STAGE MECHANISM, MACHINE

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Ancient Theatre.

«[...] In fact the Ancients had various kinds of devices. In addition to those fitted to rotating doors and used to introduce the Gods of the Woods and the Countryside, or marine deities, they even had machines above the Scene for the Celestial Gods, and even under the Theatre for the shadows, the furies, and the other infernal gods, [...] Pollux reports that they were a kind of planking, on which the actors were made to descend to the level of the stage and then under the Theatre by releasing the devices, which had pulled them up. These devices were ropes, wheels and counterweights, which the Greeks called ἀναπέισματα. Those placed on the doors, which they called $\pi\epsilon\rho(\alpha\kappa\tau\sigma)$, were three-sided rotating machines which were turned according to the deities they wanted to represent. The most ordinary machines were those that were lowered from Heaven for the termination, in which the Gods came, so to speak, to help the Poet, whence the proverb $\theta \varepsilon \delta \zeta \ \dot{\alpha} \pi \delta$ $\mu\eta\gamma\alpha\nu\eta\zeta$. These machines had a great relation to ours, because, except for the movements, the use was the same [...] Although all these machines had a great relation to ours, so the movements were very different [...]; theirs were recommended to a spice of Grù whose neck passed over the scene, and turning over itself while the counterweights made these machines ascend or descend, they described curves composed of its circular motion, and of their vertical direction [...]». Thus wrote Nicolas Boindin in 1746 (Boindin 1746, pp. 9-10) about ancient machines. When talking about theatre, we usually think of an art form, poetry, or an architectural structure, rather than mechanisms, devices, and techniques used to complement the protagonists and render the performance more articulate and spectacular through amplification and illusive modification of scenic space.

For ancient theatre, where the performance of drama involved simpler machines and devices, understanding this specific aspect is challenging. The issue becomes even more complicated when we look at classical Attic theatre, for which it is likely that, along with the development of drama, stage building, and technical progress in other fields, artificial devices able to meet the new demands of stage practice were introduced. However, there is still an ongoing debate regarding the kinds and extent to which theatrical machines were used in Athenian performances in the 5th and 4th centuries BC.

Much of the information on ancient stage machinery comes from indirect tradition. This includes annotations of late commentators on classical texts, lexicographers and Pollux, who lived at the time of the emperor Commodus, to whom he dedicated his major 10-book work, the *Onomasticon*. The large extract of the *Onomasticon* we possess does not differ significantly from the original edition and consists of a sort of lexicon comprising a list of synonyms, structured according to subject rather than alphabetically (Mauduit-Moretti 2010, pp. 521-41).

However, insofar as it refers to more ancient processes that were not always in place when recorded, the Pollux's *Onomasticon*, like the erudite commentators, is often contradictory and confusing. Furthermore, practices in use after classical theatre were bundled together and often overgeneralised features of single-episodes, as in the case mentioned by Pollux of the *ekkyklema* [ἐκκύκλημα], surmounted by a throne (Mauduit-Moretti 2010, pp. 536-69).

Important sources on ancient theatre, such as Aristotle and Vitruvius, do not dwell on the various devised used in theatre: Aristotle mentions the introduction of stage design and criticises the use of the *mechané* to end the plot (Aristotle, *Poetics*, 1449 a18-19, 1454 b1-6); Vitruvius only mentions the existence of *periaktoi* [$\pi\epsilon\rho(\alpha\kappa\tau\sigma)$] (Vitruvius, *On Architecture*, 5.6.8). Attempts to find evidence of the staged use of these devices in South Italian vase paintings do not throw light on the issues of chronology, function, or technology used and relying on interpreting preserved dramas. Moreover, their dramaturgical construction, often

ALEXIA LATINI

dealt with by scholars of ancient drama, can also lead to different results. It is, therefore, necessary to collate heterogeneous data, including important archaeological research.

Pollux lists a series of theatrical devices: mechané, ekkyklema, periaktoi, keraunoskopeion [κεραυνοσκοπεῖον], bronteion [βροντεῖον], hemikyklion [ἡμικύκλιον], anapiesma [ἀναπίεσμα], and exostra [ἐξώστρα] (Onomasticon, 4.126-32).

«The mechané shows gods and heroes, Bellerophon and Perseus in the air; it is located near the left parodos [$\pi \dot{\alpha} \rho o \delta o c$] above the level of the stage building. The mechané of tragedy is the fig branch (krade [$\kappa \rho \dot{\alpha} \delta \eta$]) of comedy» (Pollux, Onomasticon, 4.128). Later he explains that the geranos [$\gamma \dot{\epsilon} \rho \alpha v o c$], crane, was a mechanema [$\mu \eta \chi \dot{\alpha} v \eta \mu \alpha$] that descended from above to pick up bodies. The geranos/mechané equivalence, not clearly stated in Pollux, is confirmed by an anonymous lexicon (Bekker, Anecdota graeca, I 232.5-8, s.v. $\gamma \dot{\epsilon} \rho \alpha v o c$). The mechané was a generic term used in different situations, ranging from war to maritime subjects. In the theatrical context, it was also called geranos, and, with specific reference to the arm that composed it, krade by the comedians (in Pseudo Plutarch, Alexandrian Proverbs, centuria 2.216 = Corpus Paroemiographorum Graecorum 1.338, is identified as the hook of the mechané), or aiorema [$\alpha i \dot{\omega} \rho \eta \mu \alpha$] (Schol. Aristoph. Pax 80, Suda s.v. $\dot{\epsilon} \dot{\omega} \rho \eta \mu \alpha$; in Pollux, Onomasticon, 4.131 aiorai [$\alpha i \dot{\omega} \rho \alpha i$]), perhaps because of the swinging movement of the suspended actors similar to a seesaw; that this last expression also comes from a witty joke from comedy cannot be excluded (Reisch 1893, col. 1044). The mechané was, therefore, configured as a device aimed at lifting actors into the air.

Comedy, and even tragedy, which it parodies by revealing what tragedy conceals, represents the surest source of its use (Newiger 1989, p. 178; Hölscher 1995, p. 84). Recurrent in comedy is the actor's grasping of the fragile and thus unstable fig branch (see also Strattis, PCG VII fr. 4 = Papyrus of Oxyrhynchus 2742). In Antiphanes' ridicule (PCG II fr. 189), this becomes the finger raised by the tragedians, lowered to resolve the dramatic action, with evident allusion to the practice that had become customary of the deus ex machina. Therefore, in case of inertia, the beam had to remain level to the surface of the stage building's roof. Comedy also shows that the *mechané* had not only to lift actors vertically, but also stage objects needed for the performance: the chariot on which Medea flies away with the lifeless bodies of her children (Euripides, Medea, vv. 1317-404), the fantastic animals, more likely fictitious, that were to appear as being ridden in flight as also confirmed by Aristotelian criticism in the *Poetics*, Pegasus in the case of Euripides' Bellerophon (TrGF 18) frr. 306-8) or the dung beetle in the Peace, to cite a few persuasive examples and, if one accepts that the entrance on the stage of Lyssa and Iris in Heracles (Euripides, Heracles, vv. 815-73), or of the Dioscuri in Helen (Euripides, Helen, vv. 1642-87) took place utilising the mechané, even of two characters at once. The image of Medea in the air also seems to be suggested by some South Italian vases: a Lucanian hydria from Policoro (National Museum of the Siritide, inv. 35296) and a kalyx krater (Cleveland Museum of Art, inv. 1991,1), both dating from around 400 BC (Taplin 2007, pp. 117-23, nos. 34 and 35).

Another important aspect that emerges from comedy is that the *mechané* could also be horizontally rotated, as shown in a fragment of Aristophanes where the machine operator is urged to rotate (*periagein* [$\pi\epsilon\rho$ iáyɛtv]) the branch as fast as possible (*PCG* III 2 fr. 160).

While most scholars do not dispute the use of the *mechané* in 5th century BC stage practice (among others Pickard-Cambridge 1946, pp. 55-56, Arnott 1962, pp. 72-74; Hourmouziades 1965, p. 169; Di Benedetto-Medda 1997, pp. 19-22; Di Marco 2000, pp. 61-62), the moment of its introduction remains debated. Certainly in use in the late 5th and 4th centuries (Mastronarde 1990, p. 247), it seems to have been ignored by Sophocles; its use in Aeschylean dramas is doubtful, perhaps in the *Psychostasis* to move Memnon's body mentioned by Pollux (*Onomasticon*, 4.130-31) when he speaks of the geranos, and in *Prometheus Bound* for the appearance of Oceanus on a griffon (Aeschylus, *Prometheus*, vv. 284-396) although this last tragedy is controversial regarding its paternity and, consequently, chronology. However, its use is confirmed for *Peace*, when Trygaeus, astride a flying dung beetle, goes to Zeus (Aristophanes, *Peace*, vv. 80-178), the *Birds*, vv. 1196-261), and the *Clouds*,

at least in relation to the first appearance of Socrates (Aristophanes, *Clouds*, vv. 218-38). The frequent references of comedians to a *mechanopoiós* [$\mu\eta\chi\alpha\nu\sigma\pi\sigma\iota\delta\varsigma$], i.e. a machine operator (Aristophanes, *Peace*, vv. 174-76; *PCG* III 2 frr. 160 and 192; Strattis, *PCG* VII fr. 46), indicate that the *mechané*'s use in this period was widespread and customary and reference to its operator also points to an activity that required specific professionalism which was recognised by contemporary society (Roselli 2017, pp. 401-2).

Based on the caricature disguises of comedy, it is arguable that Euripides exploited this device's potential on several occasions (in addition to those mentioned, for example, in Andromeda, TrGF 10 fr. 124), especially for the appearances of gods or heroic figures. In the 4th century BC Plato (Cratylus, 425 d), Aristotle (Metaphysics, 1.985 a18), Demosthenes (Against Boetus, II, 59), and Alexis (PCG II fr. 131) recall the frequent and abused use of the deus ex machina as an expedient. The representation of ancient dramas from 386 BC onwards partly justifies the perpetuation of the mechané's use in the 4th century BC. Two mentions of the mechané in Menander (PCG VI 2 fr. 6 and PCG VI 1 fr. 213) and the role of the *deus ex machina* in a purely metaphorical sense would suggest the device's loss of significance of in the second half of the 4th century BC. (Pöhlmann 1995, pp. 158-59). Nevertheless, it did remain in use (Plutarch, Themistocles, 10.1; Quaestiones Convivales, 665 E, 724 D), perhaps along with other devices suitable for the purpose: the theatre of Priene in its Hellenistic phase has yielded a structure similar shape to a chimney, interpreted as a housing for an *anapiesma*, a sort of platform that must have served to lift an actor from the ground floor to a higher level (Goette 1995, p. 36; Pöhlmann 1995, p. 159). Pollux (Onomasticon, 4.127 and 132) discusses this immediately after explaining the significance of Charon's stairs, which were also trapdoors that allowed actors to enter the orchestra by means of ladders during performances involving the dead.

Speed of movement, solidity necessary to stabilise a weight in flight, ease of manoeuvre, as well as reduced visibility from the *koilon* [$\kappa \delta \tilde{l} \lambda \delta v$] and, on the other hand, proximity to the *skené* [$\sigma \kappa \eta v \eta$], were undoubtedly among the criteria required for the construction of the *mechané*, a metatheatrical device, whose presence on stage revealed the fiction by making the stage trickery explicit (Mastronarde 1990, p. 253). We have no specific knowledge of the cranes used in this period: engineering practice made it possible to produce a machine capable of moving a weight, at least from the 5th century BC, as the example of the Parthenon proves (Korres 1995, pl. 16), or perhaps even earlier, as early as the end of the 6th century BC, as hypothesised for some archaic temples (Gullini 1990, pp. 80-102). Epigraphic documents from the 4th and 3rd centuries BC show the everyday use of *trochiloi* [$\tau \rho \sigma \chi \lambda \epsilon i a$], pulley systems, *mechané*, and *mechanemata* [$\mu \eta \chi \alpha v \eta \mu \alpha \tau a$] for construction. Simple forms of hydraulic machines were also in everyday use, for example, water supplied from wells (Robkin 1979, pp. 1-6), as portrayed on vase paintings such as the Attic black-figure *pelike*, preserved in the Staatliche Museen in Berlin, inv. 3228, from the end of the 6th century BC (*Corpus Vasorum Antiquorum*, Berlin, Antikenmuseum, 7, pp. 36-37, tables 28-29; Beazley Archive Pottery Database 138). Since cranes were used in wharves for loading and unloading goods, the theatrical machine could rely on known and tested systems, which could be adapted to the purpose.

Numerous attempts have been made to locate this apparatus in the classical Athenian theatre building and reconstruct its mechanism (Papastamati-von Moock 2014, pp. 63-72 with a summary of positions; Papastamati-von Moock 2015, pp. 69-70). Proposals have often focussed on the structure (now dated to the Periclean phase of the theatre) located behind the stage building which archaeological literature refers to as the T foundation. Recent archaeological investigations have challenged the hypothesis that the *mechané* consisted of a single support shaft with an attached articulated arm (Goette 1995, p. 25; Lendle 1995, pp. 165-72). These investigations seem to point towards a tower-like machine comprising two slightly oblique wooden uprights with a rectangular cross-section, well-embedded in the recesses on the T foundation's side facing the sanctuary to guarantee the structure's stability (Papastamati-von Moock 2014, pp. 68-72, fig. 1.42). The anchored arm was thought to be at the upper ends of the uprights: Antiphanes' *daktylos* [$\delta \alpha \kappa \tau \nu \lambda c c$], the dried fig of comic

ALEXIA LATINI

parody, from which, using a rope and a hook, or harness (Aristotle, *Rhetoric* 1412 a14-16), Socrates' $\kappa \rho \epsilon \mu \acute{\alpha} \theta \rho \alpha$ [*kremathra*] (Aristophanes, *Clouds*, v. 218) suspended the actor. Heron of Alexandria suggested colouring the ropes black to make them less visible (*Automata* 2.30.4). The connection of the beams would have been obtained either through a rope connection, as Papastamati-von Moock seems to suggest, or employing a primitive *carchesion*, a device consisting of three small U-shaped axes, which anchored to the arm with a pivot, at the natural point of balance, allowing articulation of both the lateral joint and vertical movement.

A system of manually operated ropes, pulleys (Aristophanes alludes to a *trochós* [$\tau po\chi \dot{o} \varsigma$] when referring to the *mechanopoiós* in *PCG* III 2 fr. 192), counterweights, or winches, ensured its mobility both from top to bottom and, to a lesser extent, in parallel. The opening on the south side of the T foundation facilitated operations. A wooden floor, of which the recesses remain, was at the base of the *mechané*. The figure could descend onto the roof of the *skené*, or directly at the orchestra level. Examples of *mechané* have been surmised for the later theatre of Phliunte (Papadogiannis-Tsakoumaki-Chondros 2010, pp. 1-9).

The *ekkyklema* is also among the devices believed in use in classical theatre (among others, Arnott 1962, p. 78-88; Hourmouziades 1965, pp. 93-108; Webster 1967, p. 11; Newiger 1989, pp. 181-85; Belardinelli 2000, pp. 243-65; Bonanno 2006, pp. 69-82; Brioso Sánchez 2006, pp. 67-85; Lucarini 2016, pp. 138-56; Casanova 2017, pp. 3-42), despite the scepticism of some scholars (among others, Pickard-Cambridge 1946, pp. 100-22; Di Benedetto-Medda 1997, pp. 22-24).

For the 5th century BC, the only witnesses are verbal forms derived from $\kappa \nu \kappa \lambda \hat{\epsilon} \omega$ (kykleo), in turn derived from kyklos, circle, wheel, whose main meaning was to carry on a chariot (Chantraine 1968, I, p. 597, sub voce; see also Bonanno 2006, p. 69): eskyklein [$\dot{\epsilon} \sigma \kappa \nu \kappa \lambda \hat{\epsilon} \tilde{\nu}$], i.e. to bring inside/into on a chariot, to indicate entry into the skené (Aristophanes, *Themophoriazusae*, v. 265), and ekkyklein [$\dot{\epsilon} \kappa \kappa \nu \kappa \lambda \hat{\epsilon} \tilde{\nu}$], i.e. to take out on a chariot, to indicate exit (Aristophanes, Achamians, vv. 408-9; *Themophoriazusae*, v. 96). The playwright's use of the term on these occasions is technical (Lucarini 2016, pp. 139-40; Casanova 2017, pp. 10-12): it serves to render the poet's parody of Euripides' tragedy more effectively by representing the characteristics of the tragic works from which he draws his inspiration in a comic guise: to introduce the tragic poet Agathon on stage, lying on his bed in the *Thesmophoriazusae* (vv. 94-95); in the Achamians (vv. 408-9) when Diceopolis, faced with Euripides' reluctance to leave, asks for the ekkyklema's help (in Wasps, v. 1475, eskyklein seems to have a metaphorical connotation).

Scenes of killings and bloody episodes were excluded from view: the *ekkyklema*, therefore, only made the outcome of the terrible action visible, bringing on stage the body or bodies of the victims as a kind of *tableau vivant*. According to Pollux, the *ekkyklema* served to show what was happening in an interior – that of the stage building – which could not be offered in its crudeness to the public; he also specifies that if bringing inside assumed the name of *eiskyklema* [εἰσκύκλημα], an obvious allusion to the movement carried out by the device, rather than to another device, different from the first, as also supposed (e.g. Caciagli 2016). Pollux places it near the doors. Its use was however broader; it staged what took place behind the facade of the *skené* – and which only in part had the character of a *tableau* – shattering the scenic illusion and combining interior and exterior: the mosaics from the Villa of Cicero in Pompeii depicting scenes from Menander's *Synaristosai* (Naples, Museo Archeologico Nazionale, inv. 9987), and from the House of Menander in Mytilene, seem to visually illustrate this use of the *ekkyklema*, showing characters from the comedy on a platform.

As for tragedy, as evidenced at least by Sophocles' *Ajax* when the hero appears surrounded by the Achaean cattle he has slaughtered (Sophocles, *Ajax*, vv. 344-595; Schol. Soph. *Aiax* 346) and perhaps already in *Agamemnon* (vv. 1372-406) and in Aeschylus' *Libation Bearers* (vv. 973-1006; Schol. Aesch. *Choeph.* 973), its presence in the comic parody of tragedy nevertheless certifies its use at the end of the 5th century BC. The commentaries to the

Achamians around 408 explains its structure: it was a platform, a kind of low wooden chariot (also described as such in Pollux, Onomasticon, 4.128 and in Suda, s.v. ἐγκυκλήθητι), equipped with wheels, capable of movements in a straight line, and, according to some sources, revolving. Familiarity with this type of device is already found in the well-known *pithos* from Mikonos from the 7th century BC, preserved in the local museum (inventory 2240), where the Trojan horse on wheels is depicted at neck height of the vase. The fact that the verbs $\sigma \tau \rho \epsilon \phi \epsilon i v$ [strephein] and $\pi \epsilon \rho i \sigma \tau \rho \epsilon \phi \epsilon i v$ [peristrephein] occur in participial form in some testimonies has suggested that it was capable of circular movement, i.e. that it revolved around a pivot or a central axis. For it to rotate on itself, three wheels were needed, two parallel and a third single, which, with the help of a system of ropes and counterweights, could allow the platform to rotate within a circular or semi-circular space, as described later by Heron of Alexandria regarding the circular motion of the automata (Automata 1.7-8). However, it has been assumed that the reference to rotation implicit in the above-mentioned verbs is to be linked to the stropheion, i.e. to the winch, the instrument which, employing cross beams or a crank, and ropes and pulleys, could facilitate the movement of the platform (Casanova 2017). This is a hypothesis in line with what has been assumed, in the light of the technology adopted, for the mechané in the same chronological phase.

According to Pollux (*Onomasticon*, 4.129, Hesychius, *sub voce*), and also confirmed by Polybius (*Histories*, 11.5.8), *exostra* ($\dot{\epsilon}\xi\omega\theta\dot{\epsilon}\omega$ [*exotheo*], push out) was synonymous with *ekkyklema*. There is an inscription, in the neuter plural, from Delos of the 3rd century BC. (*IG* XI 2.199 A 95) related to theatrical devices. However, the term cited by Pollux is feminine. It has been hypothesised that the *exostra* served to show events that took place in a room on an upper floor, hence the late meaning of the word, balcony. The term was also applied to a type of bridge thrown over the walls of a besieged city, across which the attackers marched (Vegetius, *The Art of War*, 4.21). Whatever its nature, it must have had a function similar to that of the *ekkyklema*, though simplified in its mechanism, perhaps with the latter's function ceasing at a later stage.

The *periaktoi*, introduced as a technical device in theatrical performances from the Hellenistic period onwards, belong to a more advanced period. Vitruvius defines *periaktoi* as mobile triangular machines, prisms, each having three decorative surfaces, which, when in the performance «changes are about to occur or when divinities appear with sudden thunder, rotate presenting a differently decorated surface» (Vitruvius, *On Architecture*, 5.6.8). The term *periaktos* comes from the verb $\pi \epsilon \rho i \alpha \gamma \omega$ [*periago*] and indicates a rotating movement around something. Both Vitruvius and Pollux (*Onomasticon*, 4.126) add that they were placed near the two lateral doors. According to Pollux the two *periaktoi* were placed so that the prism on the right indicated «the parts outside the city» while the one on the left indicated the areas in the city, in particular the harbour area; it could also have introduced sea gods and do what the *mechané* was unable to do. Turning only the *periaktos* [$\pi \epsilon \rho i \alpha \kappa \tau \circ$] to the right changed the location (*topos* [$\tau \delta \pi \circ \varsigma$]), moving both, changed the territory (*chora* [$\chi \omega \rho \alpha$]): rotating both, therefore, indicated that the scene had moved to a different location from the one previously depicted.

The wooden machinery must have been made of painted and removable fabrics or panels, fixed on the three surfaces. On each surface a different background was painted which, thanks to a rotating movement, was shown when the performance required it, allowing sudden changes of scene, at the orchestra's height or the *logeion*. Their function was therefore twofold: scene changes and certain types of entrance. The discovery in Kaunos in present-day Turkey, and in other theatrical buildings, of blocks with a cavity to accommodate a rotating pin that could be used to fix the mechanism seems to confirm this possibility as experienced precisely in the theatre of Kaunos, employing a wooden prism with a base of 1.80 m and an estimated height of 2.40 m (Varkivanç 2015, pp. 181-202, figs. 1-17).

Pollux also mentions a variant, the *keraunoskopeion*, i.e. the lightning machine, which he describes as a *periaktos*, located at the top (*periaktos* $\dot{\upsilon}\psi\eta\lambda\dot{\eta}$ [*hypselé*], Onomasticon, 4.130). The

ALEXIA LATINI

rotation of the *periaktos* was meant to contribute to the representation of a stormy sky with lightning. This device was therefore no more than the adaptation of the *periaktoi* to a specific function. Rather than presenting a reflective metal surface (Pickard-Cambridge 1946, p. 236), the effect of which would have been dependent on the presence or absence of sunlight, it may have been made with the painted reproduction of a lightning bolt on a dark background that, once the prism was rotated, could give the illusion of lightning (Arnott 1962, p. 89).

Another simpler mechanism was the bronteion, whose use in the 5th century BC, and the situations when it was used, is debated. The sudden sounds of thunder in The Birds (vv. 1750-52), in Oedipus at Colonus (vv. 1456 and 1460), and Prometheus (vv. 1080-87), were probably made by shaking a metal vessel containing stones (Arnott 1962, pp. 89-90). Referring to the theatrical use of automata, Hero of Alexandria later spoke of a device consisting of a perforated vase filled with lead balls which «falling on a taut and tight skin produced a roar resembling that of thunder» (Automata, 2.20.4). It was therefore an elementary device, easily reproducible and acoustically similar to a percussion instrument. The bronteion, according to Pollux (Onomasticon, 4.130), was located at the bottom behind the skené and consisted of wineskins (askoi) filled with pebbles, striking against undefined bronze objects. A more complex mechanism was reported in a lemma of Suida (β 549) and a scholium to Aristophanes' Clouds (Schol. vet. nub. 292 β , p. 71, 3, 1 Holwerda)). The bronteion was an amphora containing marine pebbles which was rolled around in a bronze kettle, causing a noise similar to thunder on impact. Other devices reproducing the roar of thunder are referred to by the Byzantine scholar Tzetzes in relation to the Clouds (Schol. Tz. nub. 291a, p. 451, 4, 2 Holwerda), but these express realities subsequent to classical theatre.

Pollux also mentions the semi-circular *hemicycle* which was placed in the middle of the orchestra and was used to indicate a place far from the city or those who swam in the sea, and the *stropheion* which could show men transformed into gods or those who had died in war or at sea. Their use is uncertain but are nevertheless related to the proliferation of spectacular effects that was gradually taking place.

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[ALEXIA LATINI]

Modern Theatre.

In the theatrical lexicon of the modern age, the term *macchina* (Fr. *machine*; Eng. *machine*; Sp. *máquina*; German. *Maschine*) was commonly used to refer to stage devices employed to create theatrical and illusionistic effects, such as scene changes, flights, appearances, or disappearances. In truth, it is a rather generic word, used in conjunction with other more specific terms, such as *apotheosis*, *glory*, *ingegno* (ingenuity), *flight*, etc., which metonymically came to identify not only stage effects, but also the related devices designed to achieve them. Exploring the significant nodal points of the theatre's progressive technological acquisitions means following a path that is neither linear nor homogeneous, but still characterised by a basic material tradition: a know-how that has been enriched over time

ALDO ROMA

through the insertions of expedients developed in areas sometimes quite distant from the performing arts, and economically consolidated through the accumulation of technical solutions which have proved effective.

Even before appearing in the field of theatre (and, indeed, even before the full definition, between the 15th and 16th centuries, of what historiography identifies as the pertinent features of modern theatre, namely the formalisation of a science of space, the reinvention of dramaturgical awareness and the gradual constitution of a repertoire, and the consolidation and diversification of the techniques of spectacle production), the use of machinery is documented in the sacred representations. Celebratory apparatuses were set up in the aisles or transepts of churches on the occasion of certain solemnities of the liturgical calendar as well as for celebrations in honour of certain saints. Famous in this sense are the ingegni (in contemporary sources, this is the term that indicates the sacred machine as a whole) created in Florence in the 1530s by Filippo Brunelleschi (1377-1446) in the Church of San Felice in Piazza for the Annunciation and later by Francesco d'Angelo, known as il Cecca (1447-1488), in Santa Maria del Carmine for the Ascension. These technological solutions were based on celebratory devices that were already in use at the beginning of the 15th century and were later improved thanks to the most recent acquisitions in the mechanical arts and civil and military engineering. The presence of analogies and even contiguities between scenic devices and war technologies is a constant in the history of stagecraft, resulting from the fact that the most distinguished and influential theatre engineers/architects were first and foremost experts in the artes mechanicae (cf. Adami 2003, pp. 25-38).

A valuable account of Brunelleschi's *ingegno* is provided by Giorgio Vasari (1511-1574), who produced a machine for the Florentine Annunciation in Santo Spirito in March 1566. In Brunelleschi's *ingegno*, an opening of almost six metres was made in the nave's ceiling, and a wooden canopy representing a sky was installed above it. Around the perimeter were twelve children dressed as winged cherubs. Suspended in the centre of the sky was a revolving iron wheel equipped with seats, each of which was occupied by a cherub, and in the centre was a "mandorla di rame vôta" (empty copper almond) housing the Archangel Gabriel. Using a system of winches and pulleys, the device allowed the wheel to be lowered and the mandorla to descend to the platform used as the Virgin's 'residence', set up on the floor of the church in correspondence with the sky; after the *mandorla* had been secured to the platform, the archangel came out from it and the annunciation to Mary took place. At the end of the episode, the device returned to heaven, and the sky was hidden with the sliding of two panels that – as Vasari recorded – produced a "romore a guisa di tuono" (thunder-like roar; Vasari 1550, ed. 1878, pp. 375-78).

As has been noted (cf. Zorzi 1988), these machines brought an element of dynamism into an initially static apparatus with a rather traditional iconography. This resulted in a multimedia device that was already 'theatrically' engaging for the worshipper/spectator, thanks to an evocative interweaving of words, image, sound, music, and light. Chronicles of the time frequently mention lamps, torches, lanterns, and *cocciòli*, which – in addition to their obvious illuminating function – contributed to the decorative scheme with a skilful arrangement simulating natural light sources such as stars (cf. Grazioli 2008).

During the Renaissance, the adoption of machines was also consolidated and expanded in specific representational and entertainment forms connected with secular liturgies and celebratory practices that characterised the context of Italian courtly festivities. Carousels, jousts, banquets, tournaments, and *trionfi* were organised to celebrate exceptional events and anniversaries (births, baptisms, weddings, the arrival and sojourn of princes, sovereigns, foreign ambassadors in the city, etc.). These machines owe much to Brunelleschi's *ingegni*, although the technical solutions could be diversified according to the material contingencies of the festivity. Such variety could be also found in the figurative schemes they featured, which were usually taken from the classical mythological repertoire, suitably refunctionalised in an encomiastic key according to the "political programme of self-justification of power that the Renaissance prince" was promoting (Tichy 2003, p. 27). The

contribution of Leonardo da Vinci (1452-1519) in his work as a stage designer and decorator at festivals and tournaments in Milan and France was both significant and original. Drawing from his studies in mechanics, he devised or perfected several scenic devices that proved to be of considerable effect. In doing so, he established himself as an ingenious interpreter of classical culture and the relative technical knowledge re-proposed by Humanism.

Among the drawings documenting Leonardo's inventions are some sketches of the machines for three stagings: *La festa del paradiso*, with verses by Bernardo Bellincioni, put on in Milan in 1490 by Duke Regent Ludovico Sforza, known as il Moro, on the occasion of the wedding of his nephew Gian Galeazzo to Isabella of Aragon; the *Comedia di Danae* by Baldassarre Taccone, performed in 1496 at the court of Count Giovan Francesco Sanseverino of Aragon; the *Favola di Orfeo* by Angelo Poliziano, possibly staged between 1506 and 1508 for Charles d'Amboise, the governor of Milan. Several drawings depicting a revolving scene with a mountain, which could probably be open using a system of counterweights to show Orpheus the gateway to hell, have been traced back to the latter production (cf. Pedretti 1981, pp. 290-95).

Medicean Florence at the height of the 16th century is the setting for a particularly prosperous conjuncture for subsequent developments in stagecraft. Here, the intermezzi between the acts of the dramas performed at court -a custom that, however, already dated back to the spectacles in Ferrara under Ercole I d'Este (1431-1505) - became, as Sara Mamone (2015, p. 19) recalls, "the favourite [spectacular] form for the audience, and thus the form of the self-representational magnificence of the commissioning lord, and the best training ground for the technological skills of his artists-designers". Emblematic of this orientation are the intermezzi for L'amico fido by Giovanni Bardi (1534-1612), performed in the new theatre of the Uffizi in 1586 at the wedding of Cesare d'Este and Virginia de' Medici, sister of the Grand Duke Francesco I; and even more so the intermezzi for La Pellegrina by Girolamo Bargagli (1537-1586), staged in 1589 for the wedding of the later Grand Duke Ferdinando I to Christine of Lorraine. In both cases, the creator of the machines was Bernardo Buontalenti (1531-1608), a designer, architect, and engineer who had already collaborated with Vasari and Baldassarre Lanci (1510-1571) in previous Medicean festivals and performances. Moreover, he was responsible for the new organisation of the Uffizi's theatrical space. In this regard, the way he optimised the space to house and operate the machines and make it functional is noteworthy: in particular, he achieved this by enlarging the theatre's attic -i.e., the upper space of the scenic tower between the ceiling and the grid, not visible to spectators – and expanding the backstage, as well as implementing the practicability of the stage floor through the use of trap doors (in addition to Warburg's famous 1895 essay, cf. Michaud 2012; Testaverde 1991; Mamone 2015). This allowed Buontalenti to fully exploit the potential of the stage box and its depth, making it possible, for example, the descent from above of clouds bearing supernatural characters (even in large numbers), and the emergence of mountains and infernal figures from under the stage. To do so, he employed a system of winches and counterweights to manage the vertical and horizontal movement of stage devices. A century later, Filippo Baldinucci (1624-1696) still mentioned Buontalenti's perspectives and machines in his Notizie, recognising them as "something unmatched, either before or after; [...] these same machines were the exemplar, from which the newest and most singular methods and artifices were taken by engineers all over Europe, through which the beautiful things that are known have been made, in Rome as well as every other city and province [...]" (Baldinucci 1688, pp. 97-98). In this experience the historiography of the performing arts has also recognised the full maturation of the knowledge of the stage machinery as well as the development of a vocabulary of technological solutions destined to become not only an integral part of the model of Italian-style theatre, but above all a codified repertoire of scenic possibilities, which would also have been a constraint in terms of dramaturgical choices (cf. Mamone 2003 and, with regard to opera, Viale Ferrero 1988).

ALDO ROMA

The so-called Baroque stagecraft seamlessly inherited the material tradition that had been elaborated and experienced in the Florentine context. It perfected the systems that allowed the movement of machines and came up with new devices, albeit based on the same technologies, to reproduce particular natural phenomena on stage with markedly illusionistic effects. The catalogue of devices was relatively limited: it included aerial machines and cranes, elevating or hoisting equipment, carts and devices for special effects (e.g. those to simulate the rippling of sea waves or the flames of hell). The variety of realisations was ensured by the different combination and multiplication of the constituent modules of the machines and by research into the possibilities of movement on stage, as well as the pictorial and therefore more properly scenographic element. The most significant innovations achieved during the first half of the 17th century were precisely the technical conditions needed to confer fluidity and agility to the movement of machines and scenic apparatus, which had as its "visual result [...] the construction of an absolute time of the image, of a fluidity of appearances that nullifies the real space and unifies the complex reality of the scenic construction also on a dynamic level". This is what Raimondo Guarino (1992, p. 54) shrewdly points out with regard to the Venetian acquisitions of Giacomo Torelli (1608-1678), an architect from Fano who moved to Venice to work, perhaps as a naval engineer, at the Arsenale. He soon became involved in the construction of the Teatro Novissimo, the city's first space specifically intended for opera, inaugurated with La finta pazza (libretto by Giulio Strozzi, music by Francesco Sacrati) in January 1641 (cf. Bianconi-Walker 1975; Bianconi 2000). According to contemporary chronicles, some historiography had attributed to Torelli the supremacy of the invention of a device for the simultaneous and visible change of all the wings - at the time, the wings were called *telari* or *teleri*, and they gradually supplanted the *períaktoi*, *i.e.*, large rotating prisms of classical ancestry, with a mostly triangular base, that allowed the scene shifting at sight. The device adopted by Torelli consisted of a single, sturdy winch placed in the centre of the under-stage in the direction of the scene depth and connected to all the wings by means of counterweighted ropes, which ran simultaneously when the winch rotated, thus allowing them to change. In fact, this solution had already been used several years earlier in the Teatro Farnese in Parma by Giovan Battista Aleotti (1546-1636), the hydraulic and theatre engineer who had conceived a device for flooding the Pilotta's stalls for the *naumachia*, staged precisely for the theatre's inaugural performance (cf. Ciancarelli 1987). His innovations were then employed by his pupil Francesco Guitti (early 17th century-1640) in Parma and Ferrara. It is, therefore, likely that Torelli perfected the fluidity of a device that, by then, was already among the technical possibilities available for the purpose (cf. Adami 2003).

Torelli's case, however, is exemplary, above all, of the phenomenon of the transfer of stagecraft knowledge related to the model of Italian-style theatre and its fortune at European courts across the Alps. Such cultural transfer depended mainly on the circulation of artists and craftspeople in the networks of aristocratic and princely patronage – Torelli, for example, worked at the French court from 1645 – but also, vice versa, on the *peregrinatio mechanica et militaris*, that is, the journeys of foreign architects and intellectuals to the Italian courts (an overview of the 'diaspora' of the "great dynasties" of Italian set designers active in the opera field is offered in Viale Ferrero 1988, pp. 54-56; for the significant case of the transfer of Italian mechanical knowledge to the Germanic area favoured by Joseph Furttenbach the Elder, cf. Lazardzig-Rößler 2016; on the British architect Inigo Jones, a pupil of Alfonso Parigi in Florence, cf. Orgel-Strong 1973).

Stagecraft – and, more generally, mechanics – fell within the realm of tacit knowledge: its transmission took place primarily in oral form. It was subordinate to dynamics of appropriation and individual implementation that were intimately conditioned by variable practical contingencies (cf. Lazardzig – Rößler 2016). It is for this reason that the sources documenting the theatrical machines of the time, even the numerous and apparently detailed reports and descriptions, are deficient, incomplete, and even obscure, most of the time not clarifying the devices' actual functioning and mainly reporting on their effects on the public. In addition, it has to be noted that these sources show a particular propensity for

secrecy, both because of issues related to the intellectual protection of inventions and because the sharing of technical knowledge with laymen would have compromised the desired aesthetic effect (the *gusto* and marvel mentioned in all 17th-century treatises). On the other hand, the emergence of treatises on architecture, stagecraft, and perspective – they became increasingly numerous and widespread during the century (see, e.g., Sabbatini 1638, Chiaramonti 1675, Carini Motta 1676 and 1688, Carapecchia 1689-1691, Pozzo 1693-1700; cf. Povoledo 1961, cols. 1616-17) – is indicative of a progressive codification of spectacular praxis: as has been noted, these treatises are symptomatic of "a general trend in the *Artes Mechanicae* towards the discursivisation and de-personalisation of tacit knowledge" (Lazardzig-Rößler 2016, p. 279).

In non-European theatrical traditions, too, the use of stage machinery is attested in the 18th century to allow rapid entrances and exits, flights, costume changes, and scene shifts. For example, in the *kabuki* of mid-18th-century Japan, a revolving stage (known as *mawari-butai*) was introduced to achieve quick scene changes thanks to a device controlled from the under-stage (for a more detailed discussion see Leiter 1976 and, more generally, Liu 2016 and the bibliography cited there).

In the centuries that followed, stage machinery underwent the gradual standardisation of the processes of spectacle production. Its importance diminished considerably in relation to the changes that affected the broader renewal of aesthetic and representational conceptions. Yet, the basic stagecraft principles remained and remain valid today. At the same time, scientific and technological advances have intervened and still intervene today, as in the past, in the realisation of the new devices, such as the use of hydraulic and then electric power in the motorisation of the stage.

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