt, Rome, Doria Collection and the X-ray visible underlayer of a soldier in the Martyrdom of Saint Matthew, Rome, San Luigi dei francesi, Contarelli Chapel.

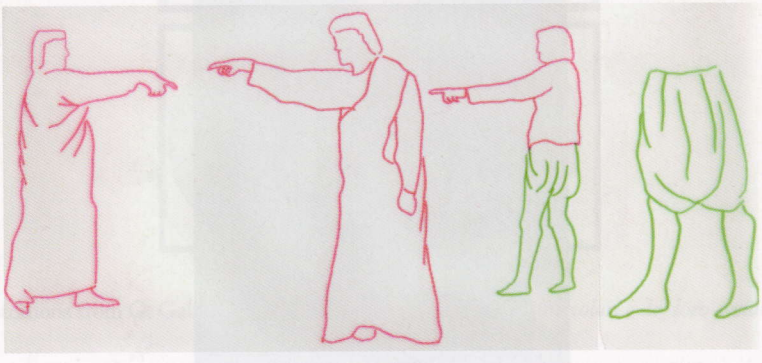

FIG. 27

R. Lapucci, Tracing of similar shapes present entire, partial, flipped left to right in various artworks by Caravaggio.

FIG. 28

Detail of the lantern in Caravaggio's Capture of Christ, Dublin, National Gallery of Ireland.

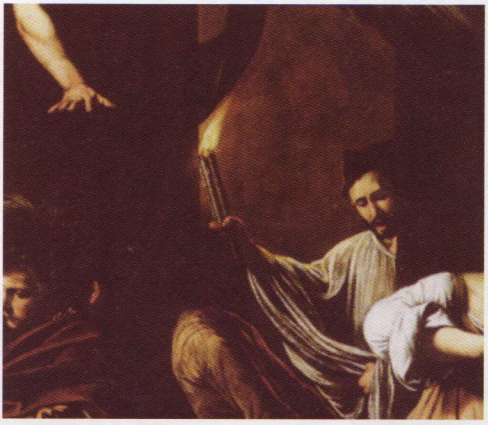

FIG. 29

Detail of the candle in Caravaggio's Seven Acts of Mercy, Naples, Church of the "Pio Monte della Misericordia".

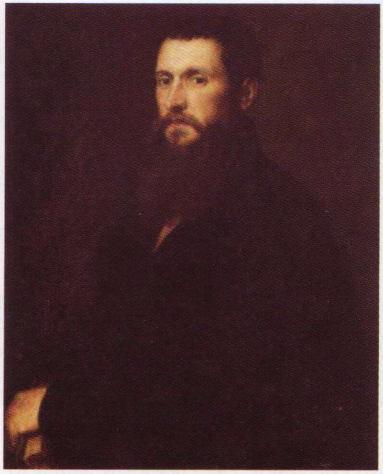

FIG. 30

Titian, Portrait of Daniele Barbaro, Madrid, Prado.

FIG. 31

Frontispiece of Niccolò Tartaglia, *La Nova Scientia*, Venice, 1550.

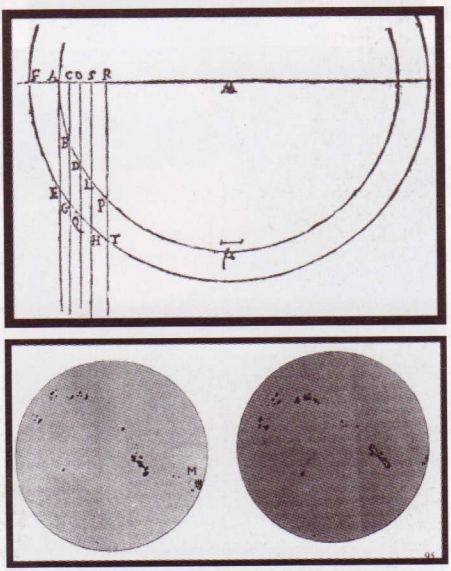

FIG. 32

Illustrations from G. Galilei, *Istoria e demostrazioni delle macchie solari e de' loro accidenti*, Roma, 1613.

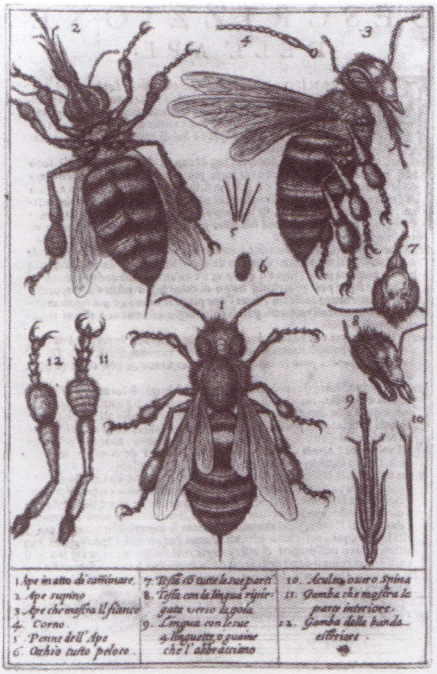

FIG. 33

The anatomy of a bee, Engraving from Stelluti, *Persio Tradotto*, 1630.

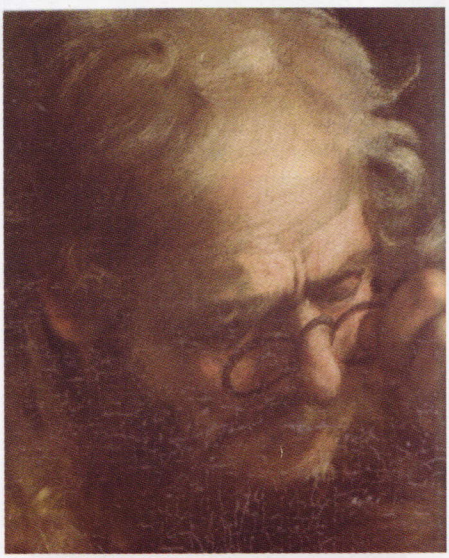

FIG. 34

Detail of spectacles from Caravaggio, Calling of Saint Matthew, Rome, San Luigi dei francesi, Contarelli Chapel.

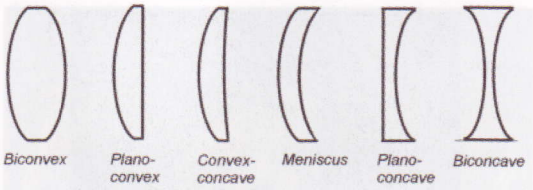

FIG. 35

Graphic of various typologies of lenses.

FIG. 36

B. Manfredi, Allegory of the Seasons, Dayton, Art Institute.

FIG. 37

Parmigianino, Self Portrait in a mirror, Wien, Kunsthistorisches Museum.

FIG. 38

Detail from Caravaggio's Conversion of the Magdalene, Detroit, Institute of Arts.

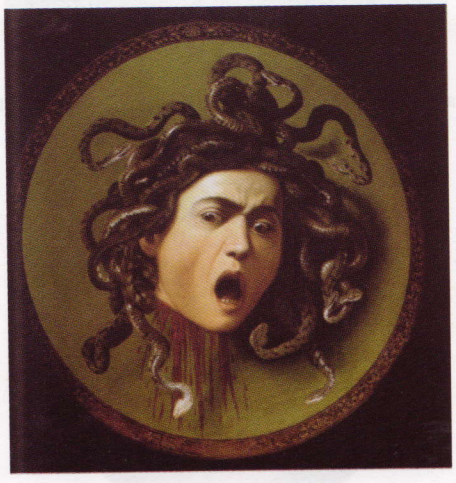

FIG. 39

Caravaggio, Medusa, Florence, Uffizi.

FIG. 40
Caravaggio, Concert of youths, New York, Metropolitan Museum.

FIG. 41
Caravaggio, Supper at Emmaus, London, National Gallery.

FIG. 42
Detail from Caravaggio, Supper at Emmaus, London, National Gallery.

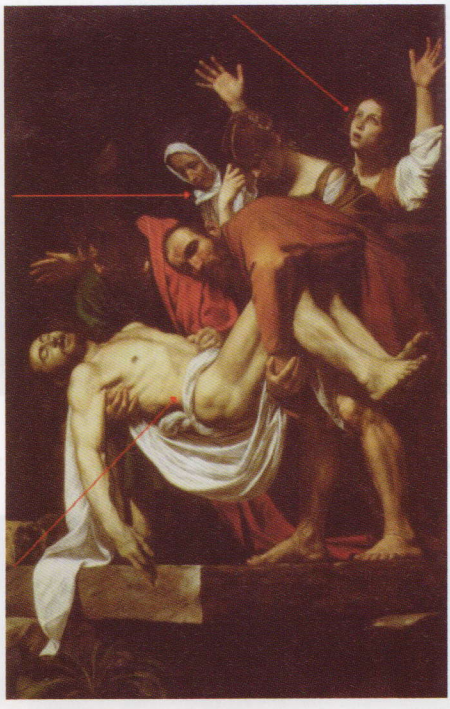

FIG. 43

Graphic of the eye levels in Caravaggio, Deposition, Rome, Vatican Museum.

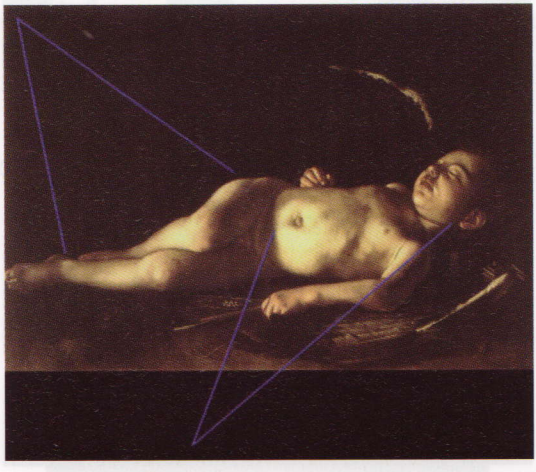

FIG. 44

Graphic of the light sources in Caravaggio, Sleeping Cupid, Florence, Pitti.

Fig. 45
Caravaggio, Conversion of Saul, Rome, Odescalchi Collection.

Fig. 46
Detail from Caravaggio, Crowning of thorns, Wien, Kunsthistorisches Museum.

Fig. 47
Detail from Caravaggio, Portrait of a Knight of Malta (Antonio Martelli), Florence, Pitti.

FIG. 48

Caravaggio, Deposition, Vatican Museums, X-ray detail.

FIG. 49

Michelangelo, Captives, Florence, Accademia Gallery.

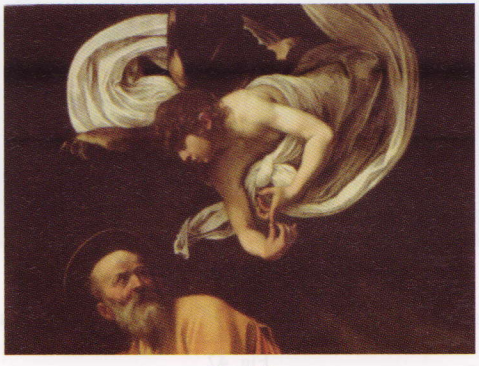

FIG. 50

Detail from Caravaggio, Saint Matthew and the Angel, Rome, San Luigi dei francesi, Contarelli Chapel.

FIG. 51
Leonardo da Vinci, Water swirls, drawing from his *Trattato.*

FIG. 52
Detail from Caravaggio, Bacchus, Florence, Uffizi.

FIG. 53

Detail from Caravaggio, Boy bitten by a Lizard, Florence, Longhi Foundation.

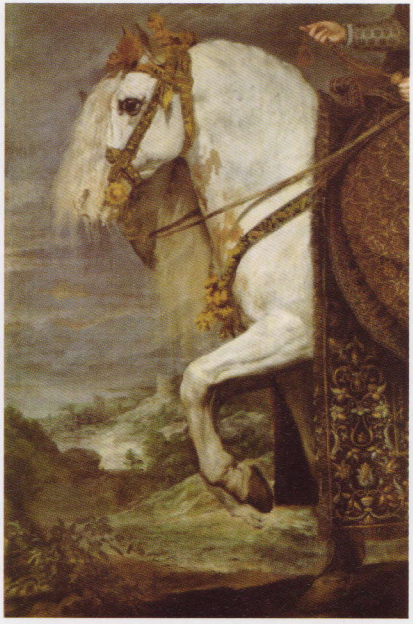

FIG. 54

Velàzquez, Queen Dona Isabel de Francia on her horse, Madrid, Prado.

FIG. 55
Detail from Velázquez, Weavers, Madrid, Prado.

FIG. 56
Leonardo, Theatrical machine called "L'ocel de la comedia", drawing.

FIG. 57

Caravaggio, Madonna of the Rosary, Wien, Kunsthistorisches Museum.

FIG. 58

Caravaggio, Death of the Virgin, Paris, Louvre.

FIG. 59

Detail from Caravaggio, Seven Acts of Mercy, Naples, Church of the "Pio Monte della Misericordia".

FIG. 60

Detail from Caravaggio, Conversion of Saul, Rome, Odescalchi Collection.

FIG. 61

Caravaggio, Nativity, Palermo, Oratory of St. Lawrence (stolen).

FIG. 62

Caravaggio, Adoration of the Sheperds Messina, Regional Museum.

FIG. 63

Caravaggio, The Good Fortune Teller, Rome, Capitoline Gallery.

FIG. 64

Caravaggio, The cardsharp, Forth Worth, Kimbell Art Museum.

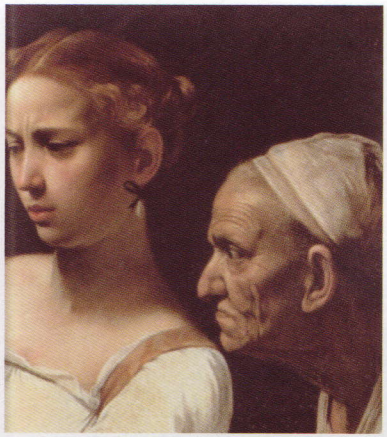

FIG. 65
Detail from Caravaggio, Judith and Holophernes, Rome, Barberini Gallery.

FIG. 66
Detail from Caravaggio, Salome with the head of St. John, London, National Gallery.

FIG. 67
Detail from Caravaggio, Salome with the head of St. John, Madrid, Prado.

FIG. 68

Detail from Caravaggio, Portrait of a Knight of Malta (Antonio Martelli), Florence, Pitti.

FIG. 69

Detail from A.L. Coburn, Vortography of Ezra Pound, point on silver emulsion, Rochester New York, International Museum of photography, George Eastman House.

FIG. 70

P.P. Rubens, Six vignettes from F. Aguilonius's *Opticorum libri sex*, 1613, engraved by Theodore Galle.