Islamic Automata in the Absence of Wonder

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ABSTRACT

This thesis looks at the interpretive difficulties posed by the Islamic automata, or *hiyal* manuscript--an ingenious genre of medieval illustrated manuscripts that describes and depicts mechanical devices such as water clocks, trick vessels, and automata. I choose to focus on the ways in which the automata manuscript has been viewed by scholars, rather than providing a history of the manuscripts themselves, precisely because this latter effort is complicated by a scholarly anxiety with what, exactly, Islamic automata manuscripts are, how they were used, or if (and how) they are valuable. This anxiety reveals not only a deeply subjective discontent with our totalizing "bourgeois" notion of technology - one that claims that we progress only by perfecting our implements - but also points to an inability to overcome this discontent. The way that this discontent is revealed through automata is that this "bourgeois" notion is not only totalizing, but also European. Automata scholarship thus allows us to see how European technology itself can be totalizing.

The thesis reviews interpretive trends of this literature: The art historical origins of automata scholarship; mid century scholarship that touted the functional principles of the devices, and today's framework, which places automata in a linear technological evolution towards robotics, cybernetics, and advancement of human self-reproduction. Automata scholarship throughout has maintained a sterile distance from the historical context of the automata production. To close this gap, I argue, the ideological character of the Islamic automata manuscript must be revealed and its problematical relationship to technology disenchanted at every step.

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This thesis would not have been possible without Rasily Tim Tim Kalinga Goli.

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| *introduction*

Until the juice ferments a while in the cask,
it isn't wine. If you wish your heart to be bright,
you must do a little work.

Rumi

The Islamic automata manuscript outlines in compendium form dozens of mechanical devices; moving birds; and the fabrication of metal humans. This genre of illustrated manuscript was conceived by craftsmen and copied for the most part throughout the 9th to 15th century in the Islamic world.[1] Islamic automata manuscripts conveyed advanced mechanical knowledge of the Late Antique and early medieval period, but they were also highly imaginative works. The branch of knowledge was so ingenious it was referred to as *hiyal*, 'trick' or 'ruse,' which is also a name for mechanics. The manuscripts[2] consist of the verbal description and visual depiction of

[1] It is significant however that there are some copies of these manuscripts emerging as late as the 18th century. See appendix.

[2] In the present work I use both *hiyal* and "Islamic automata" manuscript interchangeably because, while some of trick vessels and water clocks are not "automata" proper, this moniker I believe better connotes something that is shared by all of the manuscripts in one way or another: the conveying of mechanism though human or animal figures. *Hiyal* is a historical term across medieval Islam, and it is a looser term also referring to "mechanics" in general. Still, its use is not set in stone, for one of the manuscripts presented here, *The Book of Secrets*, of Ibn Khalaf al-Muradi, does not refer to this word and yet the genre of devices is remarkably similar. I would like to thank Ahmed Ragab for helping me clarify these issues, as he has suggested that it might have something to do with the use of the manuscripts themselves, to be touched upon later if briefly, but there is not enough evidence or argumentation to support this at this time, or in the present work.

a range of moving mechanical devices including water clocks, mechanical theaters, fountains, trick vessels, and musical automata,whose stories might depict, among other things, a monk measuring blood with his staff, destructive fire-breathing birds and thirsty bulls, the "transformation" of water into wine discharged from an idol's mouth. The devices very broadly employ systems of weights and balances, often containing water with floats connected to strings that trigger traps, open and close valves, or rotate internal gears that act as escapements similar to that which would produce the swinging motion in a clock pendulum; pneumatic devices used complicated siphons and air pressure tube tricks to trip floats or drip water in symmetrical time.

The present work offers a historiography of the Islamic automata manuscript, which is by no means straightforward. The hypothesis I begin with is that the Islamic automata manuscript poses some unique difficulties in how to understand what it says and as such, reveals tensions that are deeply entrenched in historical opinion on technology. Part of why the manuscripts are so important is that our best way of knowing about an Islamic tradition of technology is through them.[3] In order to know what the manuscripts were describing, however, scholars document the drawings above and beyond their ambient state: Sometimes the drawings are "corrected" and sometimes they get changed entirely. Just like optics or medical manuscripts; geometry manuals; or treatises on useful machines such as grain mills and water wheels from the medieval Islamic world, the information presented in the automata manuscripts would have been bound up with professional practice, and so, while the jargon and drawings might not be readily legible to those outside the profession, the devices themselves could be fabricated. Today this process is even less straightforward--there are no

[3] There is some literary allusion to the sculptures themselves that could be referred to as evidence for automata, and ample of it at that according to T.M.P. Duggan in "Diplomatic Shock and Awe: Moving, Sometimes Speaking, Islamic Sculptures." *Al-Masaq 21:3 (2009) 229-267* However this literature offers no explanation on how the devices function, which means that it is of limited importance for historians of technology, who came to predominate the study of automata.

more medieval craftsmen. Just what an automaton ought to look like is not so clear from the manuscript. Thus we only really know the manuscripts through the interpretations, transcriptions, and reproductions of them, and this only started at the *fin de siècle,* when the booming of industrialization in Europe had dissipated enough for the bourgeoisie to grow antsy with the fruits of cultural progress that had been established in the wake of industrialization. Indeed, the 20th century would be characterized by technological advance that arguably catered more to destruction than to freedom, encapsulated by two thoroughly modern wars.

There are three hiyal manuscripts,[4] all of which outline the above functions, and all of which depict animals, and humans conveying mechanism, are codified with referable key code systems (sometimes in a "secret" alphabet), and feature relatively plain handwriting and paper.[5] (Fig 0.1) Stemming from the three original copies produced in three unique times, collectively there are 21 manuscripts with varying uses of colophons, notes in the margins, and illustration styles. The most tractable and the most prolifically copied *hiyal* manuscript is *A Compendium on the theory and practice of the mechanical arts* (*al-jami' bayn al-'ilm wa-'l-'amal al-nafi' fi sina'at al-hiyal*), probably first written in 1206 in Anatolia by the famed, "erudite engineer" Badi'al-Zaman Abu al-'Izz Isma'il b. Razzaz al-Jazari of Artuqid Anatolia in the early 13th century.[6] Al-Jazari is credited with numerous mechanical innovations such as developing the

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[4] There are a few other examples of Islamic monumental water clocks that feature human or animal figures in action, but few remaining descriptions. One was documented by Fakhr al-Din Ridwan b. Muhammad al-Sa'ati around the same time as al-Jazari, whose father Muhammad al-Sa'ati's Bab Jayrun, a monumental automata water clock at the gate of the Umayyad Mosque in Damascus, but Ridwan's observations are monographic rather than anthological like automata manuscripts, and he himself was no engineer (but reportedly a physician), containing his description to one device rather than a compendium of observations. See Finbarr Barry Flood, *The Great Mosque of Damascus: Studies on the Makings of an Umayyad Visual Culture, Islamic History and Civilization* (Leiden: Brill, 2001) p. 116

[5] See list of images for additional details on images

[6] *The Book of Knowledge of Ingenious Mechanical Devices. (Al-Jami ' bayn al-'ilm wa 'l-'amal al-nafi ' fi sina 'at al-hiyal).* trans. Donald Hill (Dordrecht, Boston: Reidel, 1974) The alternative title *Compendium on the theory and practice of the mechanical arts,* cited above, better fits the Arabic and will be used here.

crankshaft and camshaft.[7] There are fifteen copies of the manuscripts around the world that exhibit a variety of stylistic differences among them--some with colored illustrations, some with more humble graphical line drawings. Al-Jazari is the most oft studied and cited work of the genre. Before him, from Andalusia, is Ahmad Ibn Khalaf al-Muradi's[8] *The Book of Secrets in the Results of Ideas, (Kitab al-Asrar fi nata'ij al-afkar)*, originally written in the 11th century but the only known version of which was copied in 1266 according to the colophon. The images in this manuscript are markedly different and resemble geometric constructions more than painted drawings. Finally, the earliest known *hiyal* manuscript is Banu Musa's *Kitab al-Hiyal, The Book of Ingenious Devices*, a work on pneumatic trick vessels,[9] written sometime in the latter half of the 9th century in Baghdad. These brothers, "the sons of Musa bin Shakir," who was reputedly a marauding robber-turned-astronomer-engineer, were political participants of their day, the mention of which is never neglected from exegeses of their work.[10] They were Ahmad, probably responsible for *Kitab al-Hiyal*, an engineer; Muhammad, an astronomer, and Hassan, a geometer; although these vocations are rough and not exhaustive. There are three known manuscripts and two fragments, all featuring similar drawing styles that vary as to whether they display images of animals or not, and by quality.

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[7] Two mechanical parts that would be fundamental to the internal combustion engine for they help to convert rotary to linear motion moving pistons.

[8] Mario Taddei, *The Book of Secrets/Kitab al-Asrar*, trans. Ahmed Ragab. DVD/Facsimile. (Milan: Leonardo3, 2007) The authorship is not completely secure, as "Ahmad" was derived from mentions of the name in contemporary bibliographic sources.

[9] *The Book of Ingenious Devices (Kitab al-Hiyal)*, trans., Donald Hill (Dordrecht: D. Reidel Pub. Co., 1979) This refers to a jar or vessel of some type that hides tanks and tubes or siphons controlled by changing air pressure that would release their contents in measured and surprising ways. There are some gear chains involved, usually however driven by water floats levitating or falling. See Model 6, p. 65

[10] Henceforth, the manuscripts shall be referred to as the following:
Ingenious Devices--Banu Musa's *Book of Ingenious Devices*
Book of Secrets--Ibn Khalaf al-Muradi's *The Book of Secrets*
Compendium--al-Jazari's *Compendium on the theory and practice of the mechanical arts*

Hiyal was mentioned by a handful of medieval thinkers.[11] In the 14th century--when manuscripts were still being copied--"proto" social historian Ibn Khaldun said of the Banu Musa's text, "there exists a book on mechanics that mentions every astonishing remarkable and nice mechanical contrivance. It is often difficult to understand, because the geometrical proofs are difficult."[12] This would suggest that while I have listed the three known engineer authors, there either could have been more, or there was a thriving practice. The copying of the Islamic automata manuscripts spanned numerous revolutions in the Islamic world and near obliteration by the Mongols, so representational idiom changed in the process.

Rather than providing a history of the manuscripts themselves, I focus on the ways in which the automata manuscript is viewed by scholars, precisely because a history of *hiyal* manuscripts is complicated by a scholarly anxiety with what, exactly, Islamic automata manuscripts are, how they were used, or if (and how) they are valuable. What would account for the attitudes governing Islamic automata? I will look at how the "long legacy" of industrialization has molded Islamic automata manuscripts to ultimately resemble an imagined robot--the self-acting, thinking image of our better selves that has risen above cultural particularity. How automata *appear* is a question colored by the affirmation of technology, whose obverse is the perceived monopoly of the West on technological progress.

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[11] 10th century polymath Muhammad ibn Ahmad al-Khwarizmi included a section on *hiyal* in his *Keys to Science, Mafatih al-'Ulum* and turn of 9th century al-Farabi, quoted below, also includes a section on *hiyal* in his *Ihsa al-'Ulum, Enumeration of the Sciences.*

[12] Quoted from Hill, *Ingenious Devices* p. 17

european machines

It is not self-evident in the manuscripts "how" *hiyal* devices work, but 20th century scholarship has taken up the task of hypothesizing this around the broader framework of function or "use" of the devices themselves, though not necessarily around the manuscripts themselves. This repertoire of scholarship does not quite seem to know what to make of *hiyal* manuscripts, which have both a representational, "artistic" quality, as well as a functional, mechanistic, and potentially technological character. To sort them out, one must understand that Islamic automata manuscript scholarship commenced only at the turn of the 20th century and thus has always existed within the teleological landscape of the "socially useful machine," symbolized by the steam engine and, earlier, the mechanical clock. These technological advances signify points in history when industrialized production "generalized," "abstracted," or streamlined the way that commodities got produced, thus allowing for a quicker and more concentrated accumulation of capital. Production could be measured in time, products distributed rapidly, thus shortening the turn around time of production; and the physical fabrication of a good delegated to machines. Industrial or large-scale, efficient production, however, still required concrete labor to be shape material into "goods." Despite the importance of the machine, however, Moishe Postone in an imposing re-interpretation of Marx's labor theory of value, has pointed out that the machine was a function of an advance in the *social* division of labor:

> The reduction of necessary labor-time--that is, increased productivity--was first effected historically primarily by breaking down the labor process into its constituent parts, *rather than by introducing machinery*. Each resultant partial operation of manufacture...retains the character of a handicraft and, hence, remains bound to the strength, skill, quickness, and sureness of the workers. On the one hand, then, production remains bound to individual human labor, on the other, it becomes more efficient as this individual labor becomes more partial. The result, according to Marx, is the creation of a peculiar 'machine' that is specifically characteristic of the manufacturing period--namely, the collective worker, formed out of the combination

> of a number of individual specialized workers. The individual workers become organs of this whole.[13]

Postone disputes that it was machinery itself that led to the reduction of labor time; rather a social change in the production process or network historically accounts for the usefulness machine. He speaks of an abstract character of the production process--the collective whole of which individual labor is a "part." Machines can be understood insofar as, irrespective of the concrete labor performed by the worker (direct labor) the production process is increasingly divided up into more parts--a process of abstraction--and the product is surplus value itself, a social form of wealth.[14] The machine rests on the concrete side of the production process, even though it helps divide it up through abstract parts. This basic "contradiction" between the socially generalized production process and the concrete labor that it relies on constitutes production of value and is the premier dynamic of capital. "A further stage in this historical process of overcoming direct human labor's centrality to the labor process is the production of machines by machines, which provides the 'adequate technical foundation' of large-scale industry. These developments result in a system of machinery, which is described by Marx as a vast automaton driven by a self-acting prime mover."[15] Machinery has an "automatic" aspect but it is still driven politically through capital, the self-acting prime mover. This is a different landscape than, say, the medieval Islamic world, in which highly specialized but interconnected trade guilds' use of machines did not

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[13] Moishe Postone, *Time, Labor, and Social Domination: A Reinterpretation of Marx's Critical Theory* (Cambridge: Cambridge University Press, 1993) p 330

[14] That is, the social capacity to "recognize" something as valuable. Postone writes, "The contrast between value and 'real wealth'--the contrast between a form of wealth that depends on 'labour time and on the amount of labour employed' and one that does not--is crucial...to understanding Marx's theory of value and his notion of the basic contradiction of capitalist society. It clearly indicates that value does not refer to wealth in general, but is a historically specific and transitory category [...] Moreover, it is not merely a category of the market, one that grasps a historically particular mode of the social distribution of wealth... [but] is a historically specific form of wealth and is intrinsically related to a historically specific mode of production." p. 25

[15] Ibid., p 38

aim outside of the machine to evince generalizable value, but instead was bound up with the concrete edification afforded by the commodity it produced. In other words, the "whole" of labor rested in the concrete act, whereas under capitalism, "the increasing productive power of the whole is constituted at the expense of the productive power of the individual."[16]

Socially useful machines thus mean that in producing products, as well as society itself, the machine aids and abets the process, although it does not necessarily inspire it. When historians of technology thus afford importance to the steam engine or clock, the "teleological landscape of the socially useful machine" is bound up in capitalism, whether or not it is articulated, for the machine generated social (as opposed to material) wealth in such a capacity.[17] The machine is viewed as in some way fundamental to the progress of capitalism, or (perhaps somewhat tautologically), to the progress of European technology. In so doing however, the machine as such gets treated as an individual, rather than as part of the system of machinery that Postone explains as characteristic of industrialization of production.[18]

However odd it seems, as the machine comes to resemble a more autonomous entity (that is, removed from the production process that Postone takes pains to outline and understood as a "cultural" entity, or a creature of cultivation), and as it is removed from its historical context only to be re-inserted, any mechanical device can be, and is, drawn into its discourse. That is this teleological landscape has dictated the form of automata--Anson Rabinbach calls automata, for example, "machine metaphors," which allude to machines, but

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[16] Postone, pp. 329-330

[17] Some who will become familiar character of the present work have espoused such view, Lynn White, and George Saliba. Lynn Townsend White, *Medieval Religion and Technology: Collected Essays* (Berkeley: University of California Press, 1978) p. 204 George Saliba, "The Function of Mechanical Devices in Medieval Islamic Society," *Science and Technology in Medieval Society* (Dec 2006) p. 147

[18] The 18th century.

really do not possess the same role in the pragmatism of industrial production.[19] This poses a problem of usefulness for Islamic automata, which are not socially useful in the same respect as machines, and they have no overt consumers. Whether through their contribution to useful technology, or in counter-identification with it, what has governed interest in Islamic automata manuscripts has been post 19th century attitudes toward the machine.

This is of course the same for "other automata," namely, 18th century Enlightenment automata such as Jacques de Vaucanson's digesting duck.[20] In a letter to Friedrich Engels from 1863, Karl Marx mentioned Vaucanson's work in this capacity to complicate the requisite bourgeois machinery for industrialization, but he does not refer to Vaucanson's experiments as automata per se: "Nor can there be any doubt that it was the clock which, in the eighteenth century, first suggested the application of automatic devices (in fact, actuated by springs) in production. It is historically demonstrable that Vaucanson's experiments in this field stimulated the imagination of English inventors to a remarkable extent."[21] The difference in meting out automata and their relationship to the machine is that Islamic automatic devices' contribution to the clock is thrown into relief based on a demonstrable failure to progress in the same fashion as those of Europe, and no on could prove that they whetted the minds of English inventors. Vaucanson's automata could later be called automata because they, precisely, inspired inventors. Simply enough, Islamic automata are medieval devices, not

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[19] Anson Rabinbach, *The Human Motor: Energy, Fatigue, and the Origins of Modernity* (New York: BasicBooks, 1990) See p. 52-58

[20] See Jessica Riskin, "The Defecating Duck, or, the Ambiguous Origins of Artificial Life" *Critical Inquiry*, Vol. 29, No. 4 (Summer, 2003), pp. 599-633 in which Riskin says, "[The automata's] success lay in their author's transformation of an ancient art. Automata, 'self-moving machines,' had existed from antiquity, *but as amusements and feats of technological virtuosity.* Vaucanson's automata were philosophical experiments, attempts to discern which aspects of living creatures could be reproduced in machinery, and to what degree, and what such reproductions might reveal about their natural subjects." p. 600. and Elly Truitt, "'Trei poëte, sages dotors, qui mout sorent di nigromance:' Knowledge and Automata in Twelfth-Century French Literature" *Configurations*, 12.2 (2004) 167-193 Truitt uses the construct of "metal persons" to signify the occurrence of automata in medieval French literature.

[21] Marx to Engels in Manchester *Marx Engels Collected Works* 41 (New York: International Publishers:1985), p. 488

Enlightenment "philosophical experiments," as Jessica Riskin calls Vaucanson's automata.[22] Certainly there could be a direct link between 18th century devices and 19th century technology, but what about 9th century devices and 16th (Giovanni di Dondi's mechanical clock) and 18th century (James Watt's steam engine) inventions? This latter question is a less tractable problem, and it is where Islamic automata must be situated to understand how they have been viewed by scholars.

Thus the problem is endemic to the Islamic automata manuscript, perhaps precisely because the technological rubric for their study is totalizing. In his essay "The Iconography of *Tempermentia* and the Virtuousness of Technology," Lynn White observes the uncanny consensus of moderns to morally affirm technology. Where negative attitudes towards technology are found, White says, they protest the social structure that allows for the exploitation of human through machine; not the labor that the machine itself accomplishes.[23] This optimistic outlook is explained in two ways: first, implicit in White's argument and by nature incontrovertible, the machine can perform work for the human. But more specifically, White intervenes in the "dull legacy of the debate" over Max Weber's theories of cultural factors that led to capitalism. In so doing he suggests that salutary feelings toward technology and industriousness were evident in Catholic iconography in the form of virtuous symbols of time measurement and wisdom before and after the Protestant Reformation, which, we are to conclude, more than anything symptomized the integration of industrious asceticism into dogmatic discipline. In this way White suggests that technology has an ideological character

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[22] Riskin, p. 600

[23] White apprehends the machine as a class or individual, and that what he is speaking of is a bourgeois phenomenon is a point well taken here. But the idea is that like art, literature, the bourgeois opinion precisely that has constructed the disciplines of culture and these things White tends to conflate technology with machine. Just like one cannot conflate art with painting, technology and the machine are not quite the same. That being said, however, it is impossible to argue--by force of sheer physical power--that a machine cannot perform certain alleviating tasks. If this is true, it attests to the social character of labor, since although machines exist they are not a totalizing production force today.

that was formative to the bourgeoisie, and it has lingered in "Western" attitudes toward technology.

White's essay also acts as a subtle if mandatory intervention into the politics of his own day, and the drive toward development in postwar 1960s. In his words, "the problem of aiding economically backward areas has become, to a great extent, the *humanistic* problem of understanding contrasting value patterns."[24] It is significant that the medievalist White considers this a humanistic problem as though there were a "universality" that compelled the problem of world development. However, he concludes his essay saying: "The late medieval affirmation that technological advance is morally benign...remains an axiom of the modern West, and not simply of the bourgeoisie."[25] White's essay is abundant with compelling evidence and argumentation, and it is a productive intervention into the question of religion and economy, as well as the interesting question of what technology is writ large. But his interpretation of this evidence for the modern day somewhat falters on *how* this medieval iconography extends into his present moment; and how it extends to other cultures than the West. Contrary to White, it ought to be the other way around--that technological advance is an axiom of the bourgeoisie, not simply of the modern West. Is it fair to maintain that the moral imperative of industrious asceticism continued to dominate the West, when throughout the world, industrialization appeared to be a pre-requisite for state survival and independence? Furthermore, isn't this precisely a bourgeois, and not geographically Western compulsion? Looking at this subtle difference between religion's relationship to technique and technological advance as a moral phenomenon is a salient way for understanding the task set out in the present work.

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[24] White, p. 182 Emphasis mine.

[25] Ibid, p. 204

If the moral character of technology is an imperative derived from a perceived external source--religion--then it is the bourgeois aim to be able to transcend this particular origins and establish the system of consciousness in any given place. That is, not simply the West, but everyone shall embrace "technological development." White alludes to the question of cultural proclivity to technique by disenchanting technology as a moral and political enterprise with religious origins. He proposes a framework for understanding the valorization of certain technical apparatuses such as clocks, water clocks, and windmills in a medieval European context. How do we evaluate the technical "objects" and endeavors that exist outside of this patently moral discipline? This question is remarkably present in *hiyal* manuscript scholarship, which is almost always described as prefiguring many later European technological developments, but which neglected to exploit the ideological purchase of these developments and neglected to progress in the same accelerated model. The implications of White's essay are that technology rests not in objects, but in their ability to be brought into its discourse.

the culture of islamic automata

Islamic automata demonstrate how objects can be brought into this discourse of technology after the latter has been thoroughly admired for centuries, if we are to believe White. Early on automata manuscripts were not mentioned at all under the aegis of technology, but more so as a matter of artistic development, and they were collected as paintings. Late mid-twentieth century scholarship on automata, starting with the erudite Donald Hill, late pre-eminent scholar of Islamic technology, attested to the functionality of automata, which, unlike literary descriptions of automata, is made available through descriptions of construction, to be deciphered by a clever scholar. Since this lively integration

of Islamic fine technology into the discipline of the history of technology, the Islamic automata through reconstruction becomes an autonomous object that is independently "technological," and is inserted into a technologically evolutionary notion of history, in which the perfecting of implements constitutes progress.

Lynn White's argument gives us a thought model for understanding this, as he looks to the increasing autonomy of the technological apparatus to the point where it almost nearly contained and almost embodied the virtuousness of temperance and wisdom, and no longer even needed to be regulated by a wise and virtuous person, as it is in the example of King Solomon's praising wisdom and repairing a clock.[26] In this way we can suggest *why* the cultural argument White makes about the particular moral appeal of the engine, for example, combined with the relative autonomy of the technological apparatus to mediate this sentiment poses real, material, difficulties for the study of extra-European attitudes toward technology; for if we are to understand White, the moralizing of technological advance is thoroughly naturalized into the object itself.[27] The framing of evidence in this way might go so far as to suggest the difficulty of understanding *hiyal* for its perceived lack of an "object" or apparatus. Lynn White's narrative is possessed of the power to explain why it is so difficult to understand technique in a culturally defined sense when the very framing of the topic as such seems to contradict itself--that is, moralized, technology was "invented" in Europe. In this sense, the old

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[26] White, p. 198 In White's essay, King Solomon is later depicted repairing the clock that functions of its own accord. Imagery of Solomon is by no means far afield for Islamic automata. Solomon also plays a similar role--with different implications--of wisdom and ingenuity in literary accounts of Islamic automata, illusion, and tricks. In particular, his interactions with Queen Sheba in which falling for his illusions, such as a glass floor for a pool, is a sign of a dissuasion from wisdom of faith. See Duggan, pp. 270-273

[27] White first suggests a change in how labor was understood concomitant with the transformation of Saint Joseph from gullible fool to strong guardian of artisans and patron of carpenters. Second the revival of Aristotelian ethics upheld the dictum "virtue is the golden mean" whereupon virtue itself was equated with moderation between excess (sins). Finally Temperance was equated with *sapienta*, wisdom, which White speculates was more a development amongst the aristocracy than amongst the clergy. White's most robust evidence is the advent of the timepiece as a religious symbol itself, and the shift that occurs here by the mid 15th century. By this point, "Temperance...is wearing a clock on her head as a hat." White pp. 185 and 198

critique of Orientalism--something in which, since the late 1970s, Weber has been enmeshed[28]--instead of mandating deconstruction, imposes actual *physical* constrictions on understanding technique, or technology in the Islamic context.

Indeed, in another essay, White expansively defines technology as "the way people do things," adding, significantly, "in a certain sense there is even a technology of prayer."[29] This operative concept of technology bears a close resemblance to culture itself--the way in which people do or did things. So much so, in fact, that the Weberian question of cultural proclivity can be revealed for a tautology: "does the way people do things affect the way people do things?"--an absurd, and abstract, formulation. However, this seems to be what White argues as technology *writ large* became increasingly autonomous an indicator of something perennially human: the ability for humans to survive and thrive. White's imaginative work firmly establishes why medieval *Islamic* technology, particularly automata, is moored to industrialization, machine discourse, and something that does not stray far from Weber's "dull legacy of debate," cultural proclivity to technique. This has been whether implicitly or explicitly the kind of work undertaken on the medieval Islamic automata after the 1960s.[30] The character of this scholarship is reconstructive: it wishes to affirm the technological contribution of the manuscripts by gleaning useful information from it to resolve this problem by proving it contributed pre-capitalist Islamic eminence.

This study proceeds from the methodological quandary set forth by this tautology of technology and culture, on the assumption that it is a productive tension, but generally

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[28] Edward W. Said, *Orientalism* (New York: Pantheon Books, 1978) Said wrote, "Although he never throughly studied Islam, Weber nevertheless influenced the field considerably, mainly because his notions of type were simply an "outside" information of many of the canonical theses held by Orientalists, whose economic ideas never extended beyond asserting the Oriental's fundamental incapacity for trade, commerce, and economic rationality." p. 259

[29] White, p. 1 of "Technology and Invention in the Middles Ages" in *Medieval Religion and Technology*

[30] Most particularly, with the advent of Donald Hill's scholarship

underdeveloped in the sources. Throughout the course of this work, reconstruction of automata manuscripts has presented itself as a technologically affirmative way of understanding technique (the "way of doing things") which, the sources operatively assume, is symptomized by the Islamic automata manuscript. The most telling evidence of this is the focus on functioning of the devices and the pains taken to outline this process. For example, a book published by the Research Centre for Islamic History, Art, and Culture, *"Kitab al-Hiyal" of Banu Musa bin Shakir* written by Atilla Bir in 1990, interprets the Banu Musa's *Ingenious Devices* using a control systems engineering analysis. The book features extensive circuit diagrams.[31] So too does Donald Hill reproduce drawings from al-Jazari's *Compendium* and the Banu Musa's book using equations and schematic drawings to get a better convey the mode of functioning. Finally, the most recent, and most literal, attempt at reconstruction has been undertaken by a firm in Milan that produces 3D renderings and models of Leonardo Da Vinci's automata and gadget drawings; their name Leonardo3 presumably alludes to this *raison d'etre*. Leonardo3 has modeled al-Muradi's[32] *Book of Secrets in the Results of Ideas* at the behest of Qatar's Museum Authority for the inauguration for Doha's Museum of Islamic Art in November of 2008.

It is useful here to point to one work that does not exhibit a technologically affirmative attitude towards automata or *hiyal*. Seyyed Hossein Nasr in *Islamic Science* suggests that *'ilm al hiyal* was bound up with the occult, magic, and esotericism: "this branch of science...has always been related in the Muslim mind with the occult sciences and magic, as the word itself whose root means stratagem or ruse, shows."[33] While the devices made some contribution to technology, Nasr, in an apologia of the contemporary "backwardness" of the Islamic world, defends the historical lag as a prevention of later harms of technology:

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[31] Atilla Bir, *Kitab al-Hiyal of Banu Musa Bin Shakir: Interpreted in Sense of Modern System and Control Engineering* (Istanbul: Research Centre for Islamic History, Art and Culture, 1990)

[32] The identity of this author has never been completely certain.

[33] Seyyed Hossein Nasr, *Islamic Science: An Illustrated Study* (London: World of Islam Festival Pub. Co., 1976) p. 145

> Like the Chinese who had gunpowder but never made guns, the Muslims never took that step which would mean the creation of a technology out of harmony with the natural environment. Their works on machines dealt with a variety of subjects all the way from agricultural... devices...to other complicated gadgets and devices which at their extreme became combined with magic and magical practices. *They did not make practical use of all they knew in this domain,* feeling instinctively the danger of the development of a technology which makes use of metals and fire, both elements alien to and the natural environment, and which therefore ultimately results in the loss of that equilibrium *vis à vis* nature which is so central to the Islamic perspective and whose destruction is such a danger for modern man.[34]

Seyyed Hossein Nasr says that Muslims did not "make practical use" of these contrivances, a contention, as we shall see, that has plagued the Islamic automata. "Practical use" defined as steam engine, gun, even clock the objects are the marks of harmful technology. The essentialist inscription of negative sentiment towards technology in Nasr's assigning to scientific developments of Islamic technology an affinity for nature and the occult is utterly unique amongst writing on *hiyal*. In his insistence on this, conventionally understood, "irrational" interpretation of *hiyal* Nasr raises the question of to what extent the works can be called rational. Nasr thinks that Islamic technology--and with it, the whole of the rest of the non-European world--did not accelerate because it was spiritually opposed to development of technology.

Nasr is surprisingly alone in this opinion, but it is didactic: all evidence suggests that the devices were not religious or magical and while they did not condemn magic, were for all intents and purposes "rational" mechanisms. Nasr desires that the automata be representational of a (however loosely defined) Islamic mythos, of the divine itself, or a "whole;" his denial of the particular and rudimentary origins of the genre mean that he cannot accept that the automata's (or even gunpowder's!) contribution "mattered" to the modern world, nor does he desire that it did. There is only as much magic in the automata manuscript

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[34] Nasr, p. 150. It should be noted that some of these devices did engage astrological themes, which Nasr includes under some form of magic. But this absorbs parts of automata. Emphasis mine

as the beholder desires. Nasr's anti-Modern opinion expresses that technology which did not abide nature through magic gave way to violence, and he wishes to safeguard automata from any of this.[35] Nasr effectively equates Modernity with Europe in an effort to prove the universality of Islam.

By the very rule that allowed Islamic technology to influence European, and transmit Greek and possibly some Indian and Chinese techniques, the assumption at work is that it is impossible to speak of technology without evoking nearly the entirety of the world, all at once--the spirit of man, freedom, utopia. This is why it is essential that White says, "more than an aspect of economic history, medieval technology reveals a chapter in the conquest of freedom."[36] One cannot look at Islamic automata manuscript without seeing, or at least acknowledging this "utopian" urge expressed through the discipline of technology. The present work tries to uncover the truth of White's statement in the tendency to promulgate the stripped down, abstract physical conditions and functions of automata movement itself that seek, if subliminally, to emancipate themselves from the invidious limitations of culture. In automata scholarship the resounding affirmation of technology and machines is so clear as to insist in some cases that the automaton is a robot. But clearly the understanding of work that the machine accomplishes is essential to many writers' understanding of the form, even if they are critical of the automata's "ability" to be such. White does not dissolve the Weberian conundrum, but the creative complication of cultural particularity and technological expansiveness is a productive starting point for looking at the Islamic automata manuscript.

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[35] We might distinguish this from machines. For Nasr does not deny that the devices are machines, but rather that they could have contributed to technological developments. In his insistence of keeping automata out of technology, there is an interesting drive to grant the devices an artistic autonomy, via magic, that also does not appear elsewhere, although this comes at the sacrifice of any notion that the manuscripts were rational works.

[36] White, "Technology and Invention" in *Medieval Religion and Technology* p.1

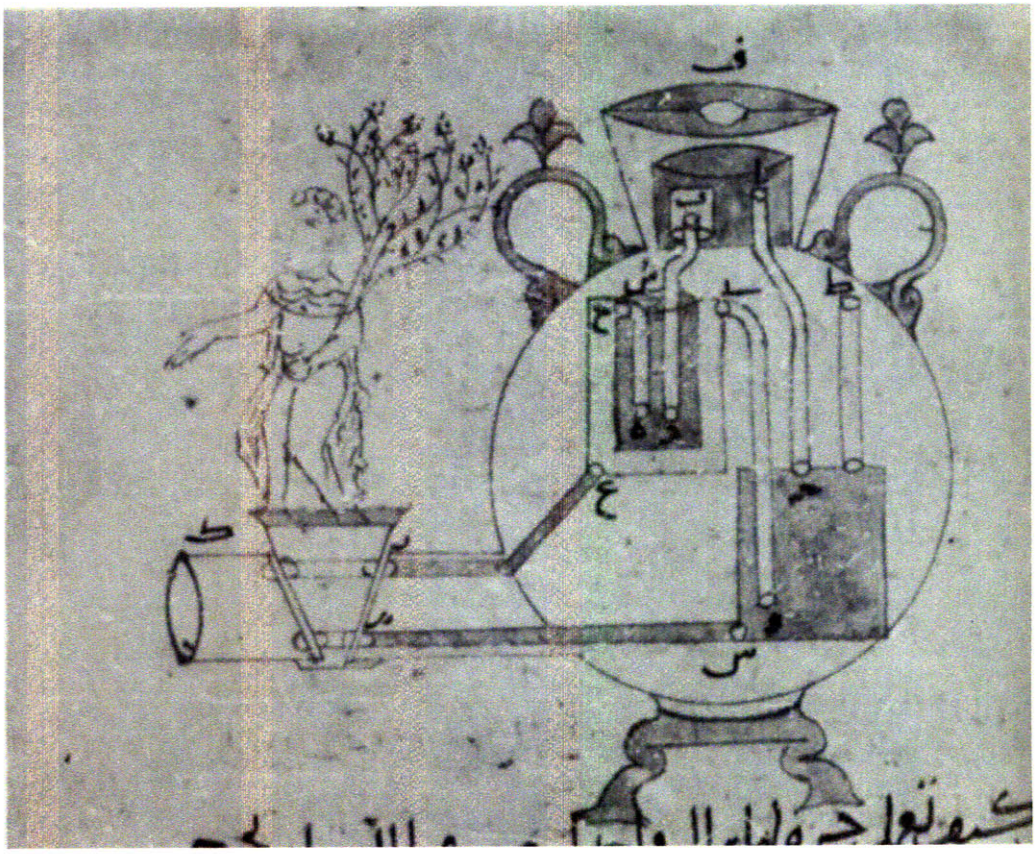

Fig 0.1

origins

Apart from a few works at the end of the 19th century, writers started discussing Islamic automata through a series of coincidences in the 20th century, the most notable of these was al-Jazari's entrance into the US and some European art museum circuit. It is now common to find references to al-Jazari in books on Arab painting style anthologies, which suggests he has been afforded spot in the annals of Islamic art history.[37] Around the same time, if a bit earlier (roughly 1908 to 1915[38]), Eilhard Wiedemann and Fritz Hauser, two German physicists who had apparently taken an interest in Islamic science, translated sections of both the *Compendium* of al-Jazari and the Banu Musa's *Book of Ingenious Devices* as the pages of the al-Jazari volume from 1315 and 1354, copied in Egypt, made their way into art collections. Much of the art historical

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[37] Marianna Shreve Simpson, *Arab and Persian Painting in the Fogg Art Museum*, Fogg Art Museum Handbooks(Cambridge, Mass.: Fogg Art Museum, Harvard University, 1980). A book on Harvard's Fogg Museum manuscript holdings. pp. 20-21; Richard Ettinghausen, *Arab Painting*, Treasures of Asia(Geneva: Skira, 1962). pp. 93, 95, 153 Anna Contadini, *Arab Painting: Text and Image in Illustrated Arabic Manuscripts*(Leiden; Boston: Brill, 2007). p. 67 See in that volume Oleg Grabar's "What does 'Arab Painting' Mean?"

[38] From a glimpse of the sources. Hill lists some earlier articles, but al-Hassan (on his website) "dates" their seven articles on al-Jazari from 1915 to 1921, so for all intents and purposes it can be suggested that Wiedemann and Hauser "made possible" the short articles that came out of this period, however, F R Martin, cited below, collected and would write about some pages of al-Jazari entirely in the absence of the two physicists. See, Ahmad Yusuf al-Hassan, "Al-Jazari and the History of the Water Clock," http://www.history-science-technology.com/Articles/articles%206.htm.

scholarship made use of the duo's work. They are also often cited but little is expanded on them regarding what caused interest in Islamic science, and as their work is more of a "technical" treatment of those manuscripts, they leave few clues themselves as to the broader motivations for their work. Most of the interest in their work has been directed towards the al-Jazari manuscripts; this demonstrates how much of an impact art historical research would have on directing further scholarship.

It is a challenge to reconstruct this period, or to answer such questions as why the interest in automata manuscripts in the early 20th century, and why the focus on al-Jazari? This is what I endeavor to undertake presently, for what is notable about this early foray into Islamic automata scholarship is that it did not seek to promote an interest in the workings of the manuscripts. For art collectors, it seems that these manuscripts bore no relationship to the machine whatsoever. This scholarship commenced with the introduction of pages deemed "automata miniatures" into the museums, where they are still today, from two manuscripts, the original segmentation of which no one knows. As such this scholarship inevitably raises questions of piece and whole since, in contrast to whole manuscripts, the pages are complicated by their incompleteness; they are "incomplete compendia." Whatever value is ascribed to their exhibition, it could be questioned by those who wish to reconstruct them later on,whether the singular pages fully "deliver." In order to be successful collected pieces, they must be framed as paintings or illuminated manuscript pages.[39] However, most of the

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[39] In other words the question of science exhibition was not nearly so important early on as it is today, theoretically, especially as it features in postmodern thought. I do not wish to engage in a conversation on science museums of displays, but only suggest that there is a problem of part and whole in the automata "illuminations" which are not illuminations at all, and whose text bears a completely functional relationship to the image. Franklin Day Jones, Holbrook Lynedon Horton, and John A. Newell, *Ingenious Mechanisms for Designers and Inventors* (New York: Industrial Press, 1930) The book's full title, *Ingenious Mechanisms for Designers and Inventors: Mechanisms and Mechanical Movements Selected from Automatic Machines and Various Other Forms of Mechanical Apparatus as Outstanding Examples of Ingenious Design Embodying Ideas or Principles Applicable in Designing Machines or Devices Requiring Automatic Features or Mechanical Control,* is startlingly similar to al-Jazari's manual in style and framing and features images and descriptions: the difference being perhaps that the book outlines "techniques" and "parts" rather than whole devices.

pages included minimal text--one or two lines if that--so what this scholarship also shows is the deficiency in calling them "illuminations." That is, their drawings can stand alone. By extension, however so could the text, critical discussion of which does not figure into this early scholarship at all.

Early art scholarship also stands in tension with technological-historical scholarship that came to characterize the study of Islamic automata manuscripts. Donald Hill for example in his rundown of the manuscripts of al-Jazari says, "A number of miniatures from two manuscripts, dated 1315 AD and 1354 AD, respectively, both originally from Istanbul, have found their way into public and private collections in Europe and the USA [...] These miniatures are well known to those concerned with Islamic Art and a considerable literature has grown up around them. A full bibliography of this literature is not included [here] since many of the papers in question are very brief."[40] Hill laments the state of these two manuscripts, expressing hope that in the very least an art historian in the future will undertake a comparison of the two manuscripts from which the miniatures are taken.[41]

Wiedemann and Hauser by way of contrasts did not work on these two manuscripts, but on the more complete MS Graves 27 in Oxford, whose images were less savory perhaps,[42] but it was nonetheless complete. And yet their piecemeal work on these manuscripts is in keeping with the atomistic treatment of them of that time. Ahmad Yusuf al-Hassan writes that two-thirds of MS 1354 was collected by Hagop Kevorkian Fund[43] in 1978, and originally

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[40] Hill, *Compendium*, p. 5

[41] Ibid., p. 6

[42] The images in this copy are not colored and arguably not complete.

[43] Ahmad Yusuf al-Hassan, *Al-jami' bayn al-'ilm wa-al-'amal al-nafi' fi sina'at al-hiyal* (Aleppo: Mahad al-Turath al-'Ilmi al-'Arabi, Jami'at Halab, 1979) p. 16. Hagop Kevorkian Fund was the legacy of Hagop Kevorkian (1872-1962) a well known Turkish-Armenian collector-dealer-archaeologist about whom little is written however. He was part of a group of enterprising mean at the turn of the 20th century bringing Islamic antiquities into the American art museum circuit, namely in New York. See Marilyn Jenkins-Madina, "Collecting the 'Orient' at the Met: Early Tastemakers in America" *Ars Orientalis* 30, (2000), pp. 69-89, 74

purchased by the elusive Sprink & Son. This manuscript was said to be of Mamluk origins. Much less is known about MS 1315, but Donald Hill calls it "Syrian in origins," although this could also make it Mamluk. To what extent Wiedemann and Hauser, or art scholars collecting MSS 1315 and 1354 knew of the whereabouts of other copies of the *Compendium* is nearly impossible to say, but the plurality of manuscripts, while it could have eased Wiedemann and Hauser's translations, were not great matters of interest enough to document them.

The earliest known copy of this manuscript comes from 1206,[44] and there are 15 known copies (roughly, as some are incomplete, see appendix) and as we have already seen, the drawing styles come in a variety of forms, perhaps depicting regional variations. Hill is correct that there is an abundance of laconic notes on these pages from the 1315 and 1354 manuscripts, that suggest regional or period variations. Hill even cites one Mughal copy from the 17th century now at the Bodleian Library in Oxford University, Frazer MS 186 from 1673, according to al-Hassan.[45] Al-Hassan and Hill also cite one copy of a manuscript from the 18th century, without illustrations, written in *nasta'liq* cursive script,[46] which would also suggest Mughal origins.[47] Al-Jazari's manuscript has been copied in a variety of styles for a long time. Although Hill and Ahmad Y. al-Hassan following Hill provide more or less comprehensive lists

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[44] Hill, *Compendium,* p.14

[45] According to Mario Losano, John Greavely (1602-1652), acquirer of what would later be MS Graves 27 for the Bodleian Library, Greavely would have been a contemporary of the copyist of this manuscript, although whether he went to the Subcontinent is not mentioned. John Greavely was an English mathematician, geometer, and Orientalist from Hampshire and a professor at Oxford University. Greavely acquired the manuscript during his travels to Constantinople, during which time he measured many monuments. Greavely visited Constantinople to see for himself a source of antique science. See "Il manoscritto oxienense di al-Jazari" Mario G. Losano, *Automi D'oriente: Ingegnosi Meccanismi Arabi Del 13. Secolo* (Milano: Medusa, 2003) pp. 91-103 whose discussion rests on Greavely's potential role in the transmission of medieval knowledge to 17th century scientists. For a look at Greavely's "pyramidology," see Zur Shalev, "Measurer of All Things: John Greaves (1602-1652), the Great Pyramid, and Early Modern Metrology" in *Journal of the History of Ideas.* 2002 pp. 555-575 There is nothing in this source about his acquisitions.

[46] This script is referred to by al-Hassan as Farsi script which connotes its Iranian origins, but this script is used in Mughal Persian, Urdu, or Arabic writing. See al-Hassan, p. 15

[47] Hill and al-Hassan, op cit. p. 5 and p. 16, respectively

of manuscripts, in their translations and transcriptions respectively, their focus would shift to the "whole" manuscript, and so we are left with only their lists in the way of comprehensive outlining of different manuscripts, but no conclusions about the possible traveling of the original.

A review of this literature[48] demonstrates that art historians' outlining of the material differs starkly from later treatment of this material so much so that were one to take up the Islamic automata manuscript as original research from scratch, the many notes from this time could come as an anomaly more than anything. Wiedemann and Hauser did heed the workings of the manuscripts, but unlike Hill would later do, they did not leave a paper trail and contribute in to any academic study. Art historians would not have much to build of off anyway, and they were not very interested to outline what engineering or physics principles were at work. Outlining the whereabouts of the more pictographically humble but complete copies of both al-Jazari's *Compendium* and the Banu Musa's *Ingenious Devices* as an academic feat did turn out to be important, for the only remains of Islamic automata are these manuscripts. Art historical scholarship with its focus on individual pages was important for dating and provenance, and it also served as a mode of distribution for these manuscripts. Current art historical scholarship on Islamic automata manuscripts is still limited to brief mentions of automata manuscripts--mostly al-Jazari's and the Banu Musa's, and rarely al-Muradi's--there is no authoritative art historical study on the matter.[49] Scientific works, such as anatomy or

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[48] See, Rudolf M. Riefstahl, "The Date and Provenance of the Automata Miniatures" The Art Bulletin 11, no. 2 (Jun., 1929), pp. 206-215; Mehmet Aga-Oglu,, "On a Manuscript by Al-Jazari" Parnassus 3, no. 7 (Nov., 1931), pp. 27-28; ; and Claude Anet "Dr. F. R. Martin and Oriental Painting: "Le Traité des Automates" *The Burlington Magazine for Connoisseurs* 23: 121 (April 1913) pp. 49-51

[49] Yasser Tabbaa, *The Transformation of Islamic Art During the Sunni Revival* (Seattle: University of Washington Press, 2001) and a very brief mention in Richard Ettinghausen, Oleg Grabar, and Marilyn Jenkins, *Islamic Art and Architecture 650-1250* (New Haven: Yale University Press, 2001), Gülru Necipoglu in her study of the production of geometry mentions at the Banu Musa's role in early Abbasid translation movement and their role in the "practical" art of geometry. See Gülru Necipoglu, *The Topkapi Scroll : Geometry and Ornament in Islamic Architecture* (Santa Monica: Getty Center for the History of Art and the Humanities, 1995)

botanics manuscripts' placement in art collections raises the question of what should be done with these artifacts, and what is the relationship between what they convey and their form. Are they symbolic, instructive, or historical?

autochthonous automata miniatures

Most of the manuscript pages that populate American and French museums or cultural institutions passed through the hands of Dr. F.R. Martin, a Swedish art collector-dealer-scholar. Martin was probably in Istanbul as part of the Swedish Consulate in the early part of the 20th century, judging from some speculation David Roxburgh has written on Martin's (specious) work on the Mirzah Bahram/Bellini Album.[50] Martin's motivations for seeking out these manuscripts--also the conditions under which he acquired them--are by no means clear from his work.

Martin, in a large book from 1912 on *The Miniature Painting of Persia, India, and Turkey*, features automata miniatures in his section, "Painting under the Fatimids and Abbasids," a subtitle that reveals a periodized approach to the creation of paintings. The automata miniature falls under the heading of Arab painting but it cannot be distinguished by its technique, according to Martin: "The Arabs who conquered the ancient world were a simple race, without great artistic feeling or interests, and in order to avoid appearing too little civilised they retained in their service all the artists they found in their newly conquered empire."[51] Early Islamic rulers were not interested in new styles. Martin says that "the more

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[50] David Roxburgh "Disorderly Conduct? F.R. Martin and the Bahram Mirza Album." *Muqarnas* 15 (Leiden: Brill, 1998), 32-58

[51] F. R. Martin, *The Miniature Painting and Painters of Persia, India and Turkey, from the 8th to the 18th Century* (London: B. Quaritch, 1912) p.1

closely Muhammadan art is studied, the clearer does it appear that it was only a natural development of the Antique [...] It was only at a later date that the Caliphs and their amirs began to demand that work should be executed in a style more in accordance with their ideas of beauty and art."[52] Martin makes tacit, if banal and hackneyed by our standards, assumptions about what technique in relation to culture is--certain cultures bear different techniques, but, the "type" of technique distinguishes the culture. Furthermore, technique develops under the whims of rulers and thus without any political will from craftsmen or painters. Visual culture, including automata representations, can be explained with ease if Martin is correct.[53] Martin's ascription of style to the "ruler's" whim, however, is not far off from how the creation of Islamic automata are understood, and excluded from craft culture in much automata literature.

Martin includes five plates from the 1354 al-Jazari manuscript, all of which he mistakingly dates to the "end of the 12th century," but which he knows to depict automata: "most of these leaves represent automata in the form of figures such as were so highly prized by the Arabs, and descriptions of which are found in the Arabian Nights Entertainment. It was an automaton that Harun al-Rashid presented to Charlemagne."[54]Martin wistfully implies that this is a description of that water clock. One of these pages he does not identity as an automata painting, but a similar image can be found in the MS Oxford Graves 27. This "miniature," the front color plate that Martin uses for his title page, is a water clock in which a figure sits under

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[52] Ibid. p. 2

[53] The Banu Musa, for a contrasting example, probably requested that colleagues in the House of Wisdom translate certain texts of which they knew were aware but could not use. Here, "technique" developed by choice and not mere cultural compulsion. Bir, op. cit. pp. 2-5.

[54] Martin, p. 10 This is so oft quoted a line as to have rendered any potential exchange between Charlemagne meaningless. It occurs in almost every monograph that so much as mentions Islamic automata that I have consulted, including Moishe Postone's book *Time, Labor, and Social Domination*. p. 204. The story comes from the *Annals* of Einhard (775-840), a "boon-companion" of Charlemagne. Einhart refers to Harun al-Rashid as "the King of Persia." Truitt, op. cit. p. 175

an arch holding two circles with lotus flowers on them. (Fig 1.1) Martin reads this image as one of the first Arab "portraits from nature," and he speculates that it is the famed Ayyubid Muslim champion of the Crusades Saladin.[55] He draws a parallel between the ruler "Saladin" seated on the balcony and a photograph of another ruler, Mulai Hafid (Mulai 'Abd al-Hafiz), short-reigned sultan of Morocco who signed the Treaty of Fez, consenting Morocco to become a French protectorate, and abdicated from the post.[56] (Fig 1.2) Martin proves his assertion that the painting is a portrait of the ruler and in so doing he also compares the composition of this painting to a 20th century photograph of the seated figure wearing Maghribian garb: "In order to convince those who may doubt that this is the portrait of a great Oriental ruler, I reproduce an instantaneous photograph of such a personage, Mulai Hafid [...] If the old Arabian artist had seen Mulai Hafid, he would probably have represented him in precisely the same manner. Saladin was the greater man, but in reality both possessed the same characteristics."[57] Martin dates the plate to 1185 before the manuscript was said to have originated. What gives the image away as an automaton, and thus, precludes it from depicting a ruler of any sort at all, but rather a sculpture from wood, bronze, and leather, is the half circle at the top of the page,

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[55] Al-Jazari's domain was after all Amid, iqta' of Saladin.

[56] Mulai 'Abd al-Hafiz overthrew his brother 'Abd al-'Aziz following the Act of Algeciras under which the French and Spanish would station international police at open ports in Morocco. Another work from of "High Orientalism" in which Mulai Hafid has his portrait drawn by the foreigner Lawrence Harris, described by Harris, further throws Martin's absurd juxtaposition into light. L. Harris, *With Mulai Hafid at Fez; Behind the Scenes in Morocco* (London: Smith, Elder & co., 1909) The name of the photographer of that portrait is not mentioned.

[57] Martin, p 11

which Martin mistakes for an arch,[58] but which is actually a common depiction of a light aperture also featured in Ridwan's drawings.[59] (Fig 1.3)

Ananda Kentish Coomaraswamy later offered a corrective to this in "A Treatise on Automata by al-Jazari," a booklet which outlined eight of Martin's plates that the Boston Museum of Fine Arts had acquired under Coomaraswamy's research fellowship in Indian, Persian, and Mohammedan art. Coomaraswamy translated into English Wiedemann and Hauser's German translation of this narrative. Coomaraswamy however seemingly understands Martin's drive to compare, writing, "This representation is not a portrait of any Sultan, though no doubt it offers us in a general way the likeness of a contemporary Sultan or nobleman."[60] The text is crucial to understanding what the image might really convey, as the man sits in front of a balustrade in a castle, and al-Jazari discusses the fabrication of the man: "one makes from jointed copper the shift (*qamis*) of a sitting man: both knees are raised from the ground [...] Feet are made for him and soldered to the hem of the shift in the position of the feet; also two hands with the palms towards the rear and their backs facing forwards, the fingers separated. Then a dark head is made. The neck is drilled through at the bottom from back to front..."[61] Coomaraswamy however had access through German to Wiedemann and Hauser's translations. The text is instructive, and perhaps would have clarified Martin's remarks, save for any political motivation, but with the image, Martin resigns to compare

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[58] Hill, *Compendium* pp. 80-81 Al-Jazari explains the construction for this component and how to use it: "It is not necessary to illustrate the disc with the glass [roundels] in it or the cut away disc which covers and uncovers the roundels, since the drawing of them is shown separately above. This was for daytime. The space between the two circumferences on the cut away disc is coloured red, and whenever half a roundel is covered it appears red from outside. The situation by night: the nail is moved from its hole to the other hole and the roundels are covered [....] All the servant of this device has to do is to move the nail at nightfall and at daybreak, turn the disc and the toothed wheel, and light the lamp."

[59] See above, n. 2

[60] Ananda Kentish Coomaraswamy, *The Treatise of Al-Jazari on Automata: Leaves from a Manuscript of the Kitab Fi Ma'arifat Al Hiyal Al Handasiya in the Museum of Fine Arts, Boston, and Elsewhere* (Boston: 1924) p. 2

[61] *Compendium*, p. 67

Mulai 'Abd al-Hafiz to an automaton, although Coomaraswamy cannot offer much in the way of an improvement over Martin's interpretation, and displays a similar understanding of the representational paradigm at hand.

So too Martin is limited in his scope for gathering historical information about pages he does successfully identify as automata manuscripts. The paintings are "representational" of people, social life, and tendencies. One of the figures that Martin discusses is the first device described by al-Jazari and it looks like a procession. Martin see in the picture the seal of the sultan--symbols of power. (Fig 1.4) Text and image, and reproducible technique make these miniatures technically comparable to 15th century print in the European context. Martin says:

> A few of the miniatures represent scenes from street life in Cairo. Thus, on one leaf, musicians are represented sitting in a doorway, on the walls of which the arms of a sultan--a golden eagle on a red ground above a golden cup on a blue ground--are depicted.
>
> For the history of painting in the east, the miniatures of the manuscripts above named are of the greatest importance, for they hold a similar position as the European woodcuts of the 15th century occupy in the history of graphic art. All nations make their first steps in art in the same manner [...] Mankind is everywhere the same, and development invariably takes the same route; it is merely the degree of speed of the form that varies.[62]

One cannot fault Martin for the state of the manuscript and research at this time, but it is useful to understand the context in which this page occurs. The problematic that arises from Martin's text resorts to simple symbolic analysis, apprehending the paintings as direct representations. With no existing text to explain the context of the image, Martin sees the representation of the automaton in a one-to-one ratio: the device here, for example directly represents a street scene, according to the scholar. Even within the poetics of the *Compendium's* own language, however, there is more to be desired, to understand what exactly the images portray.

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[62] Martin, pp. 10-11

This image has proven to be a very popular image to illustrate automata and Islamic sciences. Donald Hill, in his translation, using MS Graves 27 (the same manuscript used by Wiedemann and Hauser that Coomaraswamy consults) includes another image of the same device, which is the first device listed in the book. (compare Fig 1.5 and Fig 1.4) In the *Compendium*, al-Jazari begins the first passage in his category of "clocks (*finkan*) from which can be told the passage of constant and solar hours by means of water and candles," with a discussion on the construction of an indicator or zodiacal circle, which he acknowledges is "the method of the excellent Archimedes in distributing the twelve signs of the Zodiac over a semi-circle."[63] Al-Jazari discusses the difficulties he encounters in making this part of the device, for which the instructions are incomplete. It is clear that al-Jazari is making an intervention into "Archimedean"[64] water clock, and he ends the discussion of this construction saying, "There was no alternative therefore but to proceed with practical work and experiment, using a method which I shall mention below, from which it will appear the three designs given above are incorrect."[65] He describes the device outlined above as a house with two sets of twelve doors, a frieze where there is "a crescent moon like a Dinar"; and birds in two vases that form a bracket on the wall. The crescent moves regularly and "imperceptibly" along the frieze and passes a door. When it passes two, a man comes out of the first door abruptly. A ball drops from a bird's mouth onto the cymbals who then retreats, and at every six hours the trumpeters blow, and the cymbalist plays (see appendix). The device is intended

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[63] *Compendium*, p. 17 See *Archimedes On the Construction of Water-Clocks*, ed. & trans. Donald Hill, (Paris: Turner & Devereux, 1976). p. 17

[64] The inability to ascertain the authorship of Archimedes in any water clock treatise has led to the application of descriptor of "psuedo-Archimedean" to Islamic automata construction. Hill speculates following work by Drachman that the Archimedean work is either a compilation of Philo of Byzantium (ca. 200 BC) and Hero of Alexandria (ca. 85 AD), and says that the works that claim to be Archimedean might indeed be early works of Islamic mechanics. Donald Hill translated one such manuscript: *On the Construction of Water-Clocks* or *Kitab Arshimidas fi 'amal al-binkamat.* I feel a better synopsis of that title would be The Archimedean book on the construction of water clocks. Hill took in this book a similar approach to what will be outlined here.

[65] *Compendium*, p. 18

to be a larger water clock. That A K Coomaraswamy later quoted this passage shows why Coomaraswamy's short pamphlet is the only work of an art historical bent that scholars like Donald Hill or Ahmad Yusuf al-Hassan cite with any import: he offered snippets of translations in his pamphlet.

Coomaraswamy also clarified dating issues from Martin and other scholars such as E. Blochet and Riefstahl, who had followed Martin's monograph. Coomaraswamy speculated that while the original manuscript was written in 1206, under Sultan Mahmud, some inscription on a gate of Amida suggests that al-Jazari had performed work under Nur al-Din Muhammad. He writes: "We infer that al-Jazari was first and foremost a craftsman, and only secondarily an author. The intelligibility of his writing and the clarity of the diagrams are to be explained by his practical knowledge of the contrivances described [...] That his labors were greatly appreciated is shown not only by the patronage of three Urtuqid (sic) Sultans but by the fact that many copies of his treatise were made in the several centuries following its completion."[66] Coomaraswamy in his brief rundown of "other manuscripts," cites MS Graves 27, which would have come from Wiedemann and Hauser's work on it, and he makes a general observation that the inscriptions bearing the names of several Artuqid sultans are independent of the manuscript as a whole, and do not help to date the manuscript, but rather suggests that they serve to identify the observation of a particular "contrivance" (*hiyal*).[67] He says, "Oxford Gravely MS. 27...affords an important piece of evidence in respect of the names of Sultans appearing in the form of inscriptions on certain of the apparatuses represented." From this he suggests that the copy was effected "without reference to the regnant sultan of the time," a similar pre-occupation with the inscription above the first clock bearing the name of Nur al-

[66] Coomaraswamy, p. 6

[67] Ibid.., p. 7

Din Muhammad.[68] He does not mention that the translations Coomaraswamy himself cites would have been MS Graves 27 and not the plates collected for the museum. Coomaraswamy explains that there were multiple copies but seemingly cannot extend his look beyond Wiedemann and Hauser. He maintains a uniqueness of each manuscript and bolsters the image of al-Jazari as an "erudite engineer," a rare combination of craftsman and conveyor.[69] Coomaraswamy recognizes the plates as representations of automata that al-Jazari would observed, but no more than this.

Art historian E. Blochet, in his brief discussion of the plates in his book *Musulman Painting*, argues along lines of artistic significance of the automata manuscript painting with a plausible historical summary.

> Exceptionally, in the middle of the fourteenth century, an artist who was not without skill should, in order to amuse the Sultan of Cairo, have copied the illuminations of a treatise on the working of hydraulic automata, for the Ortokid (sic) prince of Diar Bakr in Mesopotamia...which the prince...had executed for the amusement of his son. The artist merely reproduced in a literal fashion, though with obvious misunderstandings in the process, paintings which were conceived in the pure Mesopotamian style of that period in the history of the Abbasid Caliphate; the fact seems even stranger when we observe the dexterity with which the painter used his brush [...] The art of painting had, however, always been known in the land of Egypt, if not practised for religious motives.[70]

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[68] Ibid.

[69] It is tempting to turn to Coomaraswamy's writings on use, manufacture, and "oriental art," in juxtaposition to the simultaneously "traditional art" (non-canonical/craft) and cultural-scientific qualities of automata miniatures. "Symbolism or iconography is the expression of [the] purpose [of unfamiliar arts], and the immediate vehicle of their beauty; while beauty, in this philosopher's sense, has to do, not with fooling, but with knowing." Coomaraswamy was fond of the phrase *ars sine scientia nihil*--art without science is nothing--citing (and deploying a probably conscientious positivism as to the translation of) the words of the medieval architect Jean Mignot on the construction of the Duomo in Milan in 1398. "By 'science' we mean, of course the reference of all particulars to unifying principles, not the 'laws of statistical prediction." An automata manuscript almost too neatly fits this formulation in the positivism characteristic of Coomaraswamy; it was overtly symbolic but this symbolism aspired to the art of manufacture: its purpose. Art, Man and Manufacture; Stella Bloch Papers Relating to Ananda K. Coomaraswamy, Box 8, Folder 4; Department of Rare Books and Special Collections, Princeton University Library. It is also worthwhile to draw this connection to Seyyed Hossein Nasr, whose updated anti-modernism is similarly "unaffirmative."

[70] E. Blochet, *Musulman Painting Xiith-Xviith Century* (London: Methuen & Co., 1929) p. 40

It is possible to understand the technique employed in the automata painting in stylistic terms, as illustrated by Martin. This requires that image, while it might be understood as a depiction of automata, really represents life. Blochet emphasizes the Egyptian "quality" of the 1354 manuscript from Istanbul, but acknowledges it is a *style* which originated in Mesopotamia (southeastern Anatolia). What explains the technique? Using Martin's cliché that the painting developed out of Antique styles (and also, that automata themselves developed from Greek automata), we have an example of *pure* scientific manuscripts: it is clear that science existed for the elite, and so too the artistic conveyance. Mesopotamian style, for example, is a confluence of place, people, and purpose. These art historians complicate the individual copying of manuscripts whereas this problematizing would later be lost; but they do so because the act of copying is the artistic act at hand--not in conjunction with the fabrication of the devices or the craft in which al-Jazari participated.

Most later sources cite the work of Wiedemann and Hauser, but convey reservation about their ability to separate interpretation from description. It is not unfair to assume some of the art historical scholarship that did include narratives received a pre-digested interpretation. Were Wiedemann and Hauser concerned at all with the fact that the manuscripts would have been made to "amuse" the sultan, and thus that there might have been a political *raison d'etre* of the manuscript? They leave negligible trace of historical construction. Nevertheless questions that remain unanswered include why the manuscript would travel and, for example, should the devices actually be made (Blochet and Martin are neither here nor there on the matter), if regional "stylistic" differences would occur in the resultant sculptural forms. The tension between pieces and whole--page of manuscript as painting, and manuscript itself as work--parallels the disciplinary problem concerned with developing a body of knowledge built around it. For while the art historians now must consider the concrete material context around which a given manuscript was proliferated (and

in the present work this equals three manuscripts, multiplied by number of manuscript and place of distribution!), in nearly every history of technology work addressing the topic, the three Islamic automata manuscripts are mentioned together as a form of knowledge. The irony is that the argument could be made that this unity may be described not by content of knowledge but by simple facts that art historians should be concerned with: the human conveying mechanism and motion, as well as a shared "key" system, which, for example, led Blochet to date locate the 1315 copy's origins in Egypt.

the inadequacy of art

George Saliba, historian of Islamic technology, has said, "It is only accidental that the illustrations of these texts, being artistically beautiful indeed, were first noticed by modern scholars as they surfaced in the art-collecting market before the appearance of the texts themselves. As a result, the main purpose of these texts was misunderstood, in spite of the contents of the texts and their expressed intentions."[71] It is not clear whether Saliba means the text as words, or the manuscript transcription and translation in book form. Either way, a micro history would show that this is not *exactly* true, but his opinion is telling: Wiedemann and Hauser's work on both al-Jazari and the Banu Musa were contemporaneous with FR Martin's acquisition of the miniatures, and, at any rate, some important discussions regarding dating in addition to broad sweeping theoretical issues like representation, authorship, and technique, are raised in these early texts. Wiedemann and Hauser failed to establish a "form of

[71] George Saliba, "The Function of Mechanical Devices in Medieval Islamic Society," *Science and Technology in Medieval Society* (Dec 2006) p. 148

knowledge" or discipline of automata, or to integrate the works into a history of technology--for all intents and purposes they were not quite historians of technology.

This is not far off, however, from what the art historians also "failed" to do. The role they fulfill in this narrative is that of antiquarian scientists--attracted to age with no "ulterior" theoretical motives. Moreover, the art collectors and Wiedemann and Hauser were not the only scholars to make reference to Islamic automata during this time. There is a scattering of works on mechanics by Bernard Carra de Vaux, who focused on the Greek-Byzantine precedents of Islamic automata, and notably produced detailed and conjectural line drawings of certain of Philo's (ca. 250 B.C.) automata,[72] which provide a visual contrast to the "cruder" (but also, "authentic") images of al-Jazari, Banu Musa, and al-Muradi. (Fig 1.6) Antique and Islamic automata also make a brief appearance in the *Automata: A Historical and Technological Study*, written later in 1958 by Alfred Chapuis and Edmond Droz. These works do not differ widely from the gestural treatment of automata by art collectors. Chapuis and Droz begin their book with a short treatise on representation and spirit in a chapter called "Early Automata and Articulated Masks," in which the authors explain the religio-mimetic function of very early human figural sculpture:

> Early jointed figures were essentially religious objects, though at the same time works of art. Gradually, in these imitations of nature, the point was reached at which attempts were made to reproduce the movements of a living being. Sculpture was for a long period subject to priestly authority, and a statue, like a myth, appeared as the epitome of divine thought. [...] The primitive mind attributed life to these images, which, by magical power of representation, shared in the life of the model."[73]

The stylistic analysis of automata miniature evokes the same formal evolution--a linear transmutation of characteristic that Blochet and Martin imply. This later work on automata

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[72] Bernard Carra de Vaux, 'Notice sur deux manuscrits arabes' *Journale asiatique* 8e Série (1891)

[73] Alfred Chapuis and Edmond Droz, *Automata; a Historical and Technological Study* (Neufchatel: Éditions du Griffon, 1958), p. 13

from the 1950s would prefigure a later emphasis on questions of machine and organism through the assertion that pre-historic, or pre-modern, spirit was one and the same as the artifact, and so there was no such thing as representation proper.[74] These discussion figure rather minimally in this early 20th century scholarship, but the question of magic and mimetic spirit remains a crucial attribute of being able to refer to anything as "automata." Droz and Chapuis write, "The Arabs in particular developed the art of clock-making in a very original way, and though the Moslem religion forbade representation of human beings or animals, water-clocks with mechanical figures and automata in general had a great vogue among these people...A comparison of the work of the Alexandrines and the Arabs clearly shows many points of similarity in the machines which they made, the latter being inspired by the former."[75] These two also offer a brief analysis of how the devices based off of Wiedemann and Hauser's translation and Coomaraswamy's notes, thus, is not concerned with analytics of the inner workings of the device, but rather explaining the parts that are depicted in the ever popular first clock of Al-Jazari's *Compendium*. (Fig 1.7, and Fig 3.8) This placed al-Jazari and the Banu Musa's devices in a lineage of "automata," which have their roots in the earliest figural sculpture, which was imbued with cosmological spirit, and ends in robots and automation. Chapuis and Droz serve as a type of turning point, perhaps symptomizing the turn towards a Post-War (Cold War) cultural focus on robots. The vaguely utopian outlook engraved in the automaton after a tumultuous time of war corresponds to the "humanistic" need the possession of this outlook fulfilled: almost every culture and stage in science according to this work has its own shining moment of self-actuation that is revealed through the automata or mimetic, moving creations.

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[74] Ibid.

[75] Ibid., p. 36

The art historians could not decipher al-Jazari's water clocks, but no one else could, either. What was appealing about the pieces if anything beyond age is uncertain: automata miniatures are not the best examples of miniature paintings nor do they stand out technically in the style anthologies in which they are often included.[76] The content of the paintings is hard to explain however, without recourse to the intentions of the manuscripts. Some are more suited for viewing outside of the workshop, so to speak, than others that have less polished images such as Graves 27. This fact has not been theorized, but instead, has been viewed, by Saliba, Hill, and al-Hassan, as a loss of opportunity on the part of earlier scholarship. Perhaps, rather, the art historians did not come to imbue the manuscripts with the "utopian" view set forth in later scholarship. Their model for understanding automata was probably more realistically speaking, antiquarian in form and positivist in understanding: the visuals have some exegetical autonomy, so that "scientific knowledge" was evident in itself, in its own form. Or perhaps, with all early scholarship the integration into a veritable study all the scientific "meaning" simply did not matter. For while everyone realized that the paintings depicted water clocks, or depicted certain scientific problems, they were simply not concerned with the use. Thus, when in the 1970s Donald Hill explained not just what all the devices in the paintings were "saying" figuratively but also *how* exactly they *moved*--in other words, when he transcended the manuscript itself--he also crafted an interpretive apparatus, which focused on functionality, use, and ultimately, progress.

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[76] This is the case with those anthologies cite, including in Blochet's and Martin's lustrously illustrated books: the automata paintings are some of the cruder, or crudest, paintings in the books. Or as al-Hassan calls the lesser paintings of al-Jazari, they are "petty." But their *content* is highly compelling. Al-Hassan, p. 15

Fig 1.1

FIG. 1. PORTRAIT OF SALADIN.
From a manuscript written before A.D. 1185. F.R.M.

FIG. 2. PORTRAIT OF MULAI HAFID,
SULTAN OF MOROCCO (*see* p. 11).

Fig 1.2

Fig 1.3

Fig 1.4

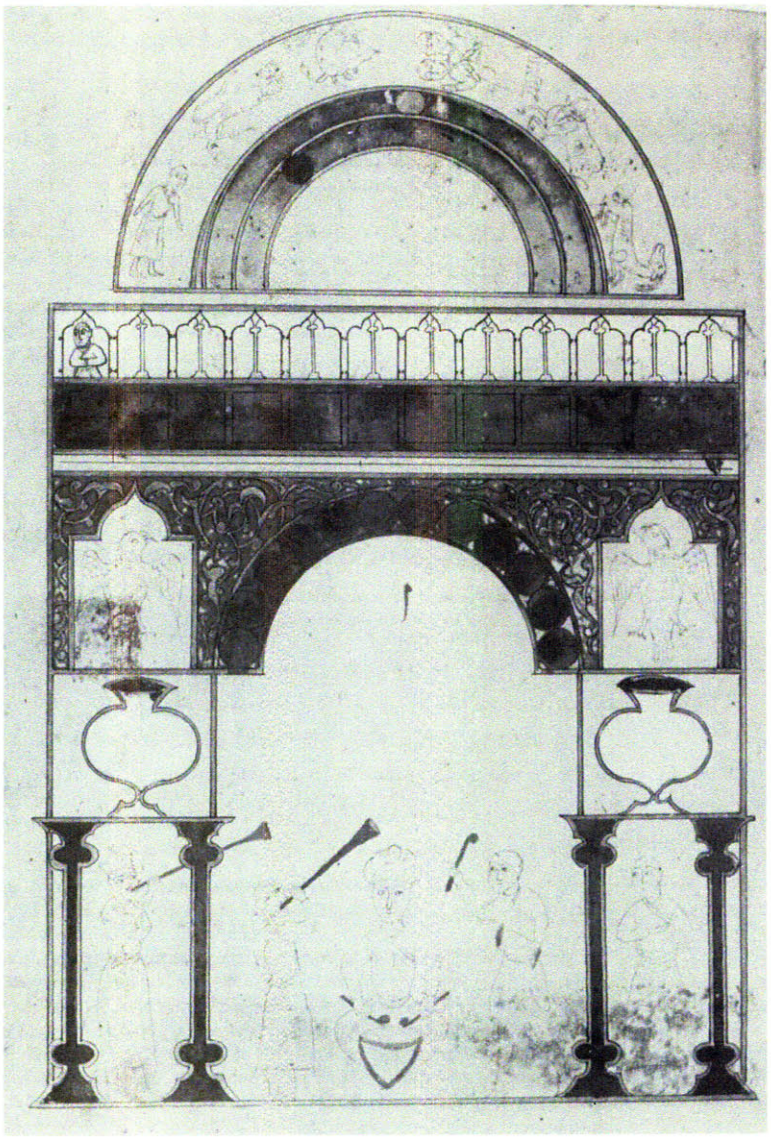

Fig 1.5

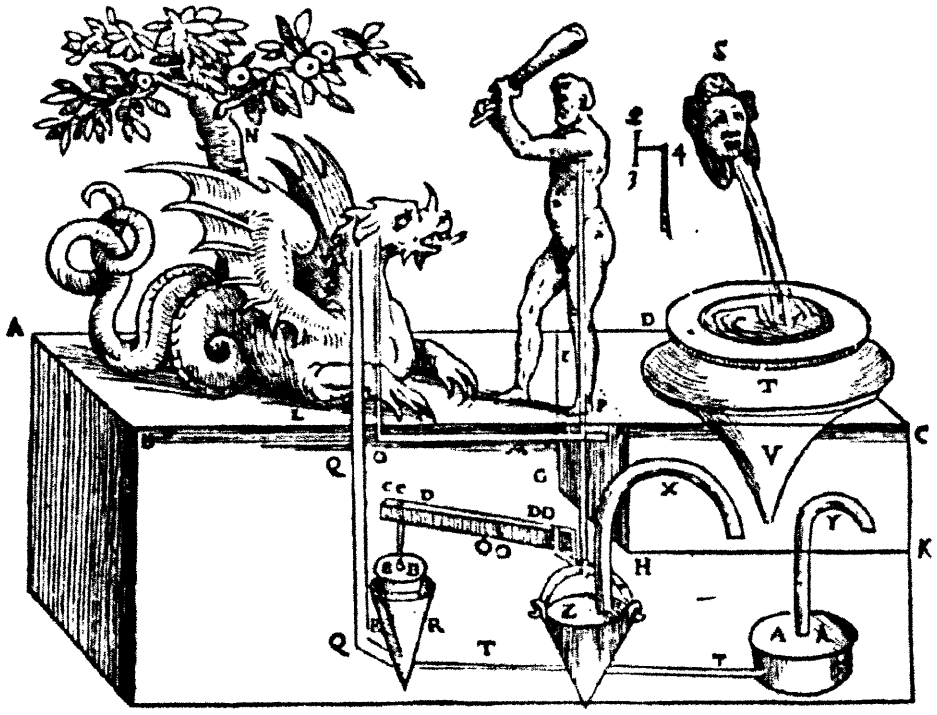

Figure 1.2 Hercules Slaying Dragon

Fig 1.6

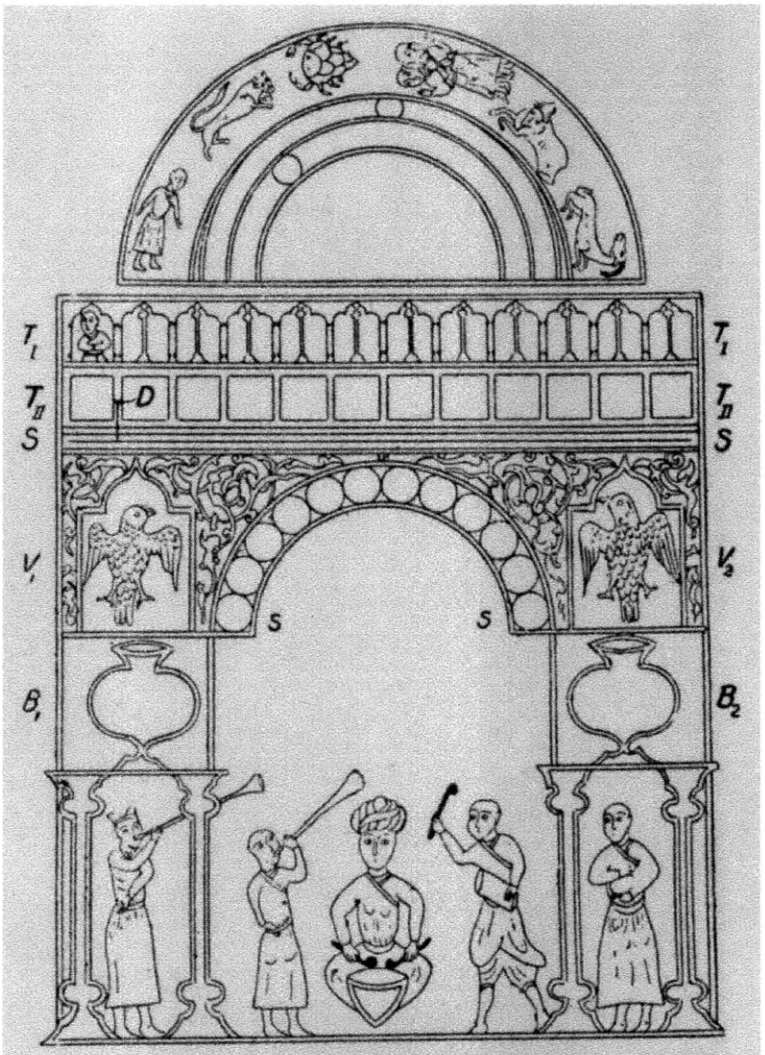

Fig. 34 Arabian clock of Al-Jazari.

Fig 1.7

the innards of automata manuscripts

The complex visual and textual meaning of the manuscript pages from the 1315 and 1354 al-Jazari manuscripts, owing to an only fleeting interest of art scholars, has yet to be critically engaged.[77] There are dozens of intriguing images in which human form is combined with the geometric shape of the device to create a blend of mechanics and anatomy. The image of "Details of the Internals of Slave,"as named in the Metropolitan Museum of Art's plate[78] of the 1315 MS, is a particularly striking as well as popular image. (Fig 2.1) It features a human head sitting on a frame-like body holding a goblet and a flower with two articulated arms jutting out from "internal organs," which are mapped out as tubes on the inside of the frame.

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[77] This is still, remarkably, the case. Finbarr Barry Flood says in his work on the Great Mosque of Umayyads, of the Bab Jayrun gate, that it is hard for non-specialists to write much about it--just like Ibn Khaldun. Tabbaa doesn't even address the devices in his book *Sunni Revival*, but discusses instead the one geometric pattern that al-Jazari gives construction details for in his *Compendium*.

[78] The title of the plate in the *Compendium*, that is as named by al-Jazari, listed under "Vessels and Figures Suitable for Drinking Sessions," is "the figure of a man, a boon-companion, who drinks the king's leavings. It is divided into two sections" The name of the Metropolitan's page suggests it is illustrating the innards of a slave; the text that accompanies the image in the manuscript in fact tells the story of the boon-companion drinking left over wine.

The image--and others from the manuscript which cannot be expounded upon here--probably would have been influenced by other medieval scientific and medical manuscripts, both in form and in content. Hill and others, including art historians of the early 20th century, however, did not undertake to question the pairing of mechanical movement with physiology that gets represented in the devices. The depiction of the same device in MS Graves 27 features two images: one that does not reveal the internal workings of the slave, (Fig 2.2) and another figure with "articulated" arms featuring subtle lines suggesting pipes and tubes on the inside of the man's robes. (Fig 2.3) There are additional detail construction drawings depicting arm joints.

The device, more than aiming to represent the innards of a slave, drinks what is left of the king's wine: "It is a kneeling figure made of jointed copper. He holds a goblet in his right hand with fingers extended along its stem, and in his left hand he holds a waterlily by its stalk. This boon-companion is placed in front of the head of the carousal. When he drinks a goblet the stewart takes it, pours what is left in it into the boon-companion's goblet, and stands aside. When left by himself, he lifts the goblet in his hand until its rim is between his lips [where it stays for a while]. Then he lowers the goblet from his head and nods several times. This happens every time wine is poured into the goblet."[79] In the 1315 manuscript the figure and its internal tubes are marked by the pseudo-hieroglyphic or -Greek keys that Blochet used to date origins of the 1315 manuscript; by contrast MS Oxford 27 has none. The text remains the same in both, and thus animates the figures similarly. The disparity between the two drawings is not too great but it throws the outward appearance of the figures--its would be 3D body--into relief. To know what the organism does--drinks the wine of the king--or how the arms finish

[79] *Compendium*, p. 115

the wine--what tricks them?--are two separate matters. Do the movements[80] distract from the narrative? What are these movements and what do they do, or what are they used for? This section examines the manifold benefits and problems of looking at functionality and by extension, use, most specifically through Donald Hill, who paid the most attention to answering the questions of "how" by putting automata under the header of technology.

Like the different depictions of innards of the slave, the manuscripts vary widely, but the text remains the same for the most part. Thus in some sense, early scholarship's lack of comprehensiveness can be deemed mere incompletion. Wiedemann and Hauser researched piecemeal al-Jazari's and the Banu Musa's manuscripts and they left a small scattering of seven articles, which early scholars nominally made use of.[81] In addition to this were works on the broader topic of automata--mostly Greek and Byzantine--but which occasionally addressed Islamic automata. None of these works ventured to make arguments about, or to theorize, the "meaning" of Islamic automata, but they did provide short narratives of what the devices depicted, plus some snippets that reported on dating and authorship, and, in Wiedemann and Hauser's case, offered some mathematical proofs. No doubt the breadth of this scholarship was important for later scholarship, but it is now dated and especially in the case of Wiedemann and Hauser who worked within a firmly established model of a scientific "discovery," has been surpassed by later scholarship. However, it is not only for lack of evidence that the automata "eluded" early scholarship. What attracted Wiedemann and Hauser to Islamic automata

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[80] I am at a loss to find a proper term that encapsulates what the physical motions of the devices, which are so bound up with physical-scientific terminology. As tedious an endeavor as it might seem, it is central to the project of interrogating the automata manuscript historiography. The makers of these manuscripts would most certainly have employed a technical jargon that described certain phenomena but it would have been quite different than those terms today.

[81] Needham's book on Chinese clocks uses Wiedemann and Hauser's sketches of al-Jazari's devices (which features fairly prominently in the book), which bore some similarities to different aspects of Chinese clockwork. The question "which came first" is a diversion from the present story but also remains to be resolved. See Joseph Needham, Ling Wang, and Derek J. de Solla Price. *Heavenly Clockwork: The Great Astronomical Clocks of Medieval China.* (Cambridge: Cambridge University Press, 1986)

manuscripts in the first place awaits research and interpretation[82] but their early contribution to a historical accumulation and subsequent distribution of manuscript material was probably not fueled by looks or collection value. Although the al-Jazari manuscript images were most abundant and "beautiful," Wiedemann and Hauser were just as interested in the Banu Musa text. But no one took them up: No Banu Musa manuscript page that I know of has ever been collected into the art market even though they do depict drawings of some nice jars and vessels.[83] Donald Hill contributed to what was originally a scanty collection of work that had been produced almost entirely in isolation from other disciplines.

Donald Hill's two authoritative English translations of the mid-seventies allowed the field of Islamic technology to exist and to "thrive" under the aegis of *fine technology*. Beyond the appearance of the manuscript page, which might look like a representation of innards, there is also a function to be discerned: it is not clear in the drawing, from the outset, that the works are technological. Only after Donald Hill completed his translation could the assertion that art historians missed the meaning of the texts writ large resonate with George Saliba. After all, most of that scholarship was explicitly concerned with a handful of drawings from two bestrewn *Compendium* manuscripts. Donald Hill on the other hand indexed the manuscript copies, neatly explained their origins, and provided a brief synthesis of historical data surrounding their composition. In so doing, he laid the grounds for automata to act as the complex mode of knowledge that it was, for, beyond the relaying of a narrative, he also

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[82] As I have suggested, it just might be antiquarian science.

[83] Some of al-Jazari's manuscripts of have already been discussed. Donald Hill lists the four manuscripts he employed in his work as MS Graves 27 in Oxford, Or. 656 and Or. 117 both in from the University of Leiden in the Netherlands; and MS 4187 in Bester Beatty Library in Dublin. Hill lists one manuscript in Istanbul that might be the earliest, dating to the first half of the 13th century, whereas Ahmad Yusuf al-Hassan suggests that the date is 1206 and he uses it on this authority, citing a controversy of the colophon; he also lists three additional manuscripts from Istanbul. See appendix Additionally, according to al-Hassan there is copy dated to 1591 in the National Library of Russia in St. Petersburg. This indexing was a much welcomed contribution of Hill and helped to disciplinarily consolidate automata.

demonstrated *how* the devices moved.[84] Through the constellation of research presented here, the "meaning" of the manuscripts largely became the function of the devices themselves.

In his translations of the *Compendium* and the *Book of Ingenious Devices,* Hill provided an exhaustive[85] summary of the various MS copies around the world and the modicum of past scholarship; he was the first to do this, and the only other scholar who surpassed this was Ahmad Yusuf al-Hassan a few years later. Hill includes comprehensive diagrams in his annotated translation of the Banu Musa outlining the known locations of devices and individual pages. We learn from him that there are three complete manuscripts--with a few possibly apocryphal additions, some of which al-Jazari himself expressed doubts over, as well as a few omissions.[86] The images amongst the three copies differ considerably. Donald Hill describes the difficulties Wiedemann and Hauser must have encountered while translating those with those two copies. The third Topkapi copy boasts superior drawings. The other two entirely lack animal and idol drawings, which Hill calls "an omission which frequently renders the drawings almost incomprehensible."[87] Hill does not speculate as to why the animal figures are not included in the working drawings from the other two manuscripts, but notes that Hauser was even "obliged to add dotted lines to the Vatican illustrations in order to make them match the text."[88] Hauser left various marks on all of the Banu Musa manuscripts; the dotted lines helped explain the functioning of the device in the drawing.

Donald Hill's vocation was not merely descriptive, but it did implicitly mandate theoretical speculation, although he does not seem to have been concerned to disclose this.

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[84] This required, but was not quite the same as devising physical formulae, which is largely what Wiedemann and Hauser did. But this approach is also present in Atilla Bir's "retranslation" of the Banu Musa's book, it will be shown.

[85] Ahmad Yusuf al-Hassan would locate twice as many, in fact. See appendix

[86] Additionally, there are fragments located in Leiden and New York Public Library.

[87] *Ingenious Devices*, p.15

[88] Ibid.

The work of reconstruction requires certain knowledge such as basic engineering concepts to uncover how the movements narrated in the devices are completed since how the devices move is not inherently separate from the narrative of what movements the devices accomplish. Broadly speaking, it is easy to arrive at an idea of what a device does, but reconstruction of how devices work depends also on the will to understand the motive and the thoroughness of manuscript. Still the standpoint of the scholar working through the manuscript's "timeless" mechanical principles is above all historical. Looking into a *hiyal* manuscript, to glean meaning the scholar cuts across the historical motifs in Islamic automata manuscripts, observes inherent structuring principles, recognizes them in other mechanist forms, extracts them, and serves them up as disciplinary knowledge. The reconstruction process is as much historical as it is scientific. At the same time, there is much more functional or movement-oriented--technological-- research than there is documentation of this historical process. The reason for this starts with Donald Hill's methods, and is most certainly bound up with the turn to the explication of the devices through their capacity to represent technological knowledge, or the history of technology.

the implications of 'fine technology'

Donald Hill, Ahmad Yusuf al-Hassan, and a host of others do not speak of *hiyal* as a manuscript genre, but as the incarnation of a type of knowledge. *Hiyal* must be categorized in today's technological lexicon. In his prolific work[89] on Islamic technology Hill reviews automata and water clocks (to be distinguished from waterwheels and water raising machines)

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[89] *Islamic Technology* (coauthored with Ahmad Yusuf al-Hassan), *A HIstory of Engineering in Classical and Medieval Times, Islamic Science and Engineering*, all bearing similar sentiment on fine technology and automata.

under the rubric of *fine technology*--"the kind of engineering that is concerned with delicate mechanisms and sophisticated controls."[90] Occasionally, perhaps in an effort to put a finer point on the undeniably anthropomorphic character of *hiyal*, Hill also uses the category "automata." Hills is critical of the inexact quality of the term however, as deployed by some of his colleagues:

> Professor Price has argued strongly and consistently that mechanistic philosophy led to mechanism[...]A natural extension of this urge is to impart movement to static simulations and so create automata. The weight of the evidence seems to favour this hypothesis, which assigns a key role to the makers of automata in the development of a rational, mechanist view of the universe...
>
> Nevertheless, it would be wrong to invest all automata with *a special significance in the development of man's view of the world.* Many were simply ingenious toys, designed to amuse or mystify...For this reason, some historians, far from detecting any significance in these devices, have dismissed them as trivial. This is about as sensible as dismissing modern communications technology because many television programmes are frivolous or banal. The comparison is not far-fetched: as is the case with astronomical instruments, many of the ideas developed in the construction of ingenious devices were later to enter the general vocabulary of mechanical technology. It is a little unfortunate that the term 'automata' is used to designate this type of construction, if only because, from an engineering point of view, it is usually the activating of mechanisms, rather than the displays themselves, that embody the most interesting ideas.[91]

Hill separates that which signifies the development of cosmology from technology that "simply amused or mystified," but at the same time he defends the latter technology's ability to "matter." Thus he suggests that ultimately, while enjoyable programming with a cultural use is productive so long as it generates further productive technology, it is not charged with signifying man's view, for this lies outside the purview of amusement and pleasure. Why would not all "automata" signify man's view? Hill suggests that automata as a category tends to

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[90] Donald Routledge Hill, *Islamic Science and Engineering.* (Edinburgh: Edinburgh University Press, 1993), p. 122

[91] Hill, *A history of engineering in classical and medieval times.* (London: Croom Helm, 1984), p. 200 Emphasis mine

overrun the interpretation of its productive capacity, or, at any rate that it is not exclusively a category based on a vague proto-mechanistic "spirit." Hill perhaps also challenges an ideologically entrenched drive that laxly wrote off Islamic technology, as it could not be absorbed into that theory.

The category of automata *must* have to do with animal and human forms in mechanism, and this is what calling this its mimetic character aims at. Hill, however, lacked the theoretical tools to arrive at this conclusion, for this more of an art historical than a technological categorization. Hill by contrast focuses on the "entrance" of the ideas in ingenious devices into the "*general* vocabulary of mechanical technology." He omits to explain what is *general* about mechanical technology. If the figural aspects are removed from the ideas of automata, and they were more enjoyable than meaningful, "general vocabulary" designates a more-or-less universal lexicon of movements. Such is how, in the cultural historical discipline, pure movement is made to be irrespective of cultural idiom, and as such has "liberating" qualities from culture. These are the implications of automata in fine technology, which grants the historian a degree of freedom the particular representational aspect of the automata.

The manuscript is a tractable archaeological document where the devices are not. And the manuscript itself poses a problem: the automata can be shown to "work" according to later scientific wisdom, affirming it in the process, but their "crafty" form also gets in the way of proving this fact. Ahmad Yusuf al-Hassan, an engineer and professor of Islamic science, published an Arabic transcription of the *Compendium* on behalf of the Institute for the History of Islamic Arabic Science[92] in 1979, which he also founded. He also served on UNESCO's International Committee on Science and Technology in Islam under the project Different Aspects of Islamic Culture, devoted to cataloguing the important Islamic works of science in

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[92] op. cit. al-Hassan, *Al-jami' bayn al-'ilm wa-al-'amal* The book was published as part of a project called *Survey of the Sources and Studies on the History of Islamic Arabic Science.* The project did not seem to take off.

the assertion that they are a matter of scientific and cultural heritage.[93] Interest in Islamic science does not occur in a vacuum however: it is no coincidence that the developing world found itself on the technological defensive from the historical standpoint.[94] Al-Hassan's and Hill's moment is inscribed in this problematic, which is not far off from Lynn White describes. Undercutting the problem of technological backwardness through Islamic technological heritage--undeniably ingenious and advanced--required arguing that they bore some import on their own society or culture, however. Automata play an important role in this, as they were important to craft and science in the Islamic world and boasted some techniques that were more advanced than those found in useful machines. Al-Hassan writes,

> Arab engineering literature...[is] frequently concerned with highly elaborate hydraulic and mechanical devices which were so sophisticated and original that they deserved description [...] These were all accomplishments of the epoch in which the Banu Musa and al-Jazari wrote their Books of Ingenious Devices. This phenomenon continued until the era of Taqi al-Din[95] and advent of the Industrial Revolution.
>
> We may safely conclude, then that the preoccupation of al-Jazari...with the description of elaborate and complicated machinery, did not preclude [his] exploiting this technological experience and knowledge to the benefit of their society. But the development of their society, and the historical period, was not commensurate with a scientific or industrial revolution such as the ones that took place some centuries later. Hence comparison of an earlier historical age with subsequent ages is not objectively sound.[96]

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[93] In 1972, UNESCO developed the category of world heritage site. Ahmad Yusuf al-Hassan and Donald Routledge Hill, *Islamic Technology: An Illustrated History* (Cambridge: Cambridge University Press; Unesco, 1986)

[94] This would make for fascinating research and is sadly outside the scope of this thesis, for the linking of medieval technology in an attempt to bolster developmental confidence is a strange historiographical development.

[95] Taqi al-Din Muhammad ibn Ma'ruf al-Shami al-Asadi was an Ottoman polymath who built automata in the 16th century. He appears somewhat frequently in the things but is probably too late to attribute much "epochal" ingenuity especially since by that time Europe was rising to power. Ibid, p. 49

[96] Al-Hassan, p. 19

Al-Hassan protests the establishment of technical parity across time: it is impossible to compare Islamic technology--whose most lucid representative [97] is automata (manuscripts)--to the Industrial Revolution. And yet, there must be something discernibly brilliant about, something that sets apart this tradition that has been in large part ignored by historians of technology. Thusly, al-Hassan's commentary lies in the strained region between the lack of established scholarship and the notion that there is "something more to" these *hiyal* manuscripts. He brings into attention the fact that al-Jazari's devices and those like them would have been influential in and important to their contemporary society. To use Hill's metaphor, not only does television programming symptomize greater technical achievement, but it also affects its socially general users. Hill's metaphor is farfetched despite his self-awareness, however. Whereas we can identify such a user group today, there is no recipient society for automata.

Instead, the problem of social function rests on the import of the automata's "epochal ingenuity," which rests in the body of a handful of manuscripts. Epochal ingenuity can be described as the account of brilliance that comes to stand for an era. Al-Hassan treats the automata manuscript as a concrete account of technical superiority, but he makes an epochal argument: the epoch itself, epitomized by its exemplars, contributes to history.[98] But this is not the same as the "creative genius" of Leonardo Da Vinci, delivering the people from a Dark Age:

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[97] As I have argued, certainly there were "other" works of technology, and, in keeping with our uneasy feelings toward Islamic technology as a cultural--rather than historical--category, many unconventional sciences would fit under its aegis. Donald Hill calls al-Khazini's *Kitab Miznan al Hikma, Book of the Balance of Wisdom* the most important and comprehensive work of mechanics in the Middle Ages, from any cultural area," *Islamic Science and Engineering*, p. 60, covers statics (loads, force, torque and movement) and hydrostatics, the use of fluids to do work.

[98]The creative genius in the history of science discipline, not only art history, has been predominant.

in order to establish that the automata were socially useful, the manuscripts first had to prove that what they represented were *functional* devices.[99]

motifs and method

In order to understand the mechanical workings of the machines and clocks that are depicted in al-Jazari's *Compendium* and the Banu Musa's *Ingenious Devices,* Donald Hill employs a mixture of historical and theoretical methods of reconstruction. In the process *hiyal* manuscript drawings and descriptions are translated into schematics of the mechanical "narratives" that were already partially discerned by Wiedemann and Hauser, and through them, Chapuis and Droz; Coomaraswamy; and others. The language of the al-Jazari manuscript, Hill says, is simple enough, and the drawings, "although crude, and in a few cases misleading [...] usually give a fair idea of the machine or component being described, particularly when read together with the text."[100] Al-Jazari's text, as suggested above, intervenes in a tradition of clock building, and it is more conversational than either the Banu Musa's or al-Muradi's with its precedents. While this alleviates certain pains of reconstruction--such as what individual parts accomplished--it also means that the devices are for Hill and al-Hassan the most advanced mechanically, which in turn means that resolving those questions is the priority. This might obstruct certain representational questions from being asked, however, and so the

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[99] Incidentally, the first criterion for the cultural heritage stated in the 1972 convention, was "outstanding universal value from the point of view of history, art, or science." *Convention Concerning the Protection of World Cultural and Natural Heritage* United Nations Education, Scientific, and Cultural Organisation (UNESCO) (Paris: November 1972) Art 1 p.2

[100] Hill, *Compendium*, p. 279

result is a retreat from how they looked in favor of focus on how they moved. The displays, after all, are not as interesting as the principles at work, according to Hill.[101]

Hill is forthcoming about the techniques he employs in order to reconstruct drawings and he emphasizes this most liberally in his annotated translation of the Banu Musa text.[102] He experimented with models of the devices, but he also relies on some historical information to glean mechanical concepts. He offers a brief note on contemporary commentary of the machines, which possessed, according to him, a "great reputation in medieval Islam," and he gives a few illuminating medieval Muslim opinions on the manuscripts suggesting that the book was well known amongst the literati. Hill outlines a succinct history of that manuscript—including a balanced comparison to the al-Jazari manuscript, in which he concludes that the Banu Musa's pneumatics are collectively sophisticated, but al-Jazari's cumulative work is more advanced. Hill outlines the delicate situation of the brothers work in the Byzantine-Greek tradition: he explains in this way that Ahmad ibn Musa's approach to the book was not to define the principles of pneumatics, as Greek works on pneumatics tended to do, but instead to describe the devices that he himself had crafted.[103] Hill concludes with some (by today's standards, compulsory) remarks on the possible contribution of the Banu Musa to the development of the conical valve (Figs 2.4 and 2.5) in later engineering, for example to Leonardo Da Vinci's works, suggesting, but for lack of evidence, it could be that the manuscript passed through Spanish scholars' hands and it is conceivable that Da Vinci could have seen it.

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[101] As we shall see this has translated into unimaginative displays produced in actual automata reconstructions. The point is not to fault Hill or al-Hassan's "being an engineer," but instead to show the interpretive locus of automata as inviting problems not only of discipline, but of epistemology too.

[102] By this time of the translation's publication, Hill would have completed work with craftsmen to make models of three of al-Jazari's devices for the Museum of Science in London, in conjunction with the 1976 World of Islam Festival. See Part 3 p 13 in *Ingenious Devices*

[103] See figure 0.1 for a formally suggestive allusion to Greek automata, the idol holding the sprig.

Hill identifies and explains five "motifs" that he extrapolates from the Banu Musa's work.[104] These recurring functional concepts in the manuscript "are those most commonly used to obtain the *desired effect.*"[105] The 'desired effect' refers to either general physical actions--such as the concentric siphon and double concentric siphon, which rely on air pressure to release water from tubes--or tropes of the devices--such as the two liquid funnel, which allows for the separation of two liquids when skillfully poured into the same opening. (Figs 2.6 and 2.7) Hill's discussion of motifs is not intended to depict homologous "parts" that recur in the machine manuscripts, nor are the motifs principles of function that the authors of the manuscript identify. They are, rather, Hill's interpretation of a number of instrumental functional characteristics of the work.

Motifs also succor Hill's translation. The concentric siphon, Hill's first and most simple example of a motif, is translated from *ka's al-'adl,* literally 'cup of equivalence'. In an example from his al-Jazari translation, Hill defends his rationale for this approach to translating: "A number of al-Jazari's technical expressions have different meanings in literary Arabic or in modern Arabic...I therefore adopted the practice of translating these words into modern expressions for the object which they describe."[106] The motifs of the Banu Musa serve as visuals and as ways of transmitting the meaning of words, in which the words become oriented towards the working order of the machine and its parts, at least as perceived by Hill. Also, however, it is simply difficult to translate the text of *hiyal*, and failing a better understanding of the literary qualities of the descriptive text and its historical relationship to the images, the translation will fall in line with the deduced functionality--this is probably more than anything helpful for the modern reader of the manuscript. The motifs Hill devises reveal the discursive

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[104] With these we discover of the "general mechanical technology," as a universal lexicon for processes as represented in Hill's thought.

[105] Hill, *Ingenious Devices*, p. 25 Emphasis mine.

[106] Hill, *Compendium*, p. 6

way he vacillates, perforce, between text/drawing and working ideal. Piecing together multiple manuscripts' content is probably essential to reconstructive efforts today.

Hill uses the two drawings of the concentric siphon and the double concentric siphon devised for the *Book of Ingenious Devices* translation in his book *A History of Engineering in Classical and Medieval Times* in order to illustrate a loosely defined "*hiyal* lexicon." In that section on fine technology, he says,

> Most of our information about manufacturing and constructional methods comes to us from al-Jazari's work. This is because he gives us step-by-step instructions, describing the manufacture of a tank, for example, from a sheet of copper to the finished vessel. Other writers simply say, 'A tank of 2 spans diameter, 5 spans long, is installed...' Although al-Jazari was a better engineer than most, it is reasonable to suppose that his predecessors' methods were similar to his.[107]

Hill provides a broad overview of construction methods and materials that would have been common to *hiyal* manuscripts (with an eye towards the fabrication of other useful machines), noting divergences where applicable. In his reconstruction of Model 76, the illustration from the manuscript is stripped of color where the original possessed it, the Arabic letter (in this copy's case) keys denoting various parts are rendered into roman equivalents, animal figures and the handles of vases are omitted. (Fig 2.8) These gestures aim towards conveying the material to the non-specialist (that is, both the non-mechanic and the non-Arabist).[108] To some extent the lines are regularized or made symmetrical where necessary, but, graphically speaking, Hill does not stray far from the original. He deploys this method, which can be reasonably called abstraction, intending to clarify the form.[109] In his section on motifs in *The*

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[107] Hill, *Engineering*, p. 207

[108] Could one also perhaps suggest that the omission of animal forms further conveys the broad appeal thus dissuading the exclusivity of an art historian's interpretation of the machines? How exactly does omitting a bird increase clarity? Presumably in the case of the copyist, the omission of animals had less to do with clarity and more to do with reigning moral and ideological norms at the time.

[109] Hill, *Ingenious Devices*, p.26

Book of Ingenious Devices, Hill even provides mathematical equations describing the rise and fall of water and air pressure, to help explain how certain motifs work.[110]

In both al-Jazari's and the Banu Musa's works, the drawings of the originals are clear enough in at least one of the existing manuscripts—each work has an arguably regularizing, clean copy, Graves 27 for al-Jazari's and Topkapi for the Banu Musa. Certainly the mode of representation of the devices does not accord with modern machine schematics, so how can Hill know how the machines would have functioned? In Model 6 of *Ingenious Devices*--"a figure of a bull [who] when offered a vessel (*ijjana*) containing water, drinks it and his voice and clamour are heard, so that anyone looking at him thinks that he is thirsty"--Hill explains some mistakes in transmission by comparing the Vatican with Topkapi; they are considerably different. (Fig 2.9) The reconstructed drawing from the Vatican copy does help explain how the device works: there is an airtight plinth inside of which is a small tank that has two openings with two valves (e) and (k). The plinth in this manuscript is larger and it more clearly illustrates the valves. One is attached to a chain (which, in one drawing, goes inside a tube, and in another, does not) that is supposed to be attached to a bull. In the Vatican manuscript, the bull probably does not exist, and is represented in Hill's drawing as a stack of shapes. The trough from which the bull drinks is connected to a tube with an outflow chamber. The bull "clamors" and his chain sets the valve (e) down in the hidden chamber, causing the water to force open the other valve (k), and the water rushes into the other chamber, causing it to move up to the trough. The holes exist so that when air is introduced the water rushes back. (Fig 2.10) Hill worked with the Topkapi manuscript of *The Book of Ingenious Devices* ca. 1210--the only one with animal figures depicted-- and for al-Jazari's translation he "aspired" to the most complete manuscript of the *Compendium*, Graves 27. Part of Hill's process of understanding the

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[110] For example, in his motif of the double concentric siphon, if x and y are space ranges from the bottom of a vessel to the top opening of an inner tube in which the placed, and $x=y$, "since x=y, pressure P = atmospheric $-x$ = atmospheric $- y$." Hill, *Ingenious Devices*, p. 27.

workings of the machines lies in assembling a "master" manuscript, in order to both translate the text, and reproduce the drawings.

With the master manuscript copy Donald Hill is able to theorize but it also takes some theorizing to create the transcription itself--this is not much different from any translation work. Each device has a purpose that the thinker deduces. Understanding how the machines work thus calls for a scientific method. The telos of the narrative--the drinking of wine, a monk moving the staff to measure blood, etc.--is grasped as the motion describes the movement, which conveys the meaning. The "function" is hypothesized, experiments constructed, executed, and conclusions drawn. Hill, as well as al-Hassan, conducted numerous experiments with models of the devices to further understand what the drawings were conveying.[111] The devices were probably not meant to be created in succession--even if there is enough information to construct the devices, it is possible that the knowledge was guarded professional knowledge, evidenced by the often proud disposition of the automata manuscript "voice." Thus the whole of the manuscript probably does not help Hill theorize outside of the ability to find similarities in devices that get listed. The compendium quality also means that it is not necessary that all devices would have existed as complete, polished, exhibited models. Hill acknowledges the minimal archaeological research or material remains of any such devices, and concludes anyway, the existence of the devices does not change the feats of engineering in the book.[112] Understanding how the machines work requires a theory that they were made to work in one particular fashion (which is not at all unreasonable), but Hill is not as interested in theorizing the historical use of the documents; for example, whether they

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[111] Ibid., p. 26

[112] This however does affect how the devices look in physical reconstruction that Hill supervises. *Ingenious Devices*, p. 28

would be used as workshop "manuals," ostentatious displays of wisdom, or observational documents. Hill does not need to reveal his opinion.[113]

transmission

The drawings themselves did not transmit enough information for the independent construction of the machines. Nor can the manuscripts be approached as manuals. There is not enough information to construct the devices as depicted: considerable theorizing, and retranslating or -transcribing, is necessary to understand the device. Atilla Bir's anomalous book on the Banu Musa's devices takes literally Donald Hill's earlier suggestion that "the closest modern parallel to their approach lies in control engineering and pneumatic instrumentation," and interprets the drawings of the entire book as modern system control engineering methods. Bir manually draws the line between the 9th century engineers and 20th century control systems. Model 49, for example, is a vessel with four internal tanks. (Figs 2.11 and 2.12) Wine and water get poured in and end up respectively in two different tanks per liquid are displaced in alternating moments. The way this is achieved is through a series of "double siphons" and "overflow pipes" according to Bir's synopsis--these are two of Hill's motifs and also two of the 15 motifs Bir deduces. The device is one of the simpler ones and works by a clever series of overflow chambers that get closed when water rises to a certain point. Understanding this device, like many others, requires following Ahmad ibn Musa's narrative of where the water or wine ends up depending on certain conditions, and thus Bir's work recasts these conditions in a symbology of "decisions," for example, if the water rises to a

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[113] Hill for example does not "dwell" on Ridwan's water clock,or the existing water clocks of Fez-being rebuilt by the way. These singular examples of clocks were different technologically than the *Compendium*.

point, action proceeds to the next condition. The water's rising to a certain point is depicted through a time-chart that shows a line crossing the tipping point, a logical way of understanding the processes at work: Bir graphs the equation of the point at which the water will be displaced. (Fig 2.13) He says, "This model works like successively connected electronic circuits which trigger each other mutually."[114]

The use of this work must be for anyone who already has familiarity with control engineering and who wants to understand historical technology in that language, so to speak. However, since Bir does not copy, translate, or transcribe any of the text, but recapitulates how the devices work, it is also more accessible to general readers who want to understand how the devices work. The knowledge has been reformatted, but this does not constitute new application of that knowledge.[115] Bir's reconstructive elements achieve a greater resolution and convey more information through the diagrams, reducing it to a series of "if, then."[116] (Fig 2.15) This process of logical translation could, in a most mind-boggling manner, be further reduced to the most minute processes of the model. Bir's closed circuit diagrams interpret the algorithm of the devices, the series or "instruction" of events, and show in the process that the Banu Musa's devices can be interpreted rationally through a series of on's and off's, thus linking them directly to today's control systems and computing devices. The difference, of course, being that the trick vessels accomplish tongue-in-cheek measures, and also require a mildly skilled user, for example, one knows to pour water in first and wine second, in the case of the many water/wine vessels, or one knows to pour the liquid slightly to the left (in Model

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[114] Bir, p. 113

[115] See pp. 111-114 in Bir

[116] In a jar similar to Model 49, Bir includes a detail of an overflow pipe, and he "zooms in" on one detail to show a higher resolution, or more information--of the parts When the water or wine overflows it travels through a pipe getting re-routed to another tank

71, an elegant system of tubes).[117] In the thirsty clamoring bull described in Model 6, the circuit drawing features an auspicious "sucking" function to explain what causes the water to rise under pressure, producing the bull's noise. Like a computing system, desired or anticipated outcome must be determined by programming the conditions of the system. (Fig 2.14, compare to Fig 2.9) The automata's movements irrespective of their motive *force*, are singular expressions of gesture and action--that is, they are completely removed from "culture" as we know it and are exclusively physically descriptive. An "organic," proto-robotic control system is tempting to imagine, but as much as he implies it in his interpretation, Bir does not suggest any potential automata craft that could be undertaken today.

If the Banu Musa book made its way to control engineering--even in a sublimated form--Donald Hill is not too far off in his elucidation of functions through motifs, but just lacks the drive to construct more abstract drawings from his motifs. The historical implications of Atilla Bir's work are that it would not be so hard for abstract processes, down to a binary level, to make their way West; osmosis would be enough. Hill's words, "The general approach of the Banu Musa...may...also have passed into European consciousness (or subconsciousness) to be resurrected when the need for it arose,"[118] although much tempered in comparison to the eccentricity of Bir's work, still paint a rather abstract picture as to what constitutes "technological transmission." This is probably for lack of other ideas.

Hill's conclusion to the translation of al-Jazari on the other hand also sees the issue of the historical "usefulness" of al-Jazari's work, once again through a problem of technological history: the creative genius. He bluntly states, "We can legitimately discuss the contribution made by Leonardo da Vinci, James Watt, and a host of others...to the development of technology, but we cannot do so in al-Jazari's case. We do not know what effect, if any, his

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[117] In fact, this makes the circuit diagrams *more* reasonable to use as a method of depicting things: it needs no specific "end" but the program itself.

[118] Hill, *Ingenious Devices*, p. 24

work had upon later generations [...] No one was moved to take up al-Jazari's ideas and incorporate them in the development of 'useful' machines."[119] Yet Hill argues for the importance of that particular work in one distinct way: as the "total work" of engineering, in which elevational views of machines are laid out next to their description of parts and sometimes a narrative of the workings of the machine. For Hill this suggests a will to communicate the functional nature of the machines in a comprehensive manner. Hill argues that the manuscript is significant precisely because of its "use of general arrangement drawings in combination with detailed drawings of individual components and mechanisms," an attribute of modern engineering.[120] He is not exactly apologetic for the devices, nor does he insist in written argument that they function, but instead he simply operates on the assumption that, in order to understand the manuscripts, the devices must be resolved. By producing a body of theoretical work that outlines the functioning of the devices, Hill provided a source for the development of later arguments around that functionality, namely, the devices' contribution to later technological developments--but he did not hazard a guess as to how.

Derek de Solla Price, coiner of the term "scientometrics" and historian of technology, wrote a rather acrid critique of Hill's translation of al-Jazari's *Compendium*. He writes, "Unfortunately though Hill has demonstrated his excellent competence in combining the skills of the Arabist with those of the engineer, he frankly admits an inadequacy of general knowledge of the history of technology. It shows, alas: and more of a pity, circumstances must have been that Lynn White...has been unable to provide him with quite enough of the background."[121] Price also contends that Hill did not go much beyond Wiedemann and

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[119] Hill, *Compendium*, p. 279

[120] Ibid., p. 280

[121] Derek De Solla Price, Review of *Book of Knowledge of Ingenious Devices, Technology and Culture* 16 (1975:1) p. 82

Hauser's admittedly "maddening" work, although he adds, "perhaps the truth of the matter is that nobody yet knows quite enough to put together the pieces of the puzzle as they now exist."[122] Ahmad Y al-Hassan has explained this criticism as Price's unfamiliarity with Arabic science and technology, which reaffirms how hard it is to establish commensurability across culture in technological history.[123] So when Price refers sardonically to the "outmoded junk" that, once disintegrated, no longer warranted manuals such as al-Jazari's, in order to suggest that this dearth of evidence poses problems for scholars, it is hard to imagine it as "junk" for any other reason than failure to progress.

Or, perhaps, it "progressed" in another culture's forms, which Seyyed Hossein Nasr would object to this as expropriation of forms. In his essay "Islamic fine technology and its influence on the development of European horology" Donald Hill commences his survey of formal technologies that contributed to the making of the mechanical clock, saying, "It is most unfortunate...that the ancestry of the mechanical clock has been largely neglected by western historians of technology and horology."[124] The article surveys toothed and meshed gears, clepsydrae, and high torque gear transmission, all of which flourished in Greece, Byzantium, Syria; were taken up by engineers of the Islamic world; and seemingly developed independently in China and India. Namely, the escapement, or what allows for continuous rotation to be converted into discrete back-and-forth motion, which allows for the sway of a pendulum, was not per se extant in Islamic sources but the gear teeth and swinging bar that allow for the transformation of continuous to discrete movement were, and they existed in a form of control engineering, Hill says. (Figs 2.16 and 2.17) The pre-requisites for the

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[122] Ibid.

[123] Al-Hassan, p. 19

[124] "Islamic fine technology and its influence on the development of European horology" from 1994 in Donald Routledge Hill, *Studies in Medieval Islamic Technology : From Philo to Al-Jazari, from Alexandria to Diyar Bakr*, ed. David A. King, Collected Studies Series(Aldershot, England: Ashgate, 1998). p. 20

mechanical clock, Hill argues, were "diffused from Islam to Europe" during the tenth to twelfth centuries, and among the important "diffusers" that Hill lists are al-Jazari and al-Muradi. The ideas were probably transmitted during the Crusades. Islamic automata in themselves are thus clever gadgets and ultimately, they provided the raw techniques when the time came for Europeans to realize the need to employ these techniques to the end of constant hour timekeeping. This essay, written thirteen years after Hill's translation of al-Jazari, exhibits a more optimistic view on the contribution of Arabic fine technology, though he parses out "direct" influences from "indirect" contribution. Al-Jazari, he says, can only be said to have made one direct contribution to mechanical clocks, a water driven pump with twin cylinders. (Fig 2.18) Hill's argument about the Islamic influence on European horology is, in a simplified form, complementary to Lynn White's explanation for the way that technique spread politically through religious ideology: "Since the church was keenly interested in methods of timekeeping, it seems likely that information about Arabic advances in horology was carried to the rest of Europe by churchmen."[125] Hill's work took up this question of the spread of technology only in a reserved manner.

Donald Hill might have realized early on that the dearth of scholarship on this "in-between" time in the history of technology is and effect of the unavailability of many sources, or that they were not translated from Arabic. But the neglect to recognize the Islamic roots of the mechanical clock also reflects general views held on technology. Derek de Solla Price, Hill says in his article, acknowledged this problem but only in a truncated way and neglected to afford much import to the role of Islamic technology in the vacuum of European horology. Price does acknowledge certain characteristics of Islamic clocks contributed to the European, but in the *longue durée*, this is a minor influence, and Price is very much concerned with the *longue durée*.

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[125] Hill, "European horology," p 42

In an oft-cited article "Automata and the Origins of Mechanism and Mechanistic Philosophy" Price breezes over a number of "pre-automata:" burial idols, "primitive masks" with jointed construction, the jackal God of the Dead with an articulated jaw in the Louvre, Re-Hamarkhis' bust now in the Cairo museum; and other jointed limbs appearing in dolls of Egyptian XII Dynasty onwards.[126] Pre-automata are not mechanistic per se, but result from man's desire to set the inert in motion, reproducing his own movement--a project that would later be more subtly streamlined by Antique automata, which, in turn imparted wisdom on further technological developments. Mechanistic philosophy serves as an ideational motivator to produce mechanism, but does not itself engender or craft the components of its world view. Together, these items are bumpers on the side of what Price calls the road of evolution: "From the Lascaux Caves to the Strasbourg Clock, to electronic and cybernetic brains, the road of evolution has run straight and steady, oddly bordered by the twin causes and effects of mechanistic philosophy and of high technology." Price's thesis--that mechanism is the effect of mechanistic philosophy--attempts to resolve a problem of "theory" and "practice" by asserting that mechanical form, through practice, originates from a mental inclination. Price represents a "progressivist" strain of thought in the history of technology, one which controverts the assumption that philosophers noticed something in the biological structures and deduced from this that the world was a certain way. Rather someone (geniuses? craftsmen?) would have "induced" the machine from a worldview already in the making: "In these special mechanisms are seen the progenitors of the Industrial Revolution."[127] Price's evolutionary road is probably a one-way highway that barrels toward the horizon; things tend to get better, more sophisticated and streamlined. "Outmoded junk" of the past, including Islamic automata, idles by the side of road.

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[126] Derek de Solla Price, "Automata and the Origins of Mechanism and Mechanistic Philosophy" *Technology and Culture* 5 (1964) p. 9-23.

[127] Ibid., p. 10

Price briefly runs by the Islamic automata, which serve as facsimiles for Greek originals:

> In the typical Islamic clock, which was in its heyday from about 800 A.D. to 1350 A.D. and may be very close to *the lost Hellenistic originals*, power is provided by a float in a vessel or emptied by dripping water. This power is harnessed, either directly by having a chain or string pull a block along a straight channel, or rotationally by having the string wind around a pulley, or by using a geared pinion and rack[128] The straight motion may trip a series of levers one by one, opening a set of doors, moving a set of figurings, or letting a series of balls fall into gongs [...] The circular motion may be used to animate automata, moving their heads or bodies or rotating their eyeballs [...] These mechanisms, though undoubtedly impressive, are mechanically simple and Heronic. They are described in detail by Ridwan and al-Jazari (both early thirteenth century).[129]

The implications of Price's theory of devices are that Islamic devices are simple and Heronic out of want of a more complexly developed worldview. The devices are "impressive"--perhaps wonderful--but not sophisticated enough to transcend their molds. Ahmad Yusuf al-Hassan was probably correct in assuming Price had limited purview for Islamic technology--Hill's translation arrived somewhat late on the scene of history of technology, anyway, and Price would not have had much else to work with before Hill.[130] He contains his sample to the late works of Islamic automata al-Jazari and Ridwan (after all the Banu Musa's devices were not properly "mechanical," and al-Muradi's manuscript was not translated at the time). Sophistication, complexity, and, ultimately progress undergird Price's concept of automata in history and the manuscripts--the only means to know them--play little role.

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[128] A "rack" is a toothed rail or bar; a "pinion," a round gear. The gear rotates on the bar, converting rotary motion into linear motion.

[129] Price, pp. 16-17

[130] Price's suggestion that Hill did not improve on the work of Wiedemann and Hauser, could be a ceremonious accounting for the "lost time" in between the team's work and Hill's, during which interregnum Price certainly was not equipped to contribute.

techne/telos, theory/practice

If Price thinks that Islamic automata are for the most part "Heronic," for George Saliba this is a virtue. Saliba paints an umbilical linkage between Islamic automata/machine, *hila*, and Ionic Greek *mechane,* μηχᾰνή. "Most writers dealing with mechanical devices in medieval Islamic technical treatises have, in one way or another, raised the question of the utility of these devices, and have mostly concluded that they were more toys than useful machines."[131] He calls al-Jazari the most famous engineer and continues, "the comparatively less famous book of Banu Musa...with its description of water fountains and dredging devices...has also contributed to the general impression that the main function of these machines was for entertainment and amusement."[132] In order to establish that the works of engineering participated in a tradition of proving the known, "philosophical models" (*ashkal faylasufiyya*) Saliba starts with the Aristotelean term *mechane,* which, like '*hiyal*', can mean trick or contrivance as well as machine. Saliba bases his argument on Aristotle's discussion of *mechane:*

> Remarkable things occur in accordance with nature, the cause of which is unknown, and others occur contrary to nature, which are produced by skill....for the benefit of mankind [...] When, then, we have to produce an effect contrary to nature...we are at a loss, because of the difficulty, and require skill. Therefore we call that part of skill which assists such difficulties, a device. Of this kind of those in which the less master the greater, and things possessing little weight move heavy weights, and all similar devices which we term mechanical problems.[133]

Saliba draws a direct connection to the Arabic term *hila,* which similarly connotes trick or machine, and writes that the Arabic term *hila* is a translation of the Greek. He defines *hila,* "any device that allows one to overcome the natural resistance, and thus perform actions contrary to the natural tendency,"[134]and he attributes an Aristotelian viewpoint to al-Jazari based on

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[131] Saliba, op. cit. p. 141

[132] Ibid.

[133] Ibid., p. 142

[134] Ibid.

evidence of the title of the *Compendium*. The Banu Musa do not betray such overt connections to Antique thought in their colophon. Saliba resolves the problem thusly, "the surviving *text* has the innocent title *Kitab al-Hiyal* with *Hiyal* to be understood as a good translation of Greek μηχᾰνή mentioned above, and lacks the introductory rationale that would have revealed the intentions of the authors"[135] But Saliba concludes that the author (who he does not identify as either Ahmad, Muhammad, or al-Hassan) "also thought that he was bringing things into actuality," a similarly Aristotelian line of thinking.[136] He briefly notes the poor condition of al-Muradi's manuscript as well, to suggest that al-Muradi's use of the term *ashkal faylasufiyya,* philosophical figures, bolsters the fact that in the Medieval period, knowledge was "practiced" through automata--automata are philosophical phenomena perched at the intersection of theory and practice.

There are two elements of "philosophical devices" that Saliba bases his argument on: Saliba's first mode of discussing this, which literarily gets its material from the stuff of Aristotelian philosophy and the opposition between matter manipulation or *techne* and *telos* (end goal/purpose), posits that a device, or machine, shall be in opposition to the conditions that it must overcome but with these devices the plausibility itself is in question. Secondly, Saliba links a theme in Islamic thought concerned with the interaction between the "science," *'ulum*, and craft or proofs, *sana'a,* as properly demonstrated by the title of al-Jazari's *Compendium*, which serves to "unite" theory and practice from our point of view--"that which combines," Saliba points out, the "theory and practice of the mechanical arts."[137] Saliba resolves the first issue of *techne* and *telos*, philosophically by arguing that al-Jazari was positioning himself vis-a-vis Aristotelian thought on mechanics, suggesting that so long as we

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[135] Ibid., 143. Emphasis mine. Does Professor Saliba realize there are three full copies and two additional parts?

[136] Ibid.

[137] Ibid.

understand the Aristotelian strain of thought in *hiyal*--which unifies theory and practice--Islamic mechanics make more sense.[138] This resolves the problem of usefulness of the devices themselves that Saliba notices. About the craft practices Saliba has little to say.

Saliba attempts through thought models to prove that the ingenious devices of the *Compendium* and *Kitab al-Hiyal* were not trifles. That *hiyal* followed in a noble tradition of high art and science is suggested by the philosophical tradition within which they were embedded, Saliba argues. In his estimate, *hiyal* unites an ontologically separate theory and practice. He need not demonstrate their functionality through proofs but rather he is concerned to equate their function with their usefulness. He finally says,

> [The] distinction between the toy and the useful machine should never conceal the fact that a free-market demand for either could give rise to a higher production irrespective of the utility concerned--if utility is to be understood as generating further production. There is obviously a distinction between a *technological tradition* that leads to the production of a steam engine, and that which leads to the production of a gadget that operates by the power of steam.[139]

But the automata in actuality filled no need for exchange, and their market unlike other commodities was by no means "free:" a toy as Saliba understands it relies on a conception of free time found only under capitalism; or apparently, under Oriental absolutism. It is unlikely that common people were playing with automata. In fact, Islamic science, including the deep connection between medieval science manuscripts, suggests that science and craft were not separate entities at all, but instead the separation of the two is, precisely, bound up with Lynn White's explanation that the productive character--based on time output--of a craft was set in

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[138] Here Saliba quotes the philosopher al-Farabi: "the science of mechanics (Hiyal) is the knowledge of the procedure by which one applies all that was proven to exist in the mathematical sciences that were mentioned above statements and proofs unto the natural bodies, and (the act of) locating (all that), and establishing it in actuality. [...] The sciences of mechanics are therefore those that supply the knowledge of the methods and the procedures by which one can contrive to find this applicability and to demonstrate it in actuality." p. 145

[139] Ibid., p. 148 Emphasis mine

opposition with the moral high ground that decided it was so. They were politically pulled apart with the advent of industriousness in the late Medieval Period. This is a crucial distinction to describe the relentless appearance of "function" in reconstruction and it illuminates use. For reconstruction rests on scientifically proving that the motion or processes underlying the Islamic automata manuscript make the narrative actions happen--they imbue them with motion. Automata's function did not serve their "use"--unlike a grain mill which mills grain, or a water raising device that raises water. The "how" is not apparent from the "what."

As we have seen, though, the problem of usefulness is nonetheless constant. Saliba's own treatment of the problem overlooks the difference between function and use: for if certain functions resolve physical problems, such as how to elevate or displace matter on behalf of someone who needs to elevate or displace, the constraints imposed on the automata are entirely literary, that is, imposed from within the logic the device sets for itself. Thus in reproducing automata, one does not reproduce the means to an end; but the means to a meaning instead. This is the problem of function and use of automata, and what goads this scholarship concerned with its function: the (theoretical fact that) automata demonstrate their own physical laws that were created for them. This was the craft and the science.

Saliba in the end admits that there is a difference in kind between *traditions* producing the steam engine and a steam powered automaton, but he defers to a mythical free market to mete out the differences in production. His misstep is only to ignore the particularity of the manuscripts beyond their titles. The question of use will be in part resolved when *hiyal*, craftsmanship, and professional practice are more adequately meted out. The unique position of the hiyal manuscript as a remnant of the unified totality of "science" and "craft" throws into question what its form is. But how much can be theorized is limited by material available.

manuscript as material

A salient, and final, demonstration of the need for functionality to establish use and the limitations posed by the manuscript appears in the responses to al-Muradi's heretofore absent work. In every one of Hill's chapters on fine technology al-Muradi procures a mention, sometimes more, sometimes less; but al-Muradi could not be integrated into any historical argument for lack of evidence. Donald Hill and George Saliba both mention the null likelihood of reconstructing al-Muradi's *Kitab al-Asrar* in its current state, that is failing the discovery of another copy of the manuscript other than Orientalé 152 at the Biblioteca Medicea Laurenziana in Florence.[140] Hill wrote an essay about the manuscript for the first issue of the *Journal for the History of Arabic Science* (edited by Ahmad Y al-Hassan) in 1977, in which he attributed the manuscript for lack of a better candidate, to the author of another bound in Orientale 152[141] This essay mostly aimed at describing the contents of the manuscript, but he makes a few conjectural statements such as, "the writer was obviously a scientist and not an engineer"[142] in response to a complete lack of summary detailing what a device was meant to do. In this essay Hill also ventures a guess that the reason for the dearth of animal and human figural representations is the Almohads' suzerainty.[143] By 1978 Juan Vernet's "Un texto arabe de la corte de Alfonso X" corrected the authorship to al-Muradi, although it is still disputed.[144] Vernet's essay speculates on how much of an influence this text could have been on later European technology, in the process making a case for the importance of Spain in the Islamic

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[140] The manuscript is one of eight bound in Or. 152, which led to some confusion about the authorship.

[141]Hill, "A Treatise on Machines by Ibn Mu'adh Abu 'Abdallah al-Jayyani" [treatise by Ibn Khalaf al-Muradi ed.] in *Studies in Medieval Islamic Technology pp. 33-44*

[142] Ibid., p. 33

[143] The Almohads are a 12th-13th century Berber dynasty whose suzerainty stretched from North Africa to Andalusia. While theologically and politically the Almohads are associated with stringent proscription of anthropomorphism, the historical basis for Hill's conjecture is by no means self-evident.

[144] Juan Vernet, "Un texto arabe de la corte de Alfonso X" *Al-Andalus* 43 no. 2 (1978) p. 405-421

transmission of technical knowledge. Hill, in his essay "Andalusian Technology" takes as usual a slightly more ecumenical view of that question, probably because it is not easy to find many Cordovan documents. Al-Muradi's manuscript is the only known Arabic manuscript from the court of Alfonso X, a famed patron of the astrological sciences: Many of the documents could have been destroyed during the Reconquista. Both Juan Vernet and Donald Hill struggle to synopsize the contents of this unmanageable text. The image quality however does improve as the manuscript progresses.

Juan Vernet also says that the manuscript is notable for its independence from al-Jazari but in some cases bears uncanny similitude, for example figure 18 depicting a falconer with falcon. (compare Figs 2.19 and 2.20) From the drawings available, this comparison is hard to make and apart from the shared occurrence of birds, and the long weights dangling, it is hard to make out. Notwithstanding certain "quotations" appearing in al-Jazari (who was not schooled in a vacuum in any event, and who was aware of at least the Banu Musa's work), Vernet suggests that inasmuch as the current state of the manuscript could indicate, there is less connection between this manuscript and other Arabic works than that of the work of Philo of Byzantium. Hill notes that al-Muradi's figures are much more "rugged" than the comparatively delicate structures of the Banu Musa and al-Jazari.

Ultimately, scholars do not know what to make of al-Muradi's manuscript. There are important and perhaps insular innovations in *The Book of Secrets* such as the use of mercury for balance and epicyclic gears.[145] (Fig 2.21) But as much as the dissemination of copies of the other manuscripts help achieve a master narrative of their contents, this work is unyielding in information. There has not yet been a thorough analysis of the court of Alfonso X with respect

[145] gears inside of gears

to craft at the time,[146] since the craftsmanship of al-Jazari and the Banu Musa is so crucial to understanding their unique position in the sciences--although arguably, it too is equally under-theorized. Looked at from the historian's point of view, it is difficult to imagine what more can be revealed. From the technologist's standpoint, there are still technical feats to be discovered in the book. For all intents and purposes, it is almost impossible to reconstruct, or even look at, *The Book of Secrets* and emerge with more answers than questions.

A comprehensive, perhaps eclectic, variety of interpretations of Islamic automata manuscripts have been presented here, but they all share one theme, which is that *hiyal* reconstruction has sought to focus on functionality, the only limits to which are the imagination, a historically "Western" denotation of useful technology, and the manuscript material itself. This reconstruction, for all it relies on multiple manuscripts to achieve a master narrative of device, however, also transcends the manuscript. As function was made to resemble use, which must be proven valuable, an idiom of abstract processes came to constitute the way in which the Islamic automata manuscript was integrated into the canon of progress. If the Islamic automaton remains only in manuscript form (with the exceptions of a few material remains of monumental clocks) scholars must work though them-- but to prove their excellence they must transcend them.

In his article on the social function of automata sculpture, T. M. P. Duggan has matched George Saliba's pejorative remarks on early art historical scholarship with an uncanny adjustment: "It is regrettable that the moving statues...have to date received far greater attention as examples of technology and as elements of the history of the science of mechanics than as the great and wonderful works of sculpture that they undoubtedly were."[147] Automata

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[146] Juan Vernet, *La cultura hispanoárabe en Oriente y Occidente* (Barcelona: Ariel, 1978) gives a cultural outline and many mathematical proofs, but does not offer much in the way of craft practices. Little of Vernet's work has been translated to English: this is a problem for the field of history of technology perhaps, owing to a lessened emphasis on "cultural history."

[147] Duggan op. cit. p. 231

scholarship so far has run the gamut from painting to technological manual, but there is something inside it; the automata can indeed be constructed, whether by the principles extracted, or by other, completely 21st century, constructive techniques. Judging from the discontent with each other's disciplinary takes, no one is satisfied with how the automata manuscript gets treated.

جنية مقلبه وعلى طرفه
ط وقد ارتفع كاس ك
الى ان صارت حافته
بين شفتى النديم
واندفع راسه الى وراء
قليلا بالكاس ثم
ينصب الشراب من
طرف مقلب ط الى
فم ج ويجتمع فى حوض
ب ثم يجف جق وفيه
من الشراب بقية
يخرج من المقلب فيرتفع
وتخط اليد والكاس وعند مفارقة جافة الكاس شفة النديم
يعود راسه الى قدامه بسرعة ويخدم به مرارا ويستقر وامايده
اليسرى وعليها س فانما تخط كلما ارتفع الشراب فى حوض ب
ورفع العوامة وعليها ع والخيط المتصل بها وهو ملوى على بكرة
تحت كتف النديم وعليها ه ثم يلوى تحت بكرة اخرى
وعليها م وهى تحت طرف مرفق اليد ويرتفع الى فوق ويتصل
بثقب ص والنبلوفرة تخط باليد وعليها ح حتى يمر اسفل
ساقها بماس فخذ النديم ولا يزال كذلك حتى يرتفع الشراب فى
حوض ب الى ان يقارب جنية مقلب الحوض وعليه ن فحينئذ

Fig. 2.1

Fig. 94.

Fig. 2.2

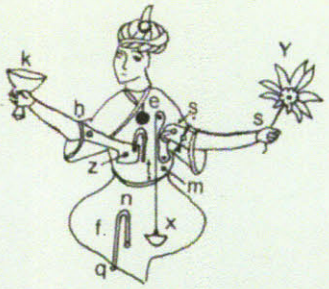

Fig. 97.

Fig. 2.3

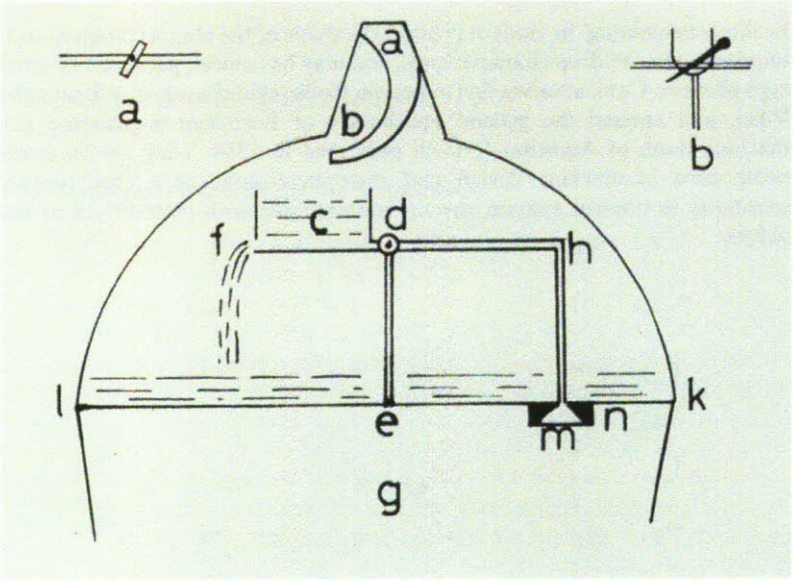
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Fig. 2.4

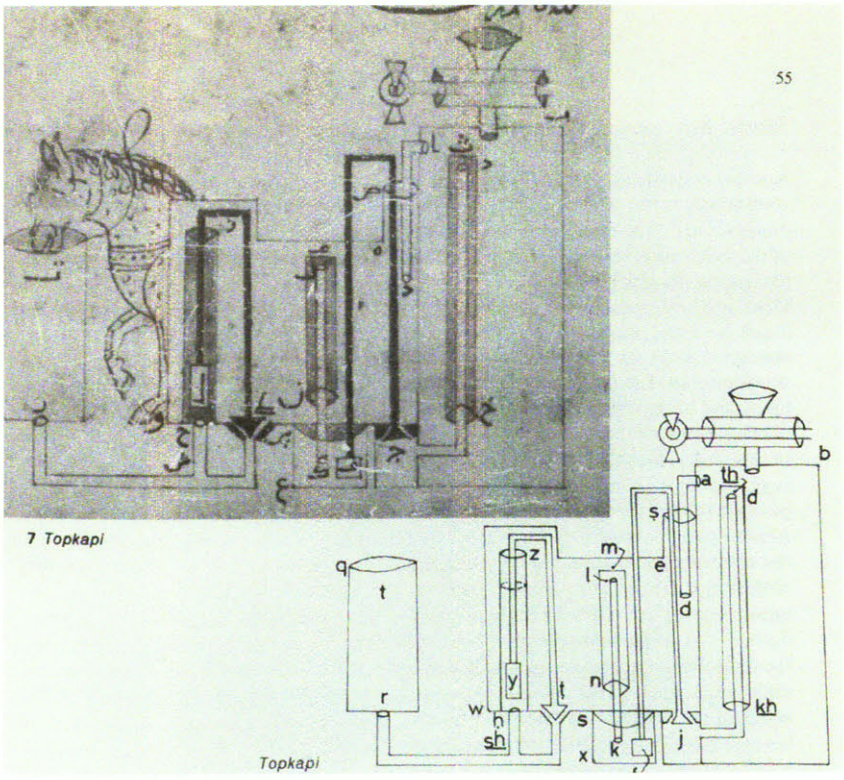
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Fig. 2.5

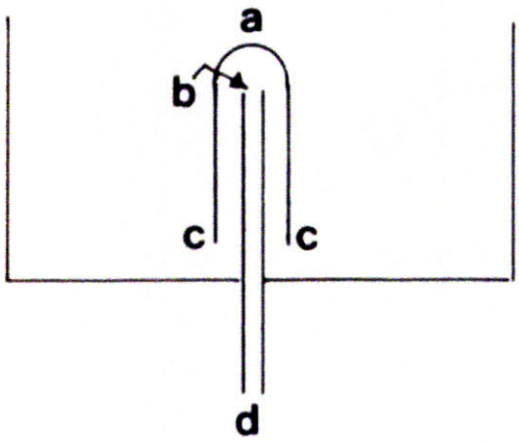
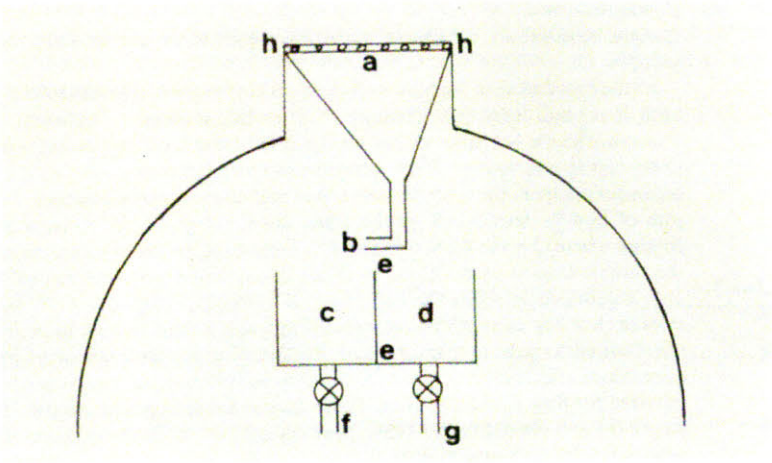


Fig. 2.6



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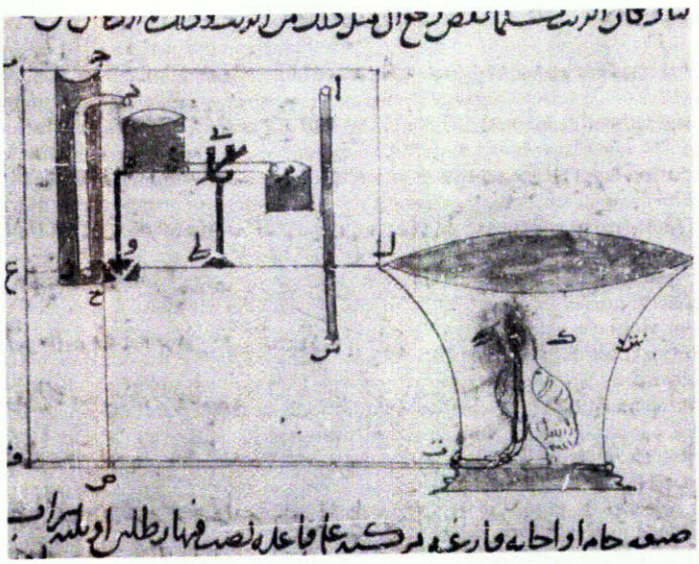


76 Topkapi

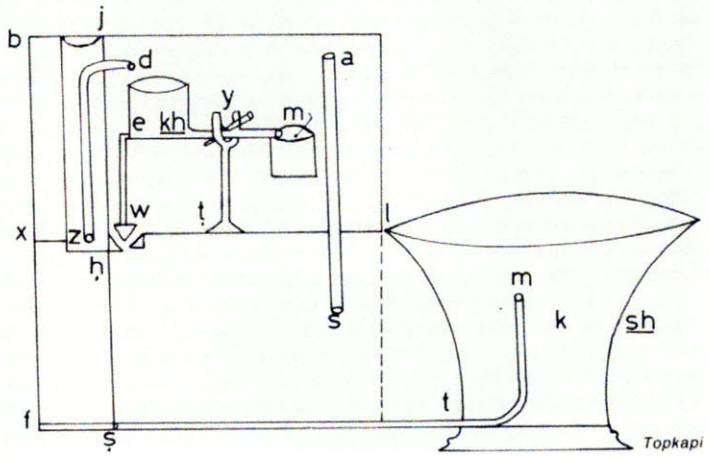


Fig. 2.8

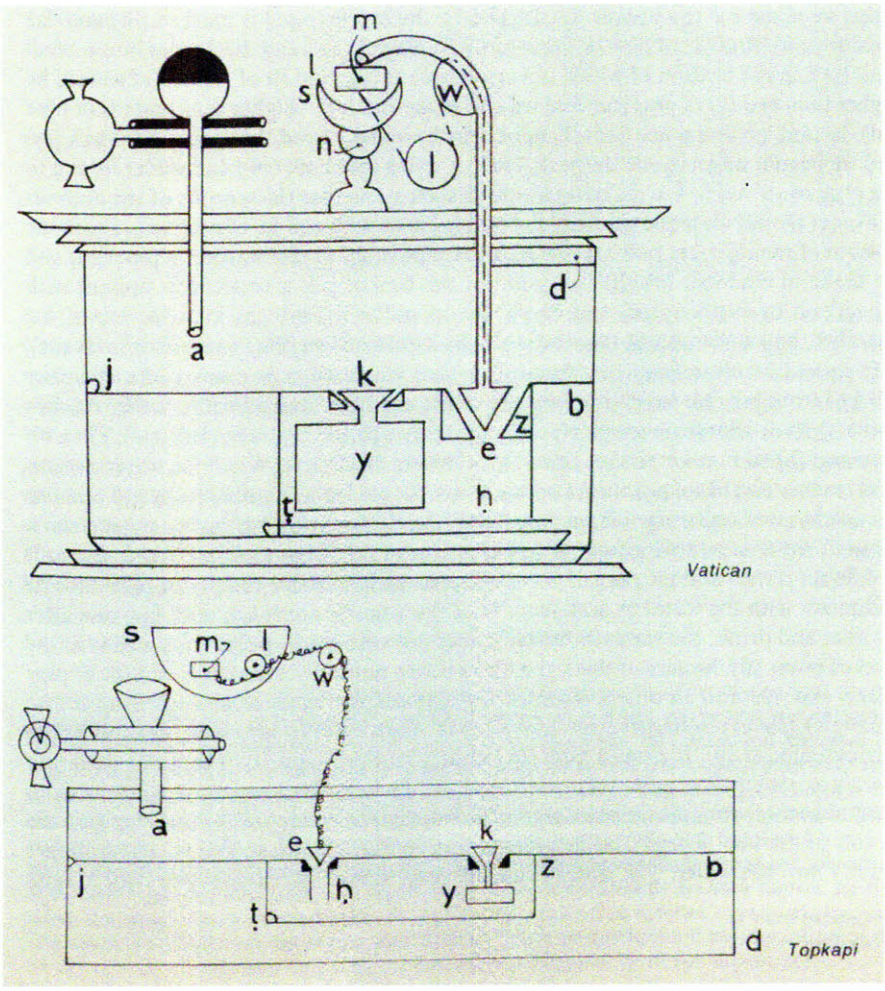
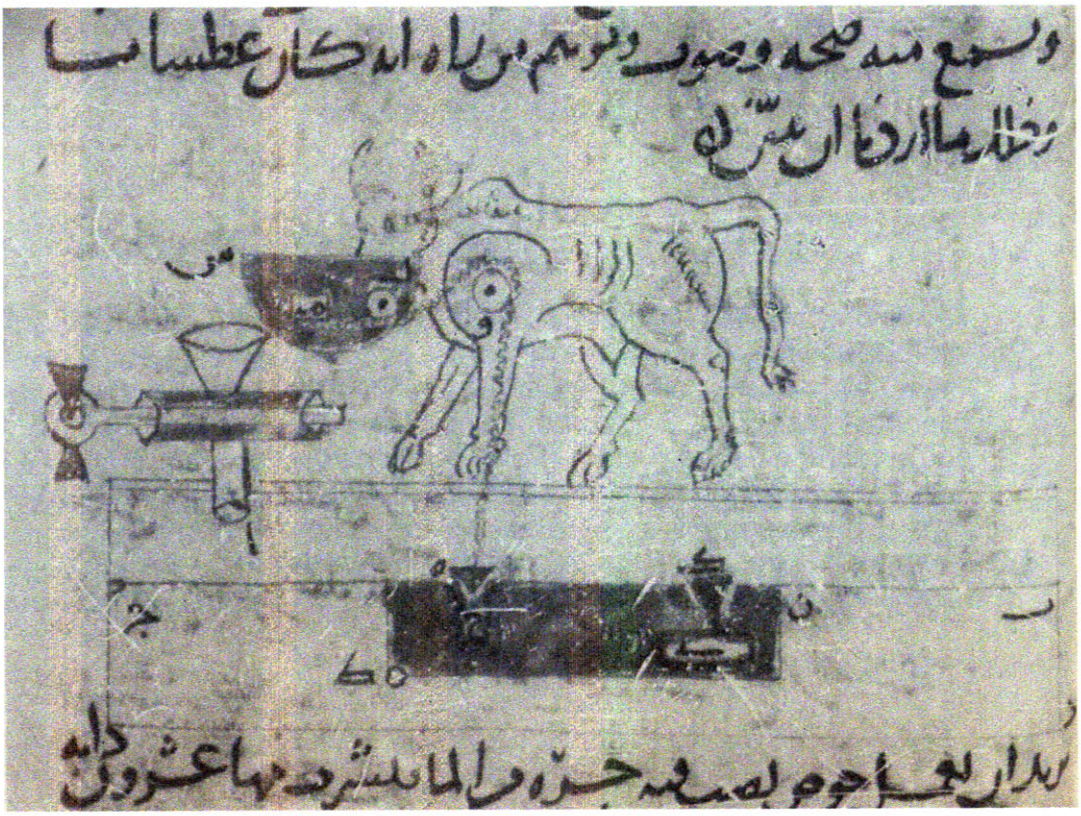


Fig. 2.9



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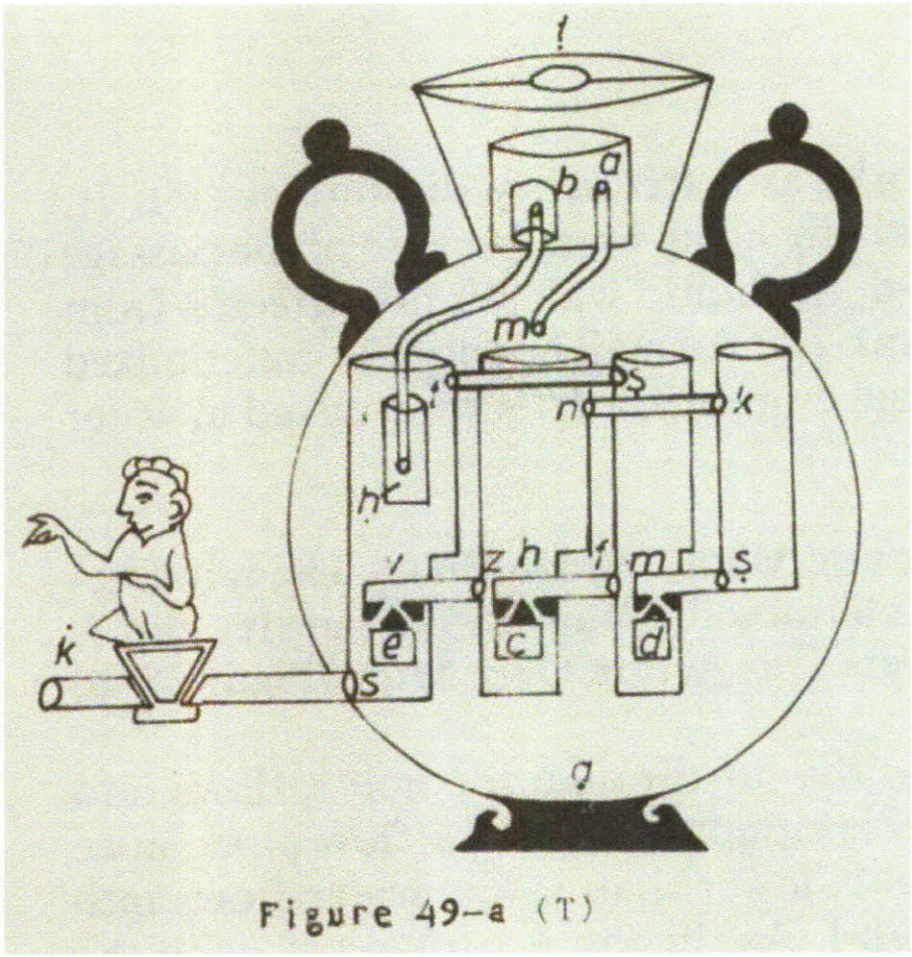

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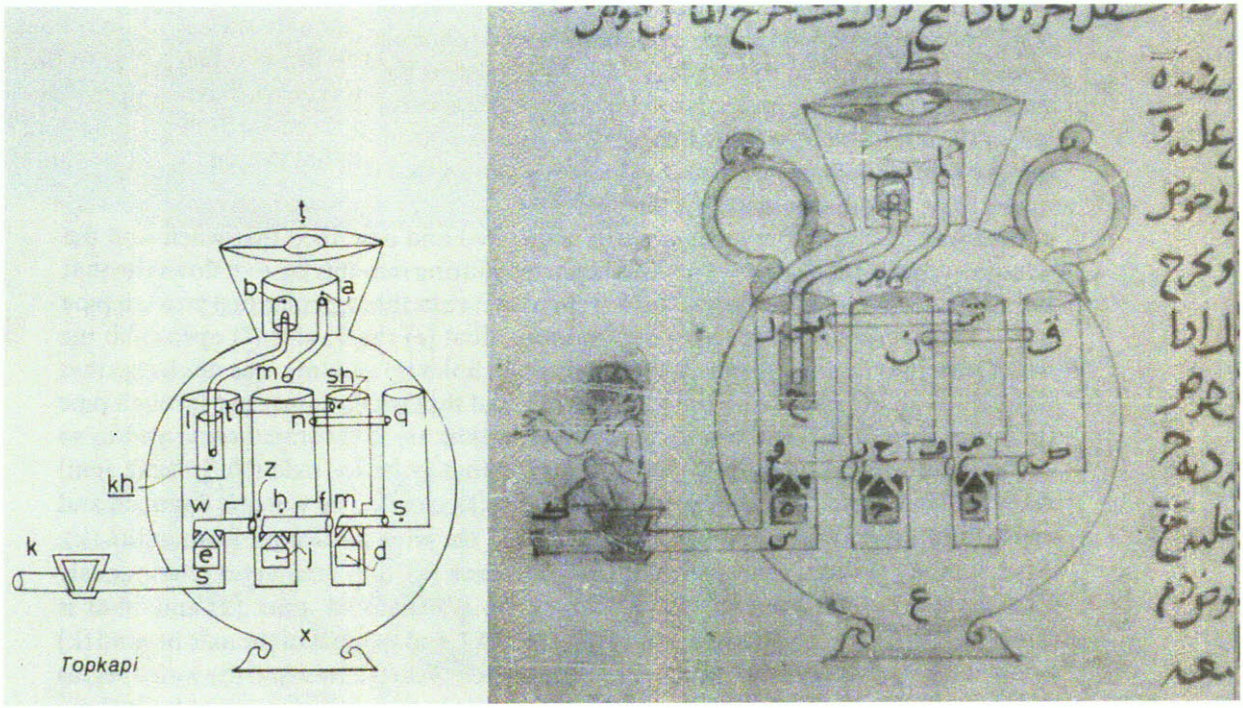

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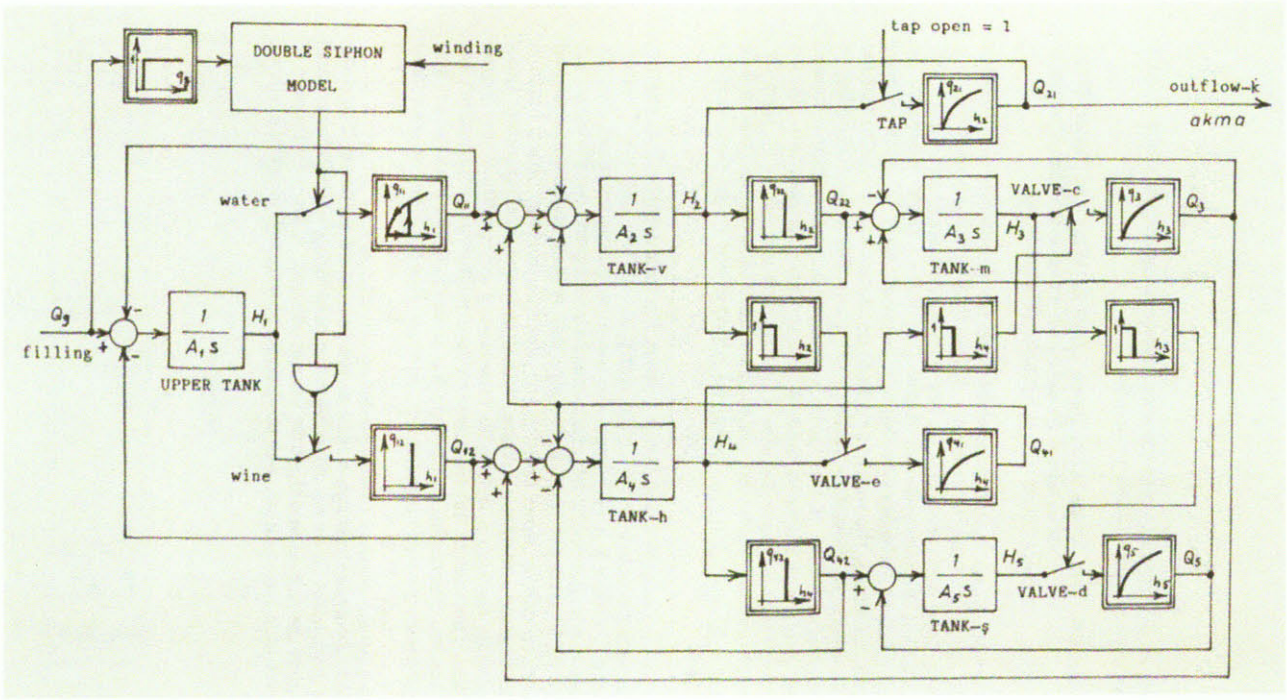

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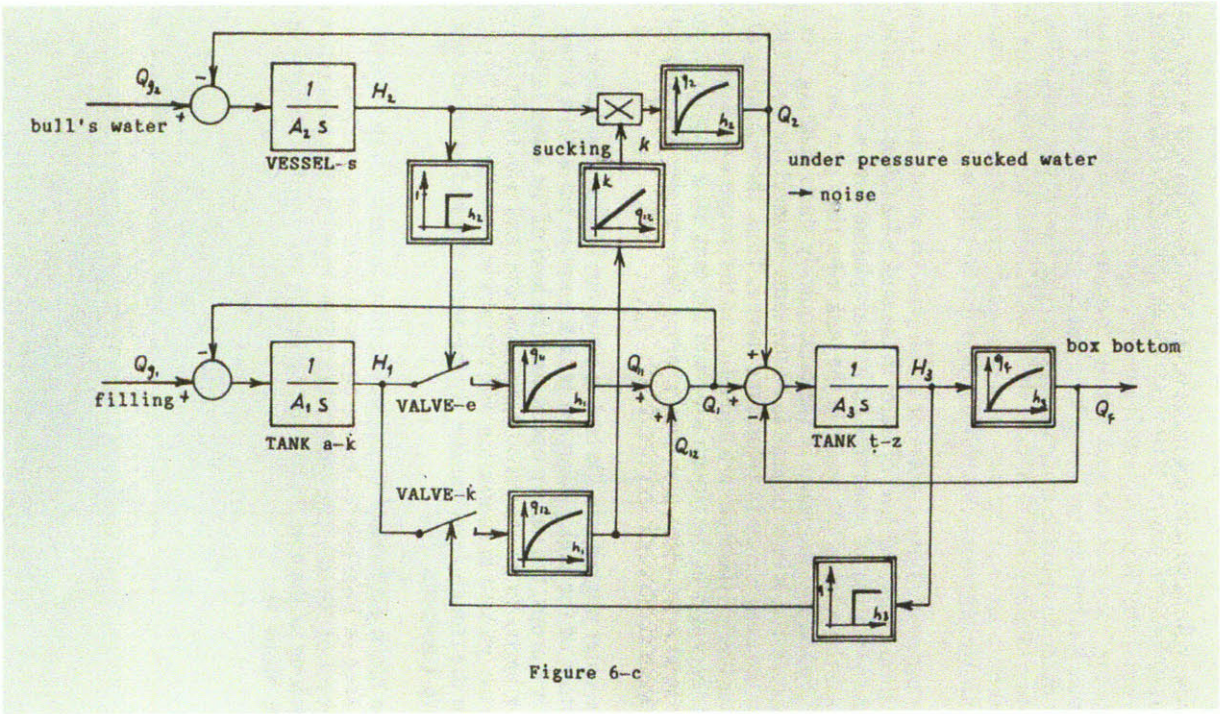

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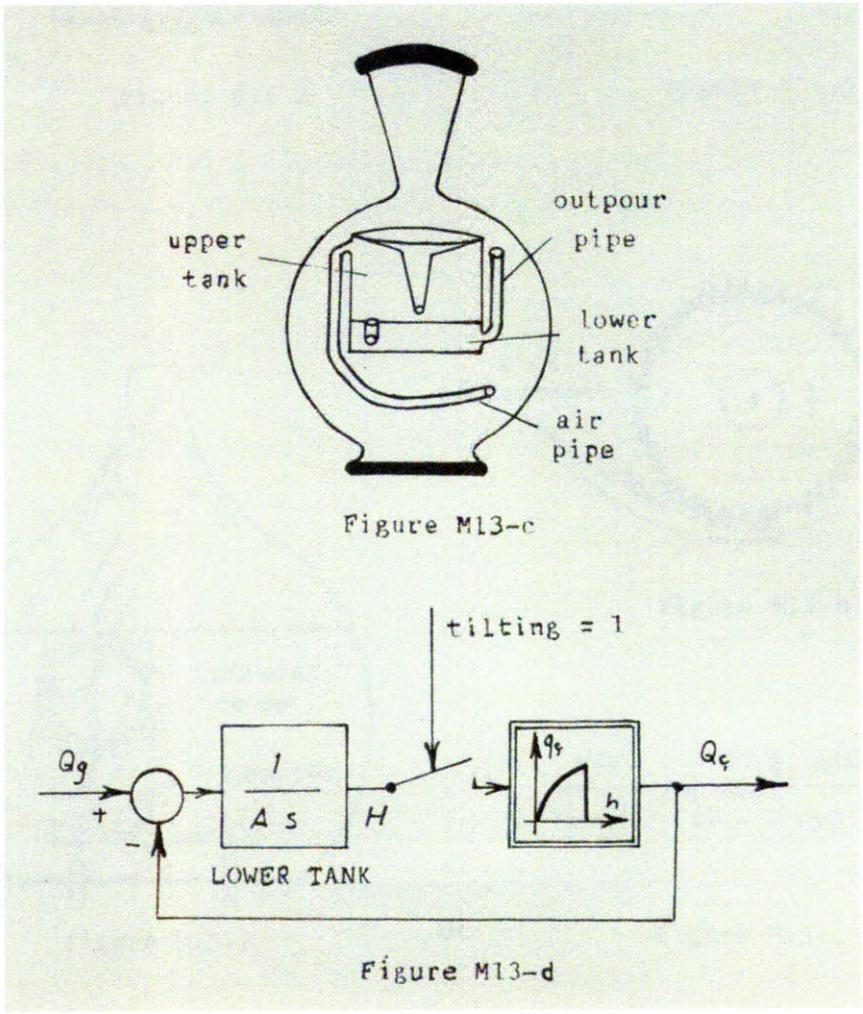
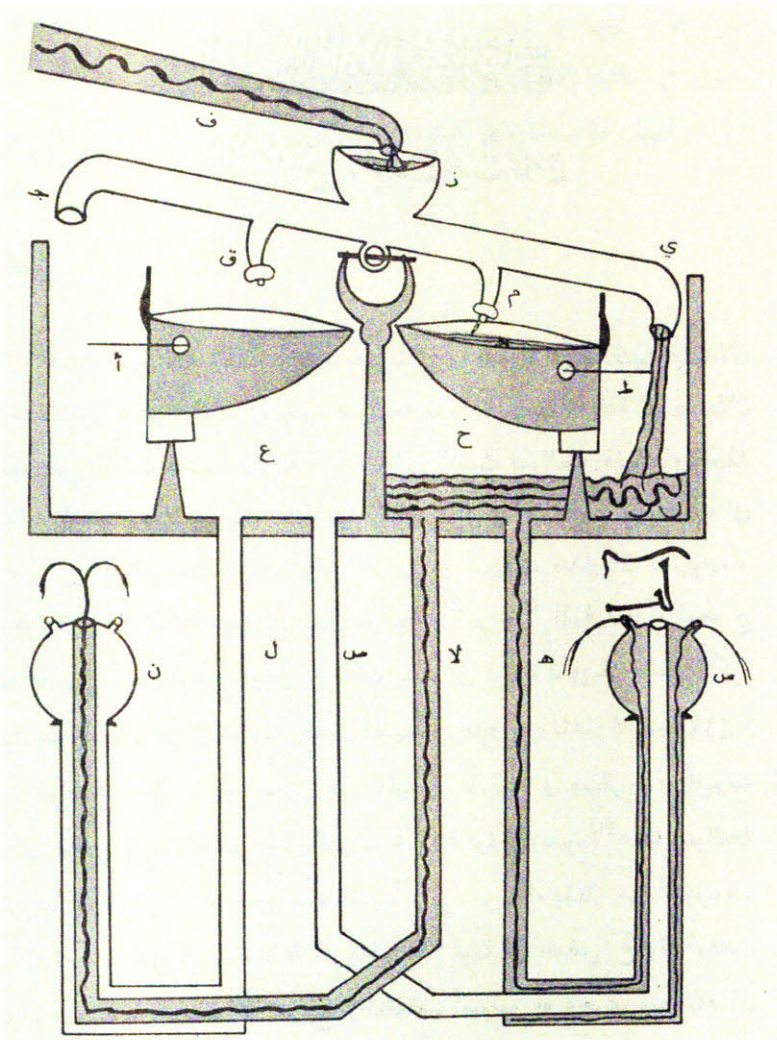


Figure M13-c

Figure M13-d

Fig. 2.15



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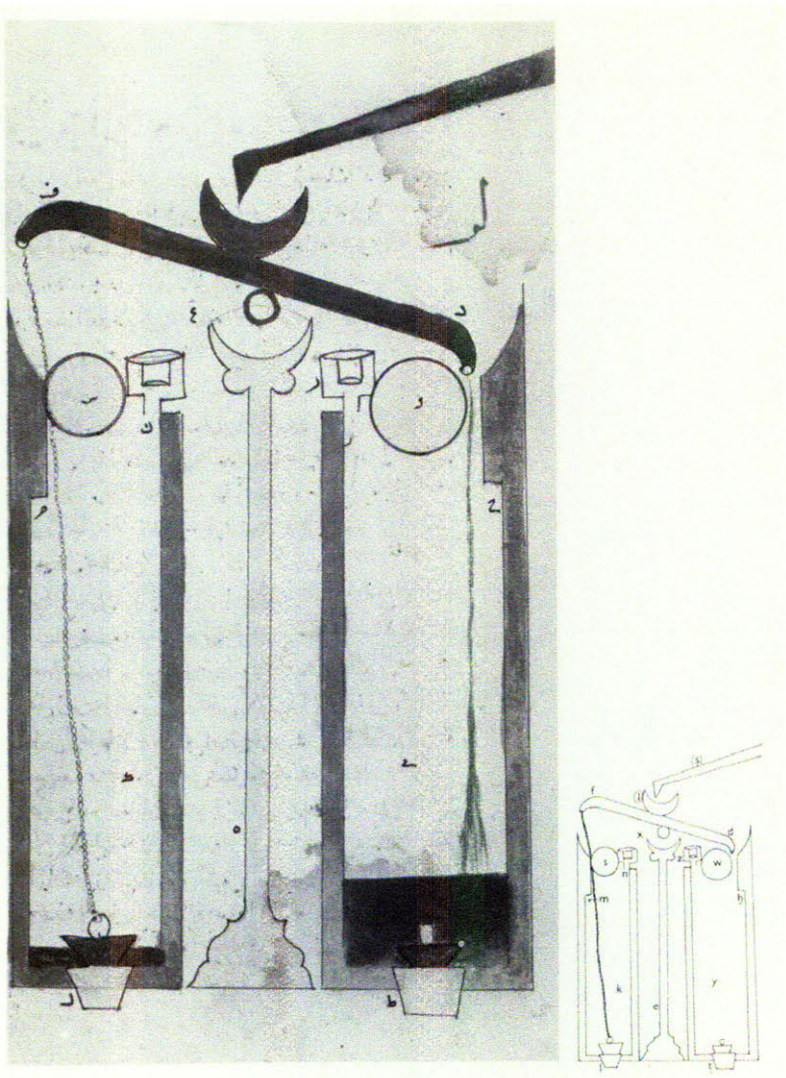

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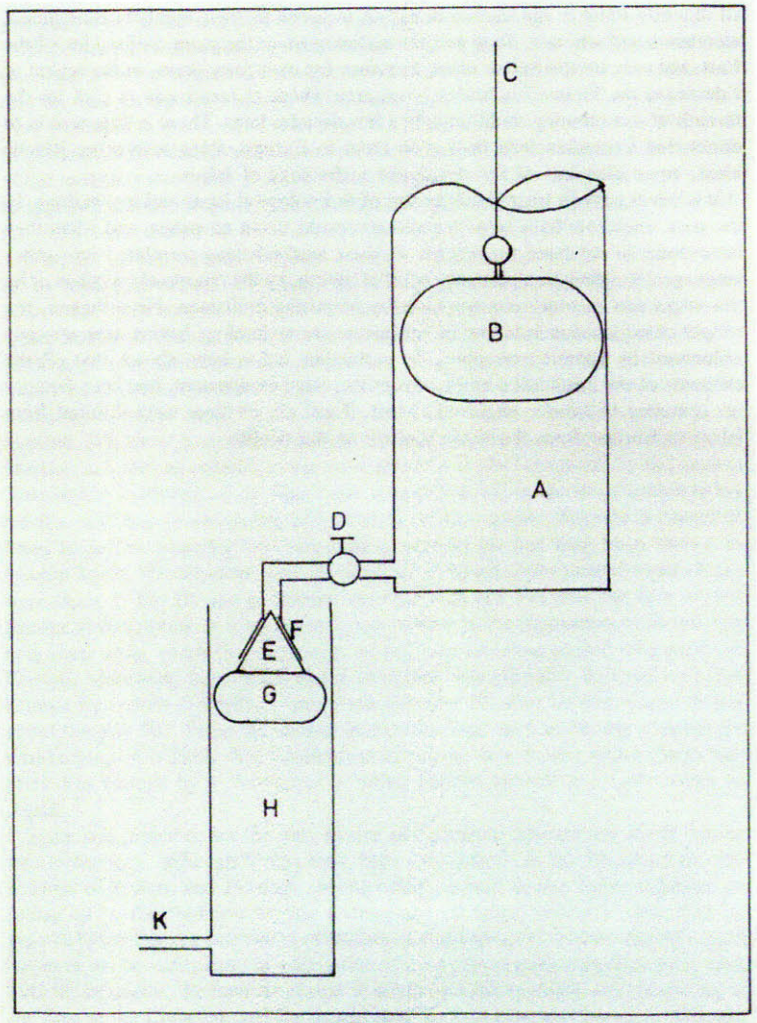

Figure 1

'Archimedes' Water-machinery as used by al-Jazarī and Ridwān

A-Reservoir; B-Main float; C-Cord to actuate mechanisms; D-tap; E-valve-plug; F-valve-seat; G-float; H-float-chamber; K-outlet pipe.

Fig. 2.18

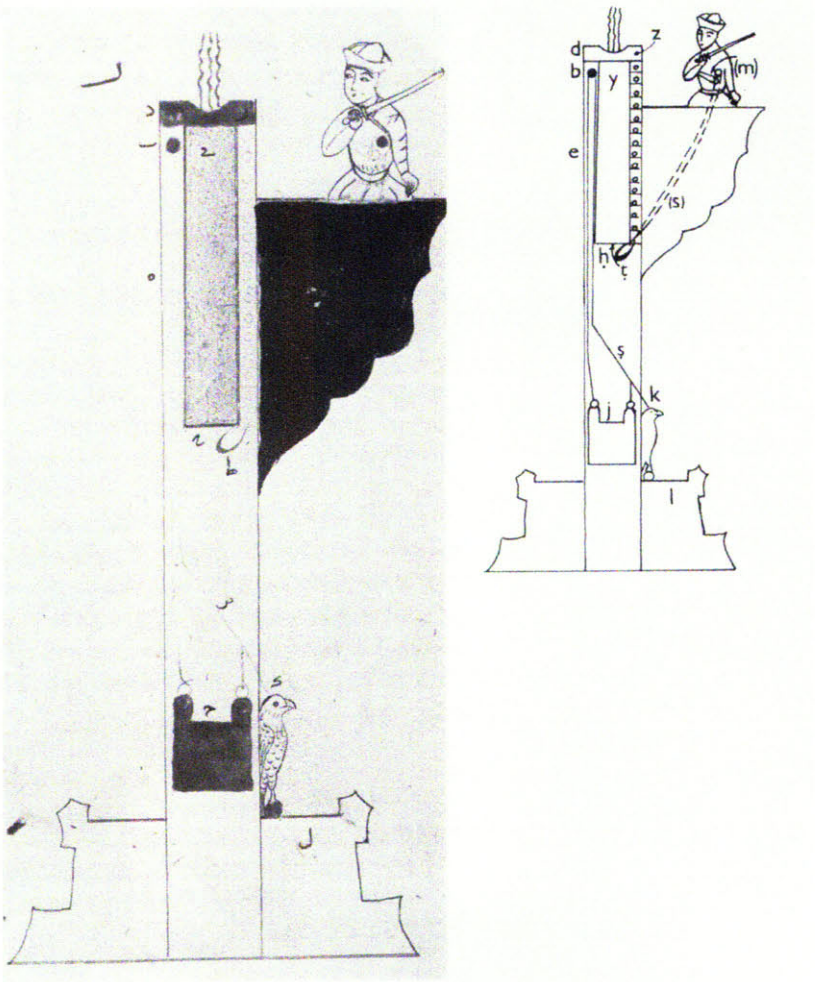

Fig. 74.

Fig. 2.19

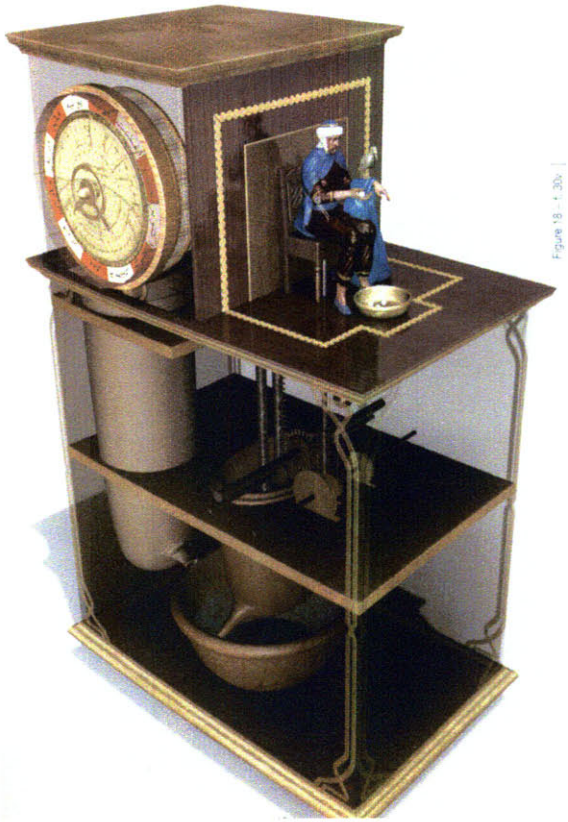

Fig. 2.20

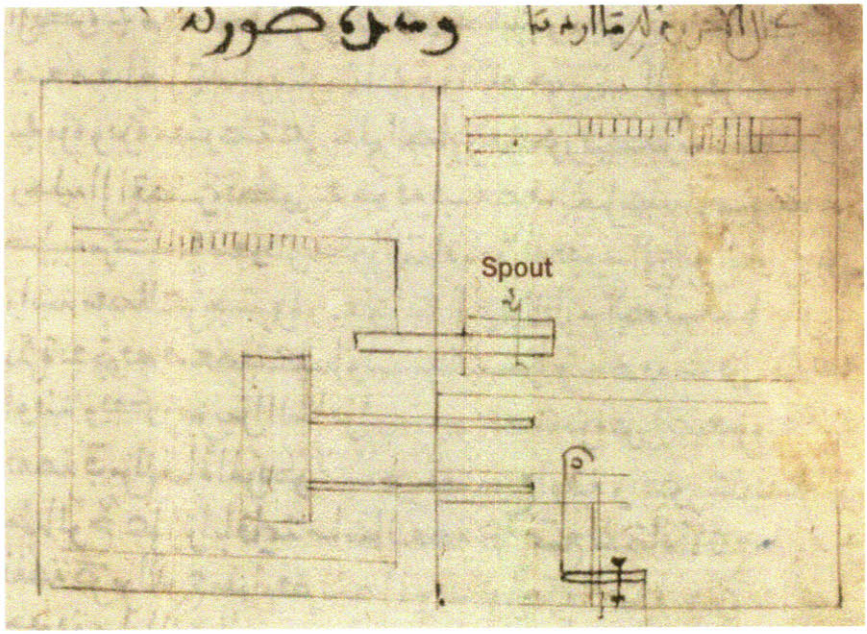

Fig. 2.21

3 | *mimesis*

real automata

It is remarkable how central to late automata scholarship the "body" of the automata or their conception as objects has become. Here I will demonstrate that an emphasis on automata as object--as opposed to knowledge and contribution of techniques promulgated in the 1970s and 80s, roughly speaking--helps condition the idea that automata are proto-robots. Every interpretation presented here relies on this line of thought to traverse the historical material of the Islamic automata manuscript. Just as functionality was a way of establishing social usefulness in Donald Hill's time, the objectification of the automata manuscript as a proto-robotic form of sculpture or technology resolves apprehensiveness about the whether the automata did exist, or were "real." In other words, scholarship and reconstruction efforts frame automata as robots in order to evade a useless fate of intangibility: there is a lack of material evidence, but a modicum of desire to see the automata. The implications of this desire, and its counterpart distrust of the reality of the automaton, form the basis of literature

presented in this chapter.

Islamic automata treatises were studied by a few men at the turn of the 20th century, and two of al-Jazari's manuscripts circulated in the art market as paintings--generating an ephemeral interest in the depictions--whereupon the manuscripts were cleaned up, translated, and reconstructed. This reconstruction did not dwell on the physical, but rather, on the functional scientific knowledge depicted inside. Automata are a fanciful subject, imbued with the theme of human imagination: scholarship on medieval European "metal people" or Vaucanson's duck, in addition to Chapuis and Droz' generalized treatments of the "automaton" has helped fuel the interpretation that Islamic automata transcend their own moment.[148]

Donald Hill, in his prolific work on the subject that made the *hiyal* scholarship an academic pursuit, might have created an interpretive apparatus outside of his purview. For the most part, however, through the study of either artistic or scientific technique, the manuscripts have been central to scholarship, and yet no one has sufficiently questioned why al-Muradi's rough-and-tumble manuscript is so visually different than either its predecessor the Banu Musa or al-Jazari,[149] for example. Without answering questions like this, the scholarship of the Islamic automata manuscript still connect it to images of contemporary and imagined forms of technology. What allows us to link 9th century trick vessels to robots? All this would suggest that we want the automata to be real; to work; and to prefigure what has come to be. Further, technology, it is believed, transcends culture and history. It ought to be the liberator. As we shall see, this is as much a historical desideratum as it is a design problem of the present.

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[148] That is to say, who would want to transcend the Enlightenment? Antiquity? Only the medieval era, or the Dark Ages, ought to be transcended, and the potentially "futuristic" appearance of the Islamic automata can achieve this.

[149] This is certainly a question that art historians could tackle.

robot silhouette

Theoretically, robots convey a sense of autonomy, or self-movement. Donald Hill, Ahmad al-Hassan, Derek Price and George Saliba all lacked the theoretical vocabulary to muse over what it meant for Islamic automata to be "automata" in the catholic sense. One possibility could have been the unique deployment of animal and human figural forms to convey mechanism, however, as I have argued, no one could probe the representational aspects of the manuscripts. It could be argued, as Price did nonetheless, that automata are one chapter in man's self reproduction.

Mark Rosheim, in *Robot Evolution*, introduces his genealogical look at the historical anatomy of robots with Greek and Islamic automata. He begins with the claim that "from the dawn of time man has been interested in recreating himself by technological means."[150] Rosheim however has limited attention to these pre-robots; he claims to focus exclusively on "well documented designs" leaving "mythological" accounts to others. Rosheim traces the "beginning of robots," to the fount of Western culture, with the Greek engineer Ctesibius (ca. 270 BC).[151] He says that this tradition failed due to a lack of practical application, which is where Islamic automata contributed.[152] Rosheim traces biomimicry throughout parts and techniques, providing drawings of arms and joinery that aspires to it; the last frontier is the successful reproduction of the human brain. The robot according to this work is a (standard) biomimetic enterprise. This is a fair portrayal of the way in which robot is understood through

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[150] Mark E. Rosheim, *Robot Evolution: The Development of Anthrobotics* (New York: Wiley, 1994) p.1

[151] Ibid.

[152] Ibid., p. 7

the works on automata outlined here.[153]

The word 'robot' is evoked today to connote often *human-like* self moving, *thinking* and cognitive machines that are able to learn, but it is known to have originated in 1920 with Karel Capek's play coining the term to denote android factory workers, connoting labor and drudgery. Whatever the origins of the word, an important distinguishing factor between the automaton--*any* automaton--and a robot is the laboring role of the robot, which helps achieve tasks in a smart manner. Yet for Rosheim, through the lens of technology, the robot as such, not work, is the premier technological problem.

> The quest for the anthrobot has captivated great minds throughout the ages. Leonardo Da Vinci, Descartes, and Tesla all were attracted to making mechanical beings, anthrobots. In each age the made use of the technology of their time, risking ridicule or even imprisonment. Perhaps still the greatest technological problem of our age, this search continues to drive scientists to create anthrobots, a mirror unto man.[154]

If the quest for "anthrobots" has been centuries in the making, then it is logical that Islamic automata must contain a seed of the "anthrobot" spirit. The manuscript in all of this becomes more of a burden than anything, for it only attests to plan, not the "practice" of robot: Rosheim does not have to argue through evidence that Greek and Islamic automata prefigure the robot, because the connection is clear. The circuit of automata manuscript is completed as technological opinion is fully integrated into the object such that the manuscript becomes a burden, and falls away. With it, the rigorous "proof" of technological prowess retreats to a previous state of unknown with the added element of whimsy, as we shall see, and comparisons can be made in silhouette--Model 6, the clamoring bull, resembles a robot.

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[153] See especially for a similar evolutionary treatment, legal historian Mario Losano's *Automi D'oriente: Ingegnosi Meccanismi Arabi Del 13 Secolo.* Losano writes, "considering the interconnection of Antique automata and those of today, it is useful to look back at the time and mull over the constructions of al-Jazari, as ingenuous as they are ingenious, and unearth in his work the roots that run deep to the current world." p. 23 It is also worth pointing out that in Italian, "robot" can be synonymous with automa, automata.

[154] Ibid.

The category of robot, as Rosheim admits, has recourse to the age old trope of mimesis: man is still representing himself, apparently, and only the complexity and distance between original and representation have grown. Rosheim says,"Man's desire to depict himself, from cave paintings to the present effort to build a mechanical replica, speaks of his desire to understand his own existence and ease his burden...The melding together of human form present in the earliest designs with modern functionality will produce the future synthesis known as anthrobots."[155] The robot, unlike the automaton, performs work on behalf of downtrodden workers. The downtrodden workers, however, fear the robot as replacement, and at any rate will probably not acquire a robot soon, so the robot for all its connection to *work*, is not capable of alleviating these woes. These above all social (perhaps political) attitudes toward robotics are kept out of Mark Rosheim's survey,[156] so the automaton's resemblance to robots falls within a "formal" or asocial, and "natural" capacity, an evolutionary framework.

Robot can refer to the specification of any machine to work on behalf of people, even if what constitutes "work" itself has been excluded from understanding a social dynamic of robots. Put differently, the robot, if mimetic, raises ethical questions, but it best points to imagination of work: it is difficult to imagine concrete labor being done by anyone other than a human because labor is a thoroughly social concept. Even if, as we have seen, mechanical processes and process in general need not be social, the ability to accomplish meaningful work is.[157] This has recourse to the same problem borne by Islamic automata, however, in which

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[155] Rosheim, p 381

[156] Indeed, are kept out of general discussion of robots, which usually has recourse to "ethical" arguments that depend on the anthropomorphism of the robot. The imagination of dozens of robots "laboring" but resembling humans evokes the image of slavery. Why robots must resemble humans?

[157] Postone, pp. 148- 171 in "Abstract Labor." Postone says that labor's "function as a socially mediating activity is externalized as an independent, abstract social sphere that exerts a form of impersonal compulsion on the people who constitute it. Labor in capitalism gives rise to a social structure that dominates it." p. 159

they must be industrious to matter historically,[158] but by imposing a formal evolutionary framework of robot upon them, Islamic automata skirt by this problem.

replication

The most readily available way understanding the "formal robotic" allusion of Islamic automata in contemporary scholarship is, predictably, through the fabricating models of the devices. Leonardo3's reconstruction of al-Muradi's *Book of Secrets* suggests that the reconstruction of Islamic automata ought to be a technological feat in its own. The desired outcome is a working object that could be put on display at a science and culture exhibition. It is not the only time models of *hiyal* devices have been crafted--but never has there been an entire fabrication of a "complete" manuscript.[159] Replicas of al-Jazari's automata were fabricated[160] under the direction of Donald Hill in conjunction with the World of Islam Festival[161] in 1976 in London. The devices from 1976 are now on display at the Museum of

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[158] In other words, "mattering to history" is another type of value. It has already been suggested that enlightenment automata are more readily "matter to history" by nature of their relationship to early industrialization from the 18th century.

[159] The sole manuscript, as has been pointed out numerous times, is far from complete.

[160] Donald Routledge Hill, *Arabic Water Clocks*(Aleppo, Syria: University of Aleppo, Institute for the History of Arabic Science, 1981).

[161] It is no coincidence that The World of Islam Festival, occasioned the first fabrication of automata. A contemporary Saudi Aramco article John Sabini writes, "It is only recently that one civilization has been capable of looking at another civilization objectively, rather than as a potential rival or convert. It is only within the last generation or two that Western scholars have developed and applied the principles and techniques of research necessary to reach a deep understanding of other peoples. And it is only in the 20th century that technology has enabled scholars in distant lands to reach each other swiftly, to find, pack and transport thousands of rare and delicate treasures and to provide recordings, films and transparencies. In sum, the Festival required an unusual unity in philosophy, psychology and technology." This "unity" was to characterize the legacy of the festival, around which a few automata were incidentally fabricated, as a uniquely essentializing force in Islamic art scholarship. John Sabini "The World of Islam: Its Festival" *Saudi Aramco World* (1976) pp. 2-4 It was as part of this project too that Seyyed Hossein Nasr's book *Islamic Science* was published.

Science in London and Natuuurmuseum Asten in the Netherlands. Donald Hill explains the process in his book *Arabic Water Clocks*, in which he writes, "Considerable care was taken to make the reconstruction of the clock a faithful copy of the original design. This meant that the limits imposed by mechanical considerations had to be reconciled with the proportions shown in the original drawings for the outside appearance of the clock[...]Some compromise between the use of modern and medieval materials and methods was inevitable[...]It would obviously have been over-meticulous (sic) to have followed medieval practices to the letter."[162] The team included two museum supervisors, Hill, and two craftsmen; Hill was pleased with the outcome. The appearance of the clock followed the drawings from the 1354 MS pages quite literally--this is probably a result of Hill's relaxed emphasis on appearance--and Hill includes some low quality photographs from the insides of the device to show their structure. (Figs 3.1, 3.2, and 3.3) Hill has little to say about the World of Islam Festival itself--the motivation for the project--but as there were numerous reconstruction projects of Islamic science instruments to go in the Museum of Science, it is not hard to imagine how well the project fit within a larger drive to promote awareness of Islamic cultural and scientific heritage.

There are also large sculptures after al-Jazari's clocks in the India Court of Dubai's Ibn Battuta Mall. (Fig 3.4) The two automata, both from al-Jazari's *Compendium* act in a large scale pop-ornamental capacity. One is al-Jazari's elephant clock, and the other, the device illustrated in the first page of his *Compendium*, a musical water clock. This device *moves*, but not in the manner described by al-Jazari. Tim Mackintosh-Smith in an report for Saudi Aramco on the state of the Ibn Battuta Mall, "Edutaining Dubai," noticed this in the elephant clock: "But as the figures on the elephant clock moved, operated not by al-Jazari's intended hydraulics but by microchips and, because of the brevity of modern attention spans, every 10 minutes rather

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[162] Hill, *Arabic Water Clocks* pp. 103-104

than every hour."[163] The dials might be fixed in place. The doors show no sign of opening at any hour, and were one to read al-Jazari's description of the original plans for the monumental clock, he might miss the sound of tin cymbals upon to which the ball drops from the birds' mouths. It is as though real movement in the sculpture would startle the onlookers, and in a pacifying measure, the device has been disarmed. The sculpture can be best described as a relief sculpture of F.R. Martin's "guard page" now housed in Boston's Museum of Fine Art, although it is not much different-looking from Hill's construction.[164] Onlookers surely enjoy the display, and it adds to the real time wonder aroused by the whimsy of the mall's "multinational" interior. The display will strike many as pastiche, but it cannot be deemed out of hand a "loss" of beauty or craftsmanship, for the archetype never was seen. What are al-Jazari's automata doing in a mall?

The immediate and most simple answer, and one not alien to discussions on development in Dubai, is commercialization--an extensive distribution of forms. In the foregoing narrative, the "evolution" of fine technology to mall decoration is not entirely surprising: at best *hiyal* are recognized as *divertissements* with the added benefit of cultural knowledge, much like Mackintosh's prohibitively awkward neologism, 'edutainment'. This tendency to produce based on perceived demand is something George Saliba noticed but also perhaps ahistorically imposed onto the medieval Islamic world. Indeed, Leonardo3 themselves are products of a "healthy" commercialization which achieves the same thing--distributing Islamic automata extensively. Similarly, the mall automata are modern-day, if dismal, marvels shaped from the material of historical technology, whatever it is--manuscript, technique, or mechanics manual.

Mackintosh-Smith was also skeptical about al-Jazari's presence in Ibn Battuta mall:

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[163] Tim Mackintosh-Smith "Edutaining Dubai" *Saudi Aramco World* (2008) pp. 14-19.

[164] It is more likely that the firm who produced these sculptures--Muslim Heritage Consulting--used Hill's reproductions as a model--not the manuscript page itself.

> "What about the 'Ingenious Devices'?" I said, as we reached India and the elephant clock. "They don't exactly have a lot to do with Ibn Battuta."
>
> "Well, after we'd planned the courts, we realized we'd ended up with these huge empty spaces, and we had to fill them with *something*" [answered Ludo]. To judge by the number of mall-goers photographing each other next to the elephant, the automata had proved an inspired choice. Moreover, Ludo told me, a recent CNN television program on Dubai had used two "iconic" shots to illustrate the city-state: Burj al-Arab, the sail-shaped and allegedly seven-star hotel in the sea; and the elephant clock. Two more eloquent public-relations images could hardly have been chosen. Dubai, they say, is futuristic, innovative, wealthy; but it is also rooted in a long tradition of Arab and Islamic ingenuity.[165]

The devices--or rather, kinetic displays--are, alas, serendipitous space fillers. Mackintosh's reading of the device-as-kitsch is reasonable (he questions whether it represents "history lite" or "instant heritage") but "commercialization" is not enough to explain why the automata look the way they do--puffed-up manuscript pages--or why the al-Jazari automata are the most popular to reconstruct. Instead, the focus on functionality as an approach, outlined above, has prevailed to such an extent that the automata has been exorcised from the manuscript, which now fulfill a three-dimensional need. Al-Jazari is the most famous water clock manufacturer, and his manuscripts also boast the clearest images (though no one knows quite what to make of them), and is the most liberal with construction details. Ironically, the display carefully follows a depiction of the automaton from a 1354 manuscript, and the result is caricatured, probably predictably and not too far off what Hill produced, with the exception that this functions of a logic entirely imposed from without, just so that it works. This distinction demonstrates only a slight change in history, however: in both instances the approach to the total device is largely sculptural. If al-Jazari's instruction were carefully followed, the outcome probably would not look like the illustration much at all.

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[165] Mackintosh-Smith, p .17

representation

Walter Benjamin used Johann Wolfgang Ritter von Kempelen de Pázmánd's (1734-1804) famous, unbeatable--and fake--chess-playing automaton in his essay "On the Concept of History" from 1940 to show that history is made to win. The unbeaten chess-playing automaton had a hunchbacked dwarf inside him, as Benjamin described him, who pulled strings in the apparatus.[166] Benjamin likens the puppet to historical materialism and the small man inside to theology: the man inside accounts for the movement but, once revealed, ruins the trick. The disunion between *telos* and *techne* in the Mechanical Turk when analogized to Benjamin's philosophical device does not make history a liar; instead it shows that history appears as the history of victories. Historical materialism recognizes the political character of history--that the ends and the means are in cahoots. The failure to "mime" the inner workings is not really a moral short falling on the part of the total device, but instead simply reconstitutes the device, history, in a meaningful, successful image. This fake automaton was quite appropriate for this metaphor, since the figural character of automata can never *really* be imbued with real life, unless the automaton ceases to be real!

In that essay, Benjamin reminds the reader of "cultural treasures," built upon the shoulders of those excluded from history. The "shell" of the automaton actually points to the unseen "moving" history, but only as a reminder, not a corrective as the historicists would have it. The difference between the "how" and the "that" in an Islamic automaton, from the standpoint of history, ought not have the moral indignation of infidelity. From the standpoint of technological "accuracy," however, it is probably deemed a "mistake." Historicism

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[166] Walter Benjamin, *Selected Writings*, ed. Marcus Paul Bullock et al. (Cambridge, Mass: Belknap Press, 1996) p. 391 "There was once, we know, an automaton constructed in such a way that it could respond to every move by a chess player with a countermove that would ensure the winning of the game. A puppet wearing Turkish attire and with a hookah in its mouth sat before a chessboard placed on a large table [...] Actually, a hunchbacked dwarf--a master at chess--sat inside and guided the puppet's hand by means of strings. One can imagine a philosophic counterpart to this apparatus. The puppet, called 'historical materialism', is to win all the time. It can easily be a match for anyone if it enlists the services of theology, which, today, as we know, is small and ugly and has to keep out of sight."

identifies *how* the movements go, and rejects the shell's movement as out of step with that which is responsible for creating meaning (in this case, movement), but a good historical materialist finds the puppet to be truth that is honestly covering its motive force.[167]

The Mechanical Turk was truly a fake automaton: there was a person inside (not to mention an allusion to the mysterious character of an Oriental with a propensity for chess, though a far cry from Martin's Mulai Hafid automaton despot). An automaton in material form always has a disjuncture between outward success and interior motives. The difference between functioning devices and "kinetic display" changes what the material of the manuscript conveys for the reconstructor. If robotics engineers desire to recreate the human brain, for example, it is clear that they will need to have a good idea of how it works, not just *that* it works. Donald Hill approaches the material somewhat in this fashion. But if an idea of work is desired, then the movements do not matter, as with the commercialized kitsch of Ibn Battuta Mall, and the manuscript acts as an image of the desired outcome. An automaton can be a contradiction between plan and object if what occurs resembles Vaucanson's duck, which was supposed to process food as a digestive system would, excreting a compressed pellet, but in fact contained a compartment to store the pellet, and so the meaning of the piece itself was put in jeopardy, although still an effective thought model--what if machines processed matter as humans did?[168]

Although it is not the 1770 chess-playing Turk, and it does not reveal (through disguising) the truths of the subjugated masses in history, Leonardo3's reproduction does reveal its dichotomy of interior/exterior in its quest to be a proto-robot, or at least a working

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[167] This is of course not to suggest that a parodied version of an Islamic automaton makes it a monument to historical materialism, however it does suggest that the parody might present itself as no one else wants to present it.

[168] Riskin, p. 600. Today the processing of food as a duck would in fact probably be more for enjoyment than to spark the imaginations of inventors, namely because the process could be made much more "efficient" if it didn't require all the organs!

machine. In this capacity it productively engages the question of how the material of the manuscript gets treated. As we have seen, there has been little accomplished in the way of this manuscript, which exists in a poor state. Looking at this project is an admitted challenge, for it is difficult to read the original drawings, and the limited amount written about it has been presented here. Leonardo3's Massimiliano Lisa has suggested that it was the manuscript's relative obscurity amongst scholars and the public that inspired the firm to choose this particular manuscript to reproduce for the occasion.[169] Al-Muradi is not missing from survey works on automata; but he always surfaces as an elusive character, and he has become perhaps more so with Leonardo3's treatment.

Donald Hill remarked how frustrating it was to translate the Banu Musa's *Book of Ingenious Devices* using just two copies:[170] the al-Muradi manuscript is severely damaged on the diagonal of each page, and there is only one copy. In one his surveys, Hill even writes, "Unfortunately, the only known manuscript copy is so badly defaced that it is impossible to deduce from it precisely how any of the machines were constructed [...] Al-Muradi's treatise is clearly a document of great significance, and it is to be hoped that a better copy comes to light some day."[171] Leonardo3's Mario Taddei also acknowledged the difficulty, revealing somewhat of a method: "The original source, the text of the manuscript, which was our point of departure, presents various problems[...]This required the patient interpretation of the missing parts, according to specific logical and interpretative rules, which definitely cannot avoid errors altogether. It is also worth remembering that the treatise itself is probably a copy

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[169] Massimiliano Lisa, in conversation, July 2009. Leonardo3 The Biblioteca Medicea Laurenziana's signature log of consultants to the manuscript has a healthy but limited number of signatures.

[170] *Ingenious Devices*, p. 14 He must have not originally had access to Topkapi, but at a later date he did get access, for his published translation uses Topkapi.

[171] Donald Routledge Hill, *A History of Engineering in Classical and Medieval Times* (London: Croom Helm, 1984) p. 203

of an earlier manuscript."[172] The poor quality of the manuscript, however, can in fact be seen as salutary to Leonardo3's project, which offers a totalizing interpretation and fabrication of devices.

A single device suffices to reveal this fortuitous setback to reconstruction. Comparing what is written in the book with what Leonardo3 interpreted demonstrates the disquiet in representation and function. In the first model that al-Muradi describes, the drawing features a long horizontal axis held at a diagonal, three quarters along which there is an octagon. Inside the octagon is a flowerlike shape with eight symmetrical petals and a central circle of the same circumference as each petal. There is a short perpendicular axis crossing at the center of the flower. Along the longer axis "dew drops" (elevational representations of suspended pans that hold liquid) and circles (pans or pulleys) are suspended from lines. The page is substantially damaged and a portion of the short axis is missing. The lines are shaky and they vary in width and in quality. The drawing is marked with letters which are referenced in the text accompanying it. The *shakl* or 'figure'[173] is entitled, "A love fairy tale and the evil snakes." (Fig 3.5)

The text has this to say about the device.

> We want to make an octagon and inside it a shape of an octagonal star with a tube in the middle. Opposite one line of the octagon, there will be a box with a door facing the tube. Inside the box, there shall be a maiden. And inside four of the eight branches of the octagonal star, there shall be four gazelles standing, and inside another three of the branches, there will be three snakes hiding. Above the tube, there will be a black man standing. And through this tube, water will ascend to the octagonal star.
>
> So let the octagon be AB [...] the star be CD. The tube, inside the star is [...] FA, the gazelles GG and the snakes [HH]. [Opposite the snakes, there will be] three tubes I, J, and X.[174]

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[172] Taddei, p. 17

[173] *Shakl* can mean shape, figure, or model.

[174] Taddei, p. 33

The text addresses the description of the drawing more than it addresses how one goes about fabricating the tubes. Al-Jazari and the Banu Musa,[175] by way of contrast, are undeviatingly concerned to explain how things are fabricated as well as what the device itself can achieve, a narrative of the events, so to speak. That no such narrative exists in al-Muradi, combined with the fact that the text is highly abstract and incomplete translates to ample room for interpretation.

Should one take a further look at the text and the drawings, the position of the snakes and gazelles as Leonardo3 executed the device is too neatly resolved. (Fig 3.6) The text tells us that inside four "branches" of the octagon there are four gazelles, and in three of the branches, there are three snakes. But it does not clarify their location, merely the magnitude of octagonal sections that contain animals. In the translation and transcription, it is conjectured that "opposite the snakes" are three tubes, I, J, X. If this speculation is true, from the drawing, it is unlikely that the snakes are in alternating "branches" of the octagon, as Leonardo3 has placed them but are more central in the octagon. If we however diligently discard this piece of evidence for want of a better manuscript,[176] the gazelles, GG, are described as "parallel to pulley P," which is impossible if the gazelles sit at alternating branches as Leonardo3 has depicted them. The necks of the gazelles, reads the text, are made of leather, and a rope passes through them so that depending on its slackness or tautness the gazelles can relax or elevate their heads, respectively, which happens as the leather is stretched. The automaton's movements are caused by the suspension of pans of mercury. When they are elevated, the rope

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[175] An example of the Banu Musa's "discursive" quality from Model 11, a trick vessel that rejects pouring: "Manufacture a pitcher similar to the pitcher [i.e. Modle 3] which operated the first time by air, and if pouring into it was stopped it did not accept anything [more]. We wish to modify it so that if pouring is resumed it accepts water again, but if repeated a third time it accepts nothing. The proof of that is that we fit the pitcher a cover plate on its top, as we did previously; and a piece in the plate either one hole or a number and bring out from the place pierced a pipe. To its end marked (b) tank (jd), measuring two fingerlengths square by one fingerlength in height, is soldered." *Ingenious Devices*, p. 62

[176] The drawing as it is is extremely difficult to make out as it combines elevation and plan symbology.

goes taut and opens a door whereupon the maiden can come out, the man dives into water as the snakes come out and the maiden retreats to indoors. Anyway, gazelles would probably graze together.

There is nothing in the text or drawing that overtly suggests that the snakes and gazelles are on alternating petals (nothing that represents this), so the interpreter must look to the way that the device works to understand. However, if the animals are not alternating, this would by the same token alter the *functioning* of the device, where the rope would not have to swing around the entire octagon to make all four gazelles' heads relax. The original drawings seems to suggest this, (compare Figs 3.5 and 3.6) whereas the renderings are difficult to read due to light noise, and many of the key letters mentioned in the text are not transposed onto the drawing. The first drawing and text are so obscured by the quality of the manuscript page that it could be prohibitive to reconstruction efforts, as it has been suggested in numerous instances.[177] Leonardo3 probably positions the animals in a more decorative way, rather than as described, so that the device could be resolved.

If al-Muradi's devices in general are "rugged," as Donald Hill suggests, probably so too are the animal figures.[178] Leonardo3's models suggest the smooth uninterrupted movement to which technological apparatuses today tend to aspire--perhaps production of the smoothness of organic motion--mimesis was not only a pre-modern impulse. According to Leonardo3's reconstruction, the devices are delicate, shiny, and have small parts--a lesser version of a mechanical clock. Others are rendered with wood grain boxes that contain wheels. (Fig 3.7) The problems raised by the reconstruction are more representational, however, than functional, but the question is, what determines the difference? In the renderings, the animal

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[177] This is not the case with all of the images and I do not wish to suggest that all of the devices are specious, or are a simple obstruction of truth; I wish instead to emphasize that the limitations posed by the quality of the manuscript are real, and so, this being true, what are we to make of Leonardo3's work? How did they create the devices? Is there a way of working *with* the limitations?

[178] Hill, "Al-Jayyani" *Studies in Medieval Islamic Technology*

figures' proportions to the octagon; the size of the human figures; the fact that the "star" of the octagon in the drawing is understood as a graphical element and conveyed through laminates in the floor (See Fig 3.6), could all be questioned from a purely representational point of view or that concerned with the "subtext" of the reconstruction. But in the case of the position of snakes, or the leather of the gazelles' necks, the material qualities of the automata determine in what manner and by what rules the device acts. Leonardo3's downplaying of the formal confines of the manuscripts--in the first sense, the lack of text--results in an abstraction both in appearance *and* in function. Whereas the need to know the "form of the functioning" was critical to Donald Hill, in reproduction, Leonardo3 have no need to qualify the fashion in which they worked, so long as the devices do indeed do something.

Leonardo3 do not rewire the brain, so to speak, but instead they create a simple algorithm to resolve the locations of certain identifiable parts. However, what really orders this device is a geometric, symmetrical system that is similar to the representational apologetics of the World of Islam Festival,[179] which witnessed the first modern, "marketable" reconstruction of automata. It is unlikely that animals would be treated as medallions in automata, at least judging from all the images and the narrative descriptions of their roles. The subtext of this exposition emphasized "unity" through abstraction, which constructed the arabesque and abstract geometric pattern as paradigmatic of Islamic visual "consciousness."[180] Arabesque patterns and geometric spatial ordering are visible in Leonardo3's reconstruction, and so the professional engineering exploits of the Middle Ages are reframed in the "unifying" vernacular. The added dimension present in Leonardo3's work is that functionality itself is afforded an abstract, timeless character: the devices must work, even if they do not mirror the

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[179] This has been well pointed out by Gülru Necipoglu in *Topkapi Scroll*

[180] A very enjoyable example of this is Keith Critchlow's book, to which Seyyed Hossein Nasr wrote the foreword. Keith Critchlow, *Islamic Patterns : An Analytical and Cosmological Approach* (London: Thames and Hudson, 1976) Critchlow applies a "Sufi" interpretation of the construction of certain motifs in what are understood to be patently Islamic patterns.

internal workings that were described in the manuscript.[181] Leonardo3 are not interested in the historical character of Islamic automata manuscripts as much as they are interested balancing it with the whole of technological history, the developments of which are all set on par with one another, and differ in value, but not in kind. What really binds them together is nothing more than the fact that they are technological. What separates Leonardo3's reconstruction from the Mechanical Turk is that the Turk could beat any opponent as a concerted effort (in the thought model, its goal was "political"), whereas the exterior of the love story devices is purely *ornamental*, and this points to the fact that perhaps the interior is too.

> Once upon a time, there was a boy who loved a girl and used to come out of the well in her house. Once, he came out of the well in her house and called her name. Four gazelles came to keep him company and they went and drank from the stream. The girl opened the doors and came out to see him. All of a sudden, three venomous snakes appeared. They were released by his rival in love. They moved towards him, scaring the gazelles away. The girl went back in fright, and shut herself in the house behind the doors.[182]

Leonardo3's "interpretation" is a recapitulation of a story that legitimizes the device. Although it touches on the novel use of mercury balances, and, while it puts the movements of the device in some kind of perspective, it defers to a "timeless" story to make sense of certain tropes employed in the device. It is not clear who is supposed to read the text and interpretation Leonardo3 makes available, but the devices themselves are accessible to

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[181]This problematic is parallel to one presented by 18th century automata historiography. Even though an automaton appears to mechanically mimic organic processes such as digestion, there usually wasn't a one-to-one ratio of form to function: Vaucanson's duck did not actually process the food into the excretive pellet, but replaced the food with a pellet. George Canguilheim similarly took pains to argue that thinkers have misread history, and that since Descartes rather than rational mechanical sciences conforming to organic form, organic process has been "constructed" in counter-identification to mechanical reasoning. A lightened strain of this thought can be found in Derek de Solla Price but it is understood by him as endemic to technology itself. The question that arises from this discourse, and helps us understand how the cultural context of Islamic automata has been mediated, is how important the form of the mechanical processes is to the functioning of the water clock and automata--that is, is representation mimetic in an automaton?

[182] Taddei, p. 36

everyone. The devices are perhaps useless in the darkest sense of the term, for they wish that no one look at them too closely. It is possible that, barring another manuscript that can build on complexity of material available, scholars cannot understand what al-Muradi was saying, but now they do not need to, for *The Book of Secrets* has more or less been revealed. The poor state of manuscript helped Leonardo3 complete the devices with the utmost of interpretive freedom, and they are not concerned to make any historical argument about the nature of the manuscript.

Leonardo3 effectively transformed the manuscripts' devices into machines whose function it is to attest to their own functionality, but they also "re-enchant" the viewers with the sense that the devices in the manuscript are themselves mysterious and wonderful:[183] "The title itself says it: this is a book full of secrets. It is certain whoever leafs through the manuscript will be amazed when seeing the designs that look like mysterious machines resembling robotic devices [...] [T]here remain a lot of secrets, hidden behind a language that is difficult to understand, especially by the public at large. However, it was possible to interpret the devices. The machines...become more comprehensible thanks to tridimensional designs."[184] Here, the reconstruction of this manuscript conceived in the 11th century and copied in 13th, is really only possible today, and belies understanding by an ominous "public at large." Only by the power of privately owned technology today can we decipher what was meant in this mysterious time. Although the representations are extremely compromised, highly detailed models could be crafted. Seeing robots comes from wanting to--a utopian glance toward the future in things of the past--and needing to: the best thing to compare the

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[183] Bynum used this word in her address to assure readers that as a medievalist, her intention to explicate the medieval sense of wonder was not aimed toward inducing the listener into a new state of mystification. It is a tenuous topic but interesting for these purposes, as Bynum is sensitive to the issue of presentism in medieval studies. It should not be too extraneous to suggest here that this problem of relevance of medieval Europe is quite similar to the teleological problems posed by Islamic automata manuscripts.

[184] Taddei, p. 12

figural mechanical devices or sculptures to is a robot.

wonderful sculptures

T.M.P. Duggan considers automata to be moving sculptures, whose formal allusion to robots is clear, and which he also maintains by referring to the sculptures as "palace robots." His essay reads like a moving mechanical scene itself: In it, he argues that Islamic automata represent a brilliant figural sculptural tradition of bronze, bejeweled monuments to power endemic to the Ancient Greek, Byzantine, and Islamic World. Duggan implicitly proposes rubric for understanding the "middle ground" between art and science that is embodied in the Islamic automaton and gets its wondrous quality in part from the tales of Solomon in Islamic mythos.[185] Duggan, in a venture to transcend the teleological pitfalls of technology, establishes the parity of Islamic automata with the medium of sculpture by means other than scientific knowledge.

Duggan's thoughts on the scientific manuscript, like every other source here, however, still color his ability to navigate the material of particularly the automata manuscript, which he calls 'illuminations.'[186] His notion of automaton is any (self-) moving (figural) sculpture, and so, in contrast to Price, he finds early examples of automata in rolling statues described by Homer and earlier forms of painted moving sculpture, rather than progenitors of mechanistic

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[185] This is also a common theme in Valérie Gonzalez, *Beauty and Islam : Aesthetics in Islamic Art and Architecture* (London: I.B. Tauris, 2001). Valerie Gonzalez' phenomenological interpretation of Islamic art and her deference to geometric patterns as characteristic of Islamic aesthetic vocabulary however is another missed opportunity for a politically and ideologically cognizant history of forms of Islamic symbolic representation.

[186] Ibid., p. 229 This is misleading nomenclature, as the text of the *hiyal* manuscript references the drawings, and so even if the manuscripts described automata that the authors had seen, it is incontrovertible that they were concerned with the fabrication of these devices, and not chronicling the contexts in which they had seen them.

philosophy.[187] Mum as to whether or not it makes a difference that in the Islamic context there was a lacuna of *unmoving* sculpture, Duggan, having firmly established that automata were a genre of sculpture thus is able to compare this form of complex moving sculpture, to that of Europe at the time.

At the time of Islamic automata were frightening diplomats during their visits to Islamic palaces, "Western Europeans were carving somewhat crude figural sculptures, largely in wood, stucco, and stone that were then painted."[188] Duggan compares water clocks to sculpture. But to put mechanistic devices on par with wood figures assumes some parity--it cannot rest in the material, nor the mediation. It must lie in the mimetic capacity for exactitude in the level of expression of sculpture itself. The technical complexity of the automata are compared not to European technology at the time, but to European sculpture. Although Duggan admits no desire to contribute to or comment on the engineering literature that he criticizes for missing the point, framing Islamic automata as ingenious technological sculpture is an optimal way to "smuggle in" a technological critique without recourse to formulae and explications of how they moved.[189]

Duggan attempts to reunite the representational aspect of automata with their functional transmissive dimension. He is right to emphasize that automata were figural sculptures, sometimes monumental--perhaps gifts?--and at any rate, concrete, *in situ* art pieces, which, he emphasizes, accordingly evinced a peculiar reaction, wonder or in Arabic, *'ajib*. He writes, "the very success of these automata, which were primarily expressions of the

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[187] See p. 233 Price's "pre-automata" include masks with articulate joints, but he probably would not consider Homer's rolling statue by sheer force of its movement, as one. *Was* the Trojan Horse an automaton? See Sylvia Berryman's "Ancient Automata and Mechanical Expression" *Phronesis* 48 no. 4 (2003) pp. 344-369 for a retort to the assertion that Homer's Illiadic reference constitutes an automaton. In fact Berryman is skeptical of this along the lines of how indicative of a "mechanistic" consciousness this is. Thus, for Berryman, "automaton" is a category of machine/organism, and for Duggan, it is a simple formal category.

[188] Duggan, p. 230

[189] Ibid.

ruler's power, in causing *amazement, wonder, astonishment and fear*, in part relied upon the element of surprise, and [so] they are only rarely mentioned by chroniclers."[190] By suggesting that the automata were firstly expression of power, and secondly known to induce *'ajib* or shock (according to some disparate accounts that Duggan collects mostly from monographs), Duggan's work links the concept of wonder to the production of the automata but he does not give details as to what this would entail. Did the devices "embody" *'ajib*, or were they understood to do so? As far as history has provided us, and according to Duggan, this artful sculpture was produced, (presumably in the workshops), to help the "powerful" impress their foreign peers. Duggan has evidence to believe that the automata existed and that their impact was nearly sublime, but he says nothing on how they got produced.

Duggan does not broach the topic of workshops that would produce these sculptures, but he deploys his evidence to the end of proving that Islamic sculpture was superior and more evocative than that of Europe: "The fact that a work of *'aja'ib,* a marvel, a wonder, a moving, speaking statue, was described by the Western observer or reporter as an idol only reveals the ignorance of the Latin Christians during these centuries [...] an Occidental's familiarity with the thinking that underlay the technology and devices at Islamic palaces and courts might have resulted in the charge of necromancy being leveled at that person."[191] To find enough evidence to argue that Islamic automata were more advanced relief sculpture, Duggan would probably need to consult more of Donald Hill's work, but he does prove the deeply entrenched "chauvinism," competition, progressivist narratives inspired by automata. Duggan engages a central problematic to cultural proclivity and technique through automata: when "objectively

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[190] Ibid., p. 231

[191] Ibid., p. 267 Duggan omits to mention Elly Truitt's (above, n. 15)"'Trei poëte, sages dotors, qui mout sorent di nigromance:' Knowledge and Automata in Twelfth-Century French Literature" although similar literary evidence stands out in her work, and also touches on the dubious moral relationship of necromancy to European literary accounts of Islamic automata. p. 176 However, she writes, "The idea of the East--in its incarnation of the Byzantine Empire, the Islamic world, or the ancient pagan world--as a place of marvels, and specifically automata, was not new in the twelfth century." p 175

comparing civilizations,"[192] do we "compare"[193] automata to figural sculpture, or to European mechanical apparatuses or fictional accounts thereof? Perhaps the site that Duggan has in mind is a form of robot, and what most closely resembles the robot, which best approximates human ingenuity.

Duggan's emphasis on the *'ajib* rests on a handful of literary accounts, but mostly on tales of Solomon, jinn, and *A thousands and one nights:* it by no means clear what exactly is the relationship between wonder and the sculptural genre, much less the manuscripts, of *hiyal.* For Duggan wonder is a way to prove the particularity of Islamic automata and set them apart: "These wonder-workers, the 'jinn', and the works that they produced, these man-made marvels, these palace robots, were not originally in or of the Occident."[194] But wonder is a remarkably tractable medieval *topos* and there are numerous references to wonder to describe visual poetics in Islam, in a milieu in which literary expression was more theoretically articulated than visual expression.[195] Duggan cites wonder on the part of the Greeks who also *build* (as opposed to write about) the first historically recognizable automata--as though wonder is vestigial to mimesis and a pre-figuration of the sublime.[196] But the sources that imbue the automata with *'ajib* are less clear, and Duggan's political proxy for wonder, "shock,"

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[192] above, n. 161

[193] Understanding that comparison bears a relation to equating. That is, something must remain equivalent for two things to be compared in its image.

[194] Duggan, p. 267

[195] Nasser Rabbat "Ajib and Gharib: Artistic Perception in Medieval Arabic Sources" *The Medieval History Journal* 9, no. 1 (2006), pp. 99-113

[196] "Science and technique must be considered as two separate areas; that is, they do not graft onto each other but, rather, each takes from the other either its solutions or its problems. It is the rationalizing and ordering imposed by technology that makes us forget that machines have their origin in the irrational. In this area, as in all others, it is necessary to know how to accommodate the irrational, even when--and especially when--we want to defend rationalism." George Canguilheim,"Machine and Organism," in *Incorporations*, ed. Jonathan Crary and Sanford Kwinter (New York: Zone, 1992), pp. 45-65, quotation page 63. The origin of the machine that Canguilheim speaks of is the mimetic character, that the mechanical is based on the organic, the body, before it seemed to be the other way around.

is even harder to trace.

The implications of the commonly held assumption that both the automata as development of technique (art and scientific) as well as the affective response ascribed to them (wonder) are functions of power has not been further pursued, and the question still remains a problem of subjectivity--why would medievals have felt wonder from the devices? Instead of providing the space for this question to be posed, Duggan in an exclusive measure upholds wonder as a cultural treasure and ironically, substitutes it for the mimetic "spirit" imposed on automata by others like De Solla Price. Duggan is not interested in transmission of technology but in the possession of it, like an object.

It is difficult to link a material object or perceived set of them (which in this case, really are only the manuscripts themselves, or an idea of them) to the literary and affective response that gets imposed on them. Where power and wonder intersect is a substantial question--but how useful automata are to understand it is unresolved. It is doubtful that the appropriation of wonder can help explain "which history wins" or can be married to devices: as though scholars 800 years from now tried to track down the meaning of "technology" from tvs, computers, or robots.

technology as nature

Virtually every source indicates that Islamic automata took up the task of automata from Greece. Derek de Solla Price, Losano, and Chapuis et al. trace automata back to early inclination towards mimesis or the reproduction of movement in nature. Looking at some figures of al-Jazari it is impossible not to think machine/organism; this is less the case with the

Banu Musa.[197] The secrecy that surrounds the making of ingenious devices, surmised by Duggan to be considered part of the craft as well as the desired affect--shock--is not well represented in scholarship on automata or water clock fabrication.[198] It is an important factor in the dissemination and development of technical knowledge--including "cultural practice." --but by its own nature, not easily delineated. What is clear from the focus on function and much reconstruction work, however, is that the drawings must be documented above and beyond their ambient states in order to understand what the drawing is conveying, in terms of its duty to the device's functioning. We have a bad idea of what they looked like, but an acceptable idea of how, and that, they functioned.[199] What to do with that information is relatively unknown now.

This chapter has shown that *hiyal* reconstruction has had recourse to the mimetic urge to imbue the inert historical manuscripts with three dimensional movement. Reconstruction and the drive to prove automata to be commodities explains how automata are seen today. It is certainly the case that earlier scholarship bore this same tendency--that is precisely the anxiety with showing that Islamic automata is "worth" something or has a "use" and so on--so the difference must lie in the implications. For while Donald Hill and Ahmad Yusuf al-Hassan were trying to prove the universal applicability of the particularly Islamic automata, Duggan, Leonardo3, Mario Losano and others try to remove the "particularity" as a way of

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[197] Donald Hill notes, "with few exceptions, the only things that move in the *Book of Ingenious Devices* are fluids, and the components such as conical valves and tipping tanks that are essentially part of the flow systems." p. 23

[198] This would require looking at the relationship between Islamic guilds and mechanical production. They were developed around Sufi brotherhoods to keep information secret. Whether al-Muradi would have been involved, for example, is purely speculative, but is an interesting question.

[199] Fuat Sezgin emeritus professor of History of Science at the University of Frankfurt, and perhaps singularly responsible for the overseeing of 800 reproductions in the Institute of Arabic-Islamic Science takes a more historically scientific approach, but the aesthetic outcomes are remarkably similar. Sezgin continues in a long line of people to reproduce in relative intellectual isolation project Islamic scientific apparatuses, and he has extensively researched scientific manuscripts, estimating that there are upwards of 50,000. Focusing on exhibition of the instruments helps overcome language problems of the manuscripts. However much improved Sezgin's functions are, the "displays" are still questionable: would they really have remotely looked like that? See, "Islamic Science: Rebuilding the Past" *Nature* 432 (December 2004) pp. 794-795

proving that since the Islamic automata was an early harbinger of the robot imagination we will forgive it for its quirks. It is safe to say that Donald Hill would not have undertaken a project like Leonardo3's out of fidelity to the missing manuscript pieces, and because he probably had no interest in exhibiting them as curios.

In practical matters, no "case," "console" or exterior of automata reconstruction has sought to approximate (so it would seem) the opulence with which automata are described literarily such as Duggan alludes to. This includes Hill, unsurprisingly, as he remained true in the manuscript in every possible way. Instead the exteriors have acted as pastiches of the manuscript illustrations. (See Fig 3.8) This is indicative of a view of "cultural particularity" which is assigned to appearance alone. This is nothing less than Mackintosh-Smith's innocuous critique of an innocuous mall automaton: it is "history lite." If Seyyed Hossein Nasr sought to frame automata as conduits for his nebulous, unified vision of Islam, thus glossing over history--the place where Islamic automata gains its peculiarity--later automata scholarship has also glossed over the particularity of Islamic automata, but as a result of the naturalization of technology, that is, the removal of technology from history. How to formally reveal the devices from their own time, and does that have something to do with both their semblance and movements? The very act of understanding these devices in their own historical moments, under a real but uncertain genre, will probably lead to some fascinating research, for both historians of technology, and art historians. In the meanwhile, it is clear that for the future of historically exhibiting the automata manuscript will rely on reconstructions of today.

The naturalization of technology may seem banal at first. But the very thing that is supposed to separate nature from technology is work, material manipulation. If, as the automata manuscripts suggest, these things are inextricably bound up, but only through a numbness to technology and continued hope in it itself as the determinant of progress, then we will be able to say that technology and nature are no different. And once we reach this

point, every half baked utopianism couched in terms of "human nature" will suffice. The robot who works but does not help workers lives in a contradictory world, but in and of himself, he is just fine. The manuscript is not enough, but the automata were proto-robotic; the puppet cannot win because it is too kitschy; and automata were wondrous, but not by craft: The impressions from this literature tell a grim story, for all the hope imbued in robots and by extension automata, it is somewhat of an empty hope

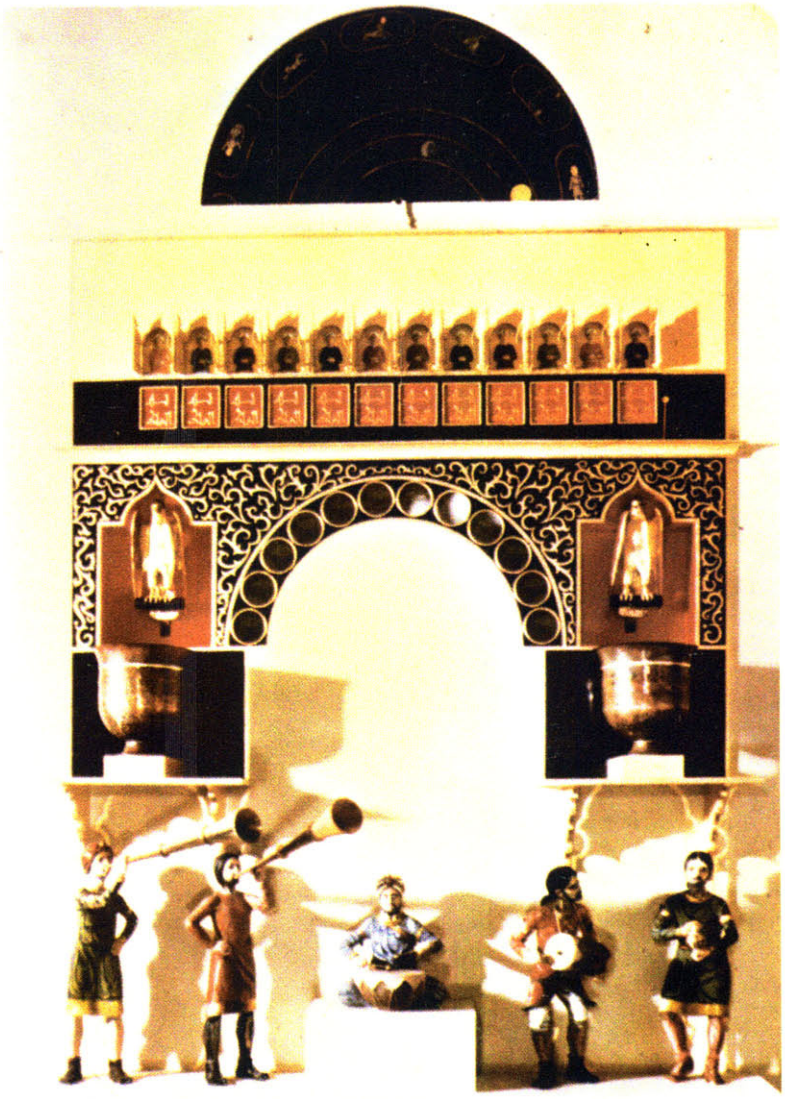


Fig 3.1

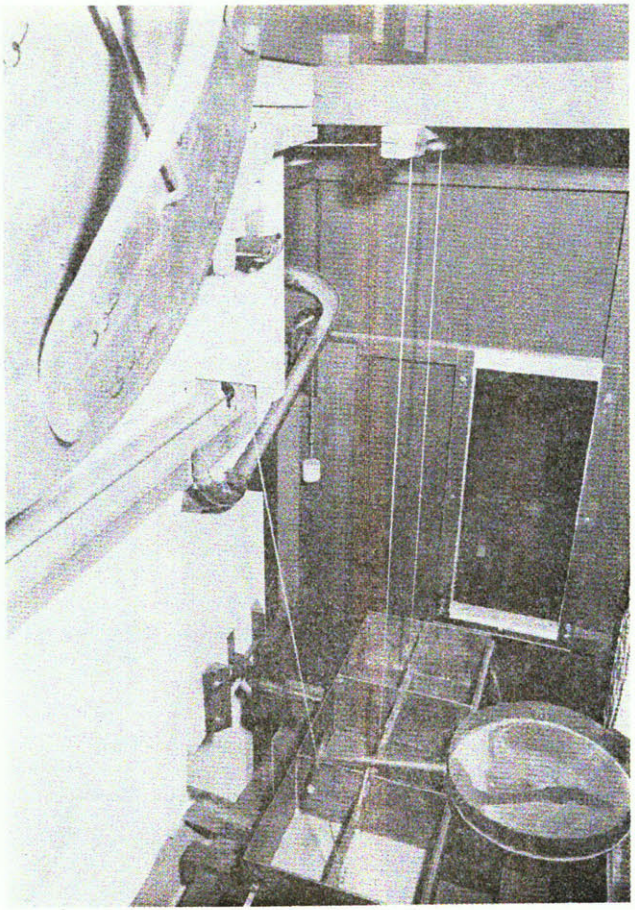


Fig 3.2

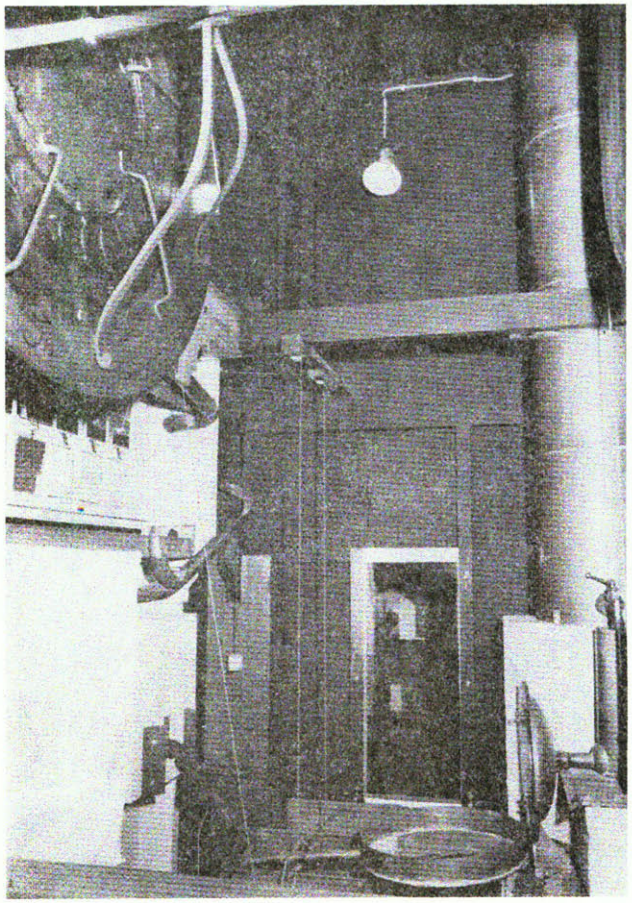


Fig 3.3

Fig 3.4

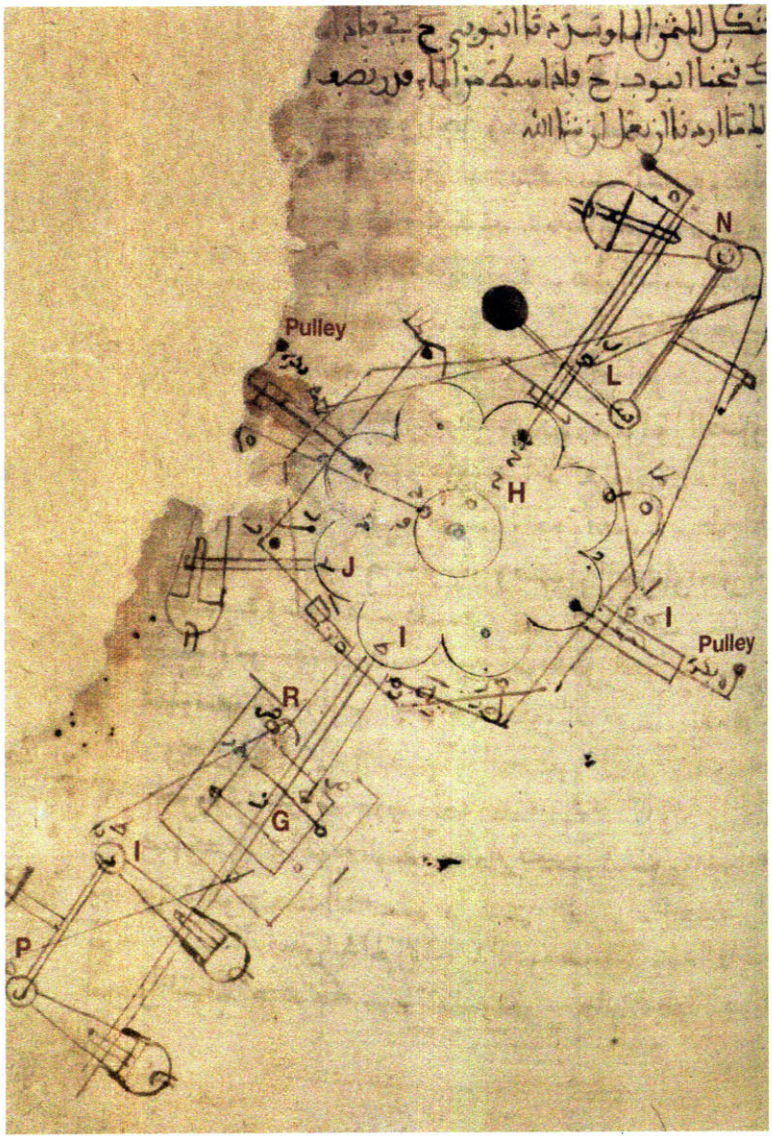


Fig 3.5

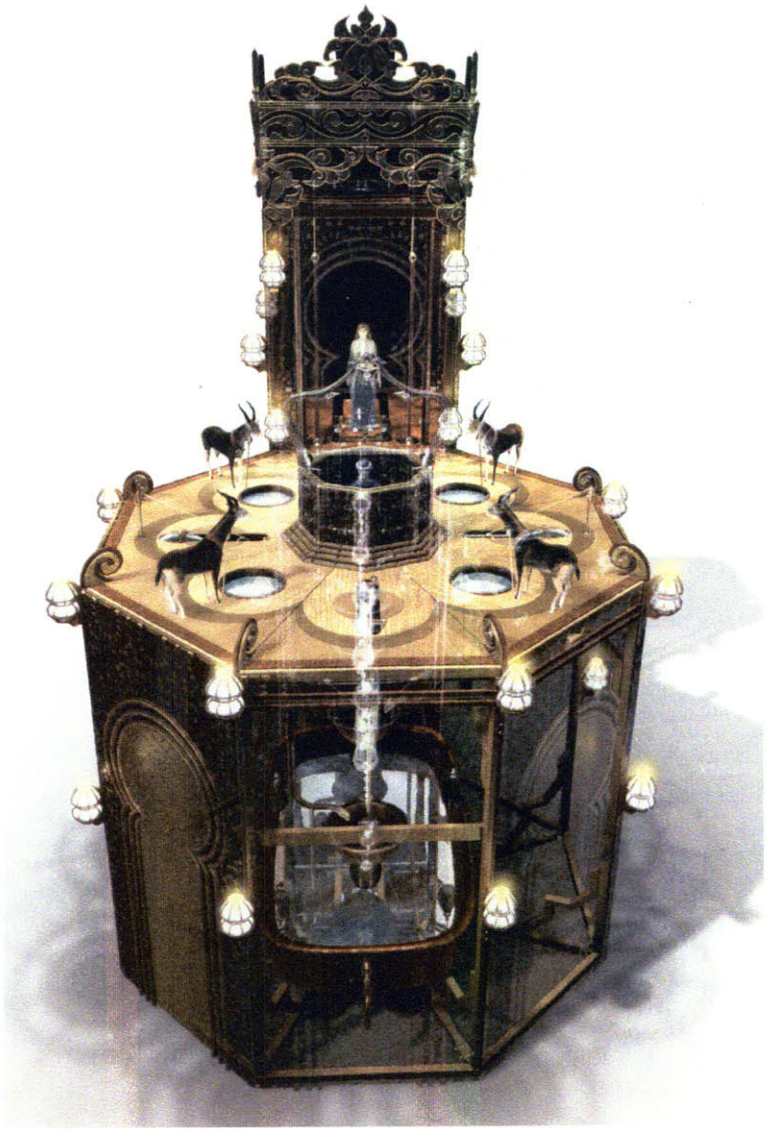
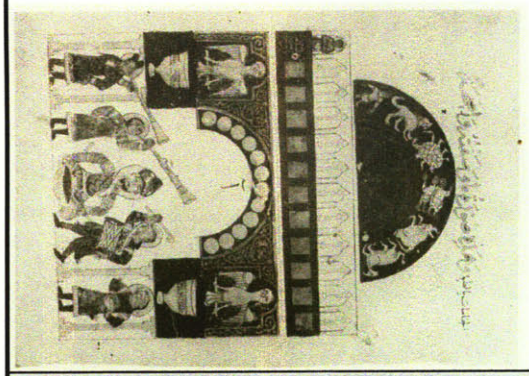


Fig 3.6

Fig 3.7

Fig. 3.8



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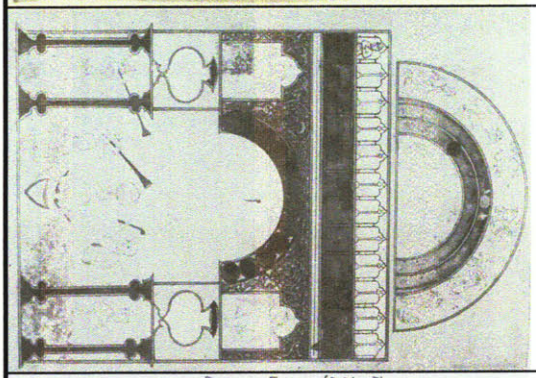


1486

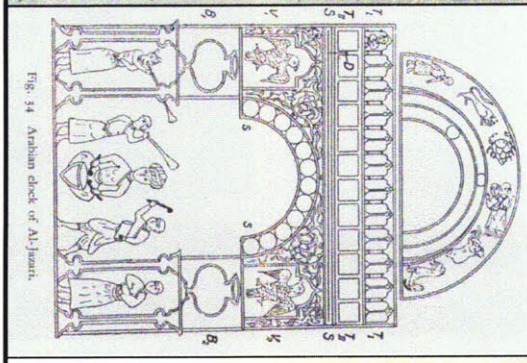
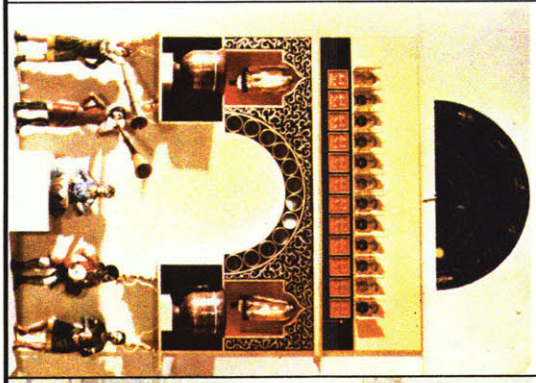
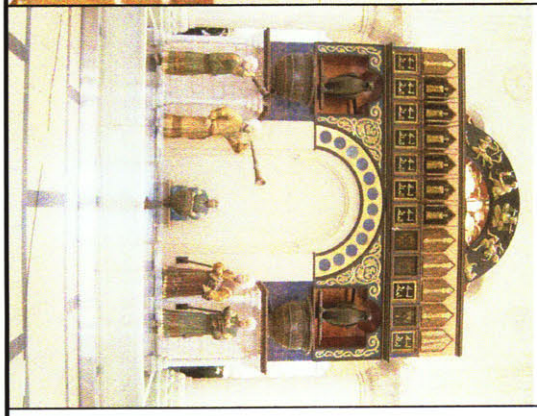


Fig. 14 Arabian clock of Al-Jazari.

1913



1976



2009

| *epilogue*

By complicating the moral character of the technological framework employed in understanding Islamic automata manuscripts, I do not wish to suggest that the whole spectrum of the rich, complicated, and sometimes strange work on the Islamic automata manuscript is "misguided." Instead, I hope to have revealed the scholarship for what it is: creative, rigorous, reconstructive and unconventional. It gains its amorphous quality in part from the representational quirks of the manuscripts themselves, although such quirks derive more than anything from the lack of historical knowledge about them. Although they are not mystical, sublime, inexplicable things, the manuscripts do pose tangible limitations to present day conceptualization. The technological element of research, which attempts to demonstrate how the automata work or their stylistic role, and is responsible for the eclectic character of this research, tends to override a historical dimension that asks the question, *what are Islamic automata*: but is this a problem?

The answer lies in the characteristic for the universal framework of technique to edge out the particular character of those techniques. Meanwhile, the particular, perhaps cultural, technique attempts to become universal, much like the machine in the labor process transcends its role in the division of production into parts in favor of the generation of a whole value. Thus, it is not a problem, but an aspect of "automata under capitalism," which are contained within a vortex of productive labor and the generation of value.[200] The most important conclusion in the absence of knowing what *hiyal* manuscripts really are, is that they like so much of art and engineering practices, were bound up with work and production characteristics of their day, but also that the 20th century attitudes towards them are too. These two sets of attitudes, however, are worlds apart. But, as Lynn White suggests, the technological morale has its roots in pre-capitalist politics. In this way, the technological opinions presented here have an element of "nature" or "permanence" to them, that expresses some desire for a better world or a future.

universal

What characterizes Islamic automata today is a positivist utopianism, that posits a "humanistic" amassment of techniques that amount to universalist future. Mario Losano, a legal historian who wrote an eclectic book on al-Jazari and "13th century ingenious

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[200] Postone writes, "When Marx discusses production resting on value, he describes it as a mode of production whose 'presupposition is--*and remains*--the mass of direct labour time, the quantity of labour employed, as the determinant factor in the production of wealth." What characterizes value as a form of wealth...is that it is constituted by the expenditure of direct human labor in the process of production, it remains bound to such expenditure as the determining factor in the production of wealth, and it possesses a temporal dimension. Value is a social form that expresses, and is based on, the expenditure of direct labor time. This form, for Marx, is at the very heart of capitalist society. As a category of the fundamental social relations that constitute capitalism, value expresses that which is and remains the basic foundation of capitalist production." p. 24-25

technology,"[201] strives to prove through a series of chance encounters with humanists that al-Jazari-cum-Islamic technology made its way to Leonardo Da Vinci, who ushered in Europe's long and undeniable monopoly on invention. He writes in *Automi dell'Oriente*, "today it is nearly impossible to identify which mechanical innovations can be ascribed to which culture, amidst all the successive developments."[202] Losano wishes to bolster his case for the historical contribution of al-Jazari and others like him to the human project of total self-reproduction: robots, artificial intelligence and beyond. But Losano's historical aggregation of technical developments is as limiting a thought as it is liberating, for by the same token, Islamic technology scholarship has sought to prove that some very important devices originated in the Islamic World, besides improving upon Greek or Byzantine progenitors. And insofar as they did improve upon antique automata, this is at least as crucial a character of Islamic history as it is important to the history of technology--for example, "what they thought they were doing" when appropriating Greek forms has yet to be answered. Through the particularity of Islamic automata, reconstruction efforts attempt to demonstrate that "technology" can cut across civilization, time and space. But, as we have seen, it is not that simple.

Whatever specifically the Islamic World contributed to "technology" as such, or Western technology, can be understood as either a set of forms or devices, on the one hand, or ways of doing something that are held in thoughts--technique--on the other. According to all the sources, even the most apologetic, it is forms and devices that Islamic technology contributes, but not thought and technique. The original "contribution" of Islamic thought to a humanist model of thinking has been consigned to the transmission of mechanical motions and formulae. Why does this matter? The bourgeois universalism that props up the utopian

[201] The book is not so much about the 13th century; it does not for example look at other mechanics at the time, or al-Jazari's life.

[202] Losano, p. 53 my translation.

universalist affirmation of technology relies on particularity. Technology fulfills concrete needs, and if there are none identified (through politics, say, even if it is the "need to win a chess game"), then people create needs under its guise. Whether technology is an accurate rubric for understanding the transmission of methods, thoughts, and ways of doing things *across cultures* is thus not a simple question except on its face: the question attempts to ignore the political identification of needs which in no short part greatly affect development. Mechanics and formulae can lose their needs-fulfilling role quickly, as new needs are produced and satisfied. The needs that "thought" or theory fulfills are much less tractable by science alone, but must have an element of desire to produce them that transcends empirical fact. It is more difficult to suggest that Islamic thought furnished thought material than mechanical motions.

Lynn White, in a strain of thought similar to Losano's, attempts to posit a "humanistic" view of technology, and the outcome is what is typically understood to be a "Euro-centric" one:

> Technology knows neither chronological nor geographic frontiers. The student of the history of invention soon discovers that he must smash the conventional barriers between Greek and barbarian, Roman and German, oriental and occidental. For mediaeval technology is found to consist not simply of the technical equipment inherited from the Roman-Hellenistic world modified by the inventive ingenuity of the western people, but also of *elements* derived from three outside sources: the northern barbarians, the Byzantine and the Moslem Near East, and the Far East.[203]

Humanist notions of technical achievement, which both Losano and White uphold, and which posit an anthropocentric view of history and an aggregating view of culture, are different from the "universalist" view on technical achievement posited by automata reconstruction, which shows above all the failure of a humanistic concept where technology is concerned. This universalist view, as it has been demonstrated, has utopian, progressive

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[203] White, "Technology and Invention," p. 4

elements and attempts to overcome culture itself through the forces of abstraction, executed through mechanism. The contemporary wish for a historically autonomous automaton--a robot--fuels the creation of objects that attest most of all to technology as the (only) way of bringing about the future. However, as we also see, this theory does not live up to its promise.

The difference between White's humanism and the pseudo universalism of robots is particularity, or the need for concrete use, as a technique must demonstrate its ability to help generate general universalized *value.*[204] So on the humanist, "Whitean" side of the matter, all devices form an agglomeration of techniques which were "modified by the inventive ingenuity of the West." On the robot universalist side, the devices demonstrate an abstract technical process that bears a more generalized *appeal* and thus has value.[205] White, who traces the moral origins of technological attitude, takes care not to step outside of the framework he presents. The universalism inspired by Donald Hill, however, brings the moral character to bear as a suppression of its concrete origins.

The result is that not a single source overtly denies a historical impact of Islamic technology on Europe--this can be regarded as *fact*--but no one can clarify what is gained from this assertion besides a euphemistic dissolution of hypothetical geographic borders.[206] Lynn White shows that interpretation molds raw, abstract material of technique, dispersed throughout the world, into valuable, hierarchical, politicized, polemical history. He shows that technology is a moral discourse whose *terminus quo* is political. This political character could

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[204] Moishe Postone writes at length on the universal particular dynamic with reference to the role of time under capitalism. It is worth noting that this work looks at Islamic and Chinese water clocks in order to examine the shift from variable hours to constant, homogenous hours or "abstract time," which Postone argues was a social, and not "technical" or "device"-driven phenomenon. p. 208. Postone's ultimate goal is to argue for the centrality of value, a social form of wealth, to Marx's critique of capital, but that the fundamental contradiction in capital occurs between concrete labor and abstract labor time.

[205] This definition of universal is thus similar to Postone's clarification of the universal character of the "machine" or the "collective worker" See above, p. 6

[206] In the 1960s and 70s this would have been more appealing than today, but perhaps equally abstract a desideratum.

mediate between the universal and the particular, but in Lynn White's estimate, no matter how much historical Islamic technical achievement attempts to be otherwise, as long as technology is measured by the "universal measure" of value, it cannot be useful, and thus, cannot be valuable. This does not, of course, mean that technological advances that come out the contemporary Middle East or Islamic World will not be valuable; for the techniques of today are different in kind from those of thousands of years ago. The techniques of today have, for all their failure to "achieve greater freedom," successfully "gone global." No one denies the global nature of technique, and no one can deny the patently "uncultural" character of "purely physical" mechanism.[207]

particular

I have shown that the best way of ascribing an abstract and thus more universal character to the automata is through the emphasis on their functionality. Even as they cut through time and space, however, technological history is not available to everyone, nor is it universally interesting. Technology is an outgrowth of bourgeois universalism made available to anyone climbing the "petit bourgeois," ladder of individualist enterprise. The significance of Lynn White's study of technological attitude and the bourgeoisie is that it shows how universal a class the bourgeoisie is: it cuts across culture, but can also cut it out. The utopian character projected today onto the Islamic automaton has its origins in the liberal, industrious, and progressive character of capital; the social form that arose as time became abstract, machines became socially constitutive, labor, emancipated from land and value measured through labor

[207] In information theory, indeed, it is "information" that allots physical laws their "ordered" appearance, or gives them an end. See, Seth Lloyd, *Programming the Universe: A Quantum Computer Scientist Takes on the Cosmos* (New York: Knopf, 2006)

time. The Islamic automata manuscript has been written into this moment because many of the techniques deployed are formally recognizable in the machines and clocks that symbolize the advent of capitalism, but were also concrete attributes of industrialization, which was, not entirely correctly, equated with capitalism.

This moral character of technological framework means that the desire to see whatever is derived from elsewhere, is a compulsion that appears rational. Scholars or reconstructors thus do not struggle with the deductive question of where to place automata in history; what gave rise to them in their own time; or why the manuscripts continued to be copied so late in their career. Instead, they preempt the question with an answer. Islamic automata manuscripts thus bear the problems of historical reconstruction, for the attention paid to manifesting the device necessarily results in an infidelity to the text and, moreover, a casual ignorance of the conditions which originally gave rise to them. Further historical research, however, can elucidate what it was about this craft that made automata possible in its own time. Islamic automata would be enriched by study of medieval Islamic labor. The automaton does not perform useful work, but was probably the object of such work. Although automata do not seem to overtly suggest medieval labor techniques, this might be exactly where they belong; reconstructive literature is limited however as to how far it can look into this, as much as it itself ought to be concerned with craft techniques.

Donald Hill's emphasis on the functioning of automata from an engineer's standpoint is entirely within reason, and moreover introduced new ways of understanding the manuscripts. It has also been for the most part dispensed with since Hill's death in 1994. But Hill himself did not ask what it was in the craft culture that gave rise to Islamic fine technology and automata. Hill contented himself with environmental arguments such as the lack of water, which is certainly an important factor but still betrays a "transhistorical" understanding of necessity itself as the primary constraint according to which technological and design

solutions arose. The wonder and ingenuity--or any other potential *social* constraints--were not part of the oeuvre of Hill or anyone to follow him. This is most certainly a side effect of the problem of reconstructing automata, which afforded a separation between what social needs automata fulfilled from a craft standpoint, and observation from without that declares these needs fulfillments to be progressive for their day. It was not within the scope of Donald Hill's work to question the connection between wonder and affect on the one hand--the literary accounts of automata--and the manuals or informational showpieces that detail their construction, on the other. Indeed there is no prima facie case for this connection. In sum, the problem of reconstruction of automata falls on the side of history, not ideology: the limitations to Hill's work was more in scope than in intent. The "bourgeois" moral inclination as a way of demonstrating the historical import of the automata is business as usual. It does deny a deeper account of what the Islamic automata were, or how to look at them, but reconstruction of automata is not a problem of *fact*.

The effect that late-mid-century automata scholarship had on early 20th century scholarship was such that it framed the latter as inutile. Still unresolved by reconstruction narratives however is the perceivable disjointedness between text and image; this could fall in line with the work undertaken by those scholars. The images of automata are similar but different; some more finished, some colorful, and some without animal or human figures. What I have tried to suggest in this work is that a meticulous study of each of al-Jazari's, but also the Banu Musa's and al-Muradi's, manuscripts is in order: stylistic narratives were not sufficient to understand medieval Islamic art practices, but betrayed an interest in the individual copies that has only featured as an indexical element in Hill and al-Hassan's work. If new art historical research took up the Islamic automaton, it could transcend collected paintings, but also, for example, interrogate the geometric constructive drawings featured in *The Book of Secrets*. This latter manuscript, of course, is the most understudied from this point

of view of them all, but also the least likely to be the object of an art historical inquiry thanks to its patently non-figural drawings. Nevertheless its text still describes figural movements, and for this reason *The Book of Secrets* continues to suggest that the presence of animal and human figures conveying mechanism in motion is crucial to the questions that the Islamic craft traditions generate.

All evidence thus suggests that the best framework to look at automata, considering the material evidence available, is nothing less than art, as art history can dwell ad infinitum on the particular. The presentism and knowing lack of historical rigor that constitutes Islamic automata reconstruction today professes an ideological desideratum that technology is not only a good thing, but is also the premier means to progress. The projection of ideology through reconstruction cannot be called a negative development from the standpoint of the "true" historical object, but it is instead constitutive of the object, and so it takes perhaps Islamic art historians to ascertain what the Islamic automat manuscript is and was.

Only after the necessity for use is overcome, will automata manuscripts be able to be looked upon, but n the meanwhile, while we "wait" for technology and art to be no longer opposed through usefulness and value, we can at least resign them to their fate as art objects, and look at their craft. If *techne* is moral, but it was not always, it is probably safe to say that the industriousness that forms an ideological base today did not drive the production of automata. Instead, it suggests that technology is disciplinary: Something else drove the production of automata manuscripts. That things can "become" historical, as technology "becomes" moral, is precisely the task set out for understanding what drove Islamic automata production and consumption. What happens to the utopian, the "good" moral dimension of technology when this divide in history is problematized? It can be thrown into the study of history as a moment in craft and production comes into light. The particularity of automata manuscripts will once again have to come into view.

LIST OF IMAGES

Introduction

Figure 0.1

Illustration of the key code used in
hiyal manuscripts; Banu Musa's Mod. 46
Trick vessel with idol spout holding sprig
MS Topkapi

1| Direct Representation

Figure 1.1

Illustration of Martin's "portrait of Saladin"
1354 MS

Figure 1.2

Martin's comparison of "Saladin" to Mulai Hafid

Figure 1.3

Illustration, "man sitting on balcony," aperture visible atop
MS Graves 27

Figure 1.4

al-Jazari's first clock, a musical automaton, collected by Martin
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Figure 1.5

al-Jazari's first clock
MS Graves 27 featured in Hill

Figure 1.6

Illustration of one of Philo's automata,
"Hercules Slaying Dragon,"
drawn by Bernard Carra de Vaux ca 1897

Figure 1.7

Image of Wiedemann and Hauser's
reconstruction drawing of the al-Jazari's clock
using MS Graves 27

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"Details of the Internals of Slave"
MS 1315

Figure 2.2

First image of the boon-companion that finishes wine
MS Graves 27

Figure 2.3

Second image of boon-companion
MS Graves 27

Figure 2.4

Donald Hill's motif of "conical valve," designated by m, used by Banu Musa something which would be later used later by Leonardo Da Vinci. These valves occur frequently throughout the Banu Musa book.

Figure 2.5

Conical valve in trick drinking tank Mod. 7. Float y rises from the water closes valve ṭ
MS Topkapi

Figure 2.6

Motif 1 from Donald Hill's translation of Banu Musa

"Concentric siphon." In the schema, water fills up to (b), (bd) being one tube, and (acc) another. When the water reaches (b) in the interior, it is expelled. The air between (ab) forces it out.

Figure 2.7

Motif 3 from Donald Hill's translation of Banu Musa

A bent funnel "motif," under sieve which allows the pouring of two different liguids into containers (c) and (d) respectively. Some skill would be required to pour forcefully. One liqiud is poured lightly so that the liquid dribbles along the tube into (d).

Figure 2.8

Model 76 from Banu Musa facsimile and Donald Hill's drawing in which bird has been omitted. and some corrections have been made

Figure 2.9

Banu Musa *Ingenious Devices* Model 6

Comparison of the two MSS images, Topkapi and Vatican, "Clamouring Bull." Hill says that valve (k) "must be of a greater bore than valve (e)" as valve (e) is an actuating valve which opens so that water rushes out of valve (k). Hill says the description is no entirely clear. (p.53)

Figure 2.10

Image of the bull from MS Topkapi

Figure 2.11

Atilla Bir's reconstruction drawing of Banu Musa *Ingenious Devices* Model 49

Figure 2.12

Hill's facsimile of Topkapi image of Model 49 and reconstruction drawing

Figure 2.13

Atilla Bir's circuit diagram of Model 49
Since there are four chambers that get filled with liquid depending on the overflow of the preceding this accounts for the diagram's seeming "complexity." Bir also explains "Double Siphon model" (one motif) and two conditions, "water" and "wine" are outlined. Water is held while wine flows, etc.

Figure 2.14

Atilla Bir's circuit diagram of Model 6

Figure 2.15

Atila Bir's "close up" of an overflow motif and symbology

Figure 2.16

Ahmad Yusuf al-Hassan's drawing of pre-escapement mechanism. The weight shifts the horizontal bar on top form side to side (which would later hang above a rotating gear and oscillate back-and-forth to produce the swing of a pendulum). Escapements are found in chapters flutes and fountains.

Figure 2.17

Escapement device from MS Graves 27 and Donald Hill's redrawing

Figure 2.18

Illustration of water-driven pump with twin cylinders

Figure 2.19

Figure 18, falconer from al-Jazari

Figure 2.20

One that Vernet compares to al-Jazari and Leonardo's reconstruction

Figure 2.21

al-Muradi's drawing "a clock and a calendar with a bird"

Figure 3.1

Image of Donald Hill's reconstruction of al Jazari's first clock

Figure 3.2

Image of interior of Donald Hill's reconstruction of the clock shows the tank

Figure 3.3

Image of interior of Hill's reconstruction shows the wheel

Figure 3.4

Image of Al-Jazari's first clock at India Court in Ibn Battuta Mall in Dubai
courtesy of Nasser Rabbat

Figure 3.5

al-Muradi's drawing of the first shape, with some (incomplete) annotations by Leonardo3

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Leonardo3's reconstruction of al-Muradi's first shape

Figure 3.7

Detail of Leonardo3's reconstruction of waterclock,
"The Dance of Nocturnal Night"

Figure 3.8

Timeline of al-Jazari's first waterclock

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LIST OF KNOWN COPIES OF AL-JAZARI'S *COMPENDIUM*

and notes about the condition based on Ahmad Y al-Hassan and Donald Hill's work

❧ Bodleian Library Oxford University

(1) Bodleian Library MS Grave 27
1486;
mostly complete

(2) Bodleian Library MS Frazer 186
17th century, Mughal (1673 al-Hassan)
good images according
to Hill and al-Hassan

❧ Library of University of Leiden

(3) Or. 656
1561 (al-Hassan);
some missing drawings, first chapter
of Section VI "omitted because
useless" according to copyist

(4) Or. 117
date unknown;
incomplete, missing first chapter of
IV; some chapters switched;
poor drawings (Hill), some are
"excessively inadequate" (al-Hassan)

❧ Chester Beatty Library Dublin

(5) MS 187
possibly 1329;
missing pages, stained,
no complete chapters; good drawings;
"helpful" (Hill)

❧ London (privately owned); elsewhere

(6) MS 1315
Hagop Kevorkian Fund bought MS
(2/3s) This is the manuscript Hill
and al-Hassan say is well known to
Islamic Art. Remaining pages available
in various museums

❧ Topkapi Serai Museum, Istanbul

(7) No 3472
Perhaps earliest, 13th century:
good condition; best copy (al-Hassan)

(8) Hazine 414*
copied from a 1206 date but actual
date not known, certainly old though

(9) No. 3461*
undated; eleven images missing

(10) No. 3350*
1459;
"pettily designed drawings"

❧ Suleymaniey Kutuphanesi* Library Istanbul

(11) MS 1354
This is the source of paintings Hill mentions, but he does not source it; according to al-Hassan 1354 lacks (only) 26 leaves

❧ Bibliotheque Nationale in Paris

(12) Arabe 2477
1485;
Second Half of MS color illustrations (only drinking sessions section) average illustrations

(13) Arabe 5101
18th century;
nastaliq; with blank spots for illustrations, which are missing

(14) Supp. 1145
Persian translation of al-Jazari's work from 1874

❧ National Public Library of Russia*†

(15) MS 2539
1591;
donated by Institute of History for the Science Moscow during 2nd Int'l Symposium on the History of Science in 1979

*mentioned only by Ahmad Y al-Hassan
† Leningrad Library (AY al-Hassan)

AL-JAZARI'S NARRATIVE OF THE FIRST CLOCK

quoted from Donald Hill's translation*

"The outside consists of a house, rising from the ground, a distance of about twice the height of a man, comprising all that is required for telling the passage of the hours. In this house there is a door about 9 spans in height and five and-a-half spans in width, which is closed by a wall of wood or bronze. Above the door, in a lateral straight line, are twelve doors, each of which has two leaves which are closed at the beginning of the day. Below these, and parallel to them, are twelve [more] doors, each with on leaf, which all have the same colour at the beginning of the day. Below the second set of doors is a frieze projecting one fingerbreadth from the face of the wall. At the side of the frieze is a crescent [moon] like a Dinar. The crescent moves along the ledge in front of the doors to the [other] end of the ledge. In either side of the wall below the ledge, is a niche like a *mihrab*, and each of these is a bird with outstretched wings, standing on its feet. Between the two niches are twelve roundels made of glass, which are so arranged that they form a semi-circle with its convex side upwards. In front of each bird is a vase (qandil) supported on a projecting bracket, and in each vase is hung a cymbal. Below the wall several figures are situated - two drummers, two trumpeters and a cymbalist. Above the wall is a semi-circle with its convexity towards the top. Around its circumference are six of the twelve Zodiacal signs [Hill: i.e. visible at a given time] and blow this is a sphere carrying the sun, a golden roundel, and below this, a sphere carrying the moon, a glass roundel.

"As to its significance: at the beginning of the day the crescent moves in its regular imperceptible way along the frieze until it has passed one door and is between the first and second doors., whereupon the two panels of the first of the upper doors open and a figure, made according to the choice of the craftsman, comes out and stands as if he had suddenly emerged. Also, the first door which the crescent has passed turns over and changes colour, the two birds lean forward until they approach the two vases, and two balls are dropped from their beaks, each on to a cymbal, and the sound is heard from afar. The birds then resume their position. This happens at the end of every hour until the sixth, at which time the drummers drum, the trumpeters blow and the cymbalist plays his cymbals for a while. This occurs also at the ninth and twelfth hours."

Islamic Automata in the Absence of Wonder

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