SOME ASPECTS IN BANŪ MŪSĀ'S PHILOSOPHY OF TECHNOLOGY WITH SPECIAL REFERENCE TO THEIR *KITĀB AL-ḤIYAL*

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Dedicated to

My parents,
Radziah binti Mohd Said
Mohd Amin bin Ramly
May God place them among the souls of the pious believers
and grant them eternal happiness

My wife,
Nur Zawani binti Jalaluddin
Whose encouragement and support have meant to me so much
during the composition of this work

My sons,
Muhammad Umayr
Muhammad Uways
May this modest labor of mine enrich their lives
and inspire them to even greater heights

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ABSTRACT

This study is an attempt to explore the life work of Banū Mūsā, a family of three scholars, scientists, and engineers of 9th century ʿAbbāsid Baghdad. The study finds that the current framework for the study of past technological development suffers as in the history of science, namely, that the past is studied independently of the worldview and epistemic framework of the scientists and the technologists. This has resulted in the separation of technology and science from the realm of worldview, ethics and society, leading to the problem of the megamachine. Gathering various accounts from medieval biographers, historians, and modern historians of technology, this study focuses on Banū Mūsā's intellectual and cultural milieu that nurtured and provided them with opportunities to develop and implement their technological ideas. Some important aspects of scientific and technological development, imprints and imperatives in the era were highlighted. This study uses the worldview of Islām as articulated by Syed Muhammad Naquib al-Attas, combined with the tools of historiography and semantic field analysis, which leads to the discovery of the architectonic nature of technological ideas. The main findings demonstrated that their seminal work *Kitāb al-Ḥiyal* signified a creative framework for technological miniaturization and fusion, based on their other works on larger scale. The synthesis of these aspects could be used to conceptualize the framework in philosophy of technology that is rooted in the worldview of Islām.

ABSTRAK

Kajian ini merupakan suatu usaha untuk menerokai kehidupan Banū Mūsā, tiga ilmuan bersaudara, ahli sains dan jurutera abad ke-9 kota Baghdad pada zaman pemerintahan Banī ʿAbbāsiyyah. Kajian ini menemui bahawa kerangka semasa pengkajian perkembangan teknologi masa silam mengalami kekurangan sebagaimana sejarah sains, iaitu masa silam yang dikaji berasingan dengan pandangan alam dan kerangka keilmuan para ahli sains dan ahli teknologi. Ini telah menyebabkan pemisahan antara sains dan teknologi dari wilayah etika dan masyarakat, yang membawa kepada masalah *megamachine*. Kajian menggunakan pengumpulan pelbagai riwayat dan rakaman daripada para periwayat dan sejarawan teknologi untuk memberi tumpuan terhadap persekitaran Banū Mūsā, yang telah memberikan mereka pendidikan dan peluang untuk membangun dan melaksanakan idea teknologi mereka. Beberapa sisi penting pembangunan, kesan dan intipati sains dan teknologi dalam era tersebut ditonjolkan. Kajian ini menggunakan pandangan alam Islām sebagaimana dijelaskan oleh Syed Muhammad Naquib al-Attas, dengan gabungan alat-alat pensejarahan dan pengupasan medan makna, yang membawa kepada penemuan sifat arkitektonik idea teknologi. Penemuan utama menunjukkan karya berpengaruh mereka *Kitāb al-Ḥiyal* melambangkan suatu kerangka berdaya cipta untuk pengecilan dan pelakuran teknologi, berdasarkan usaha mereka pada skala yang lebih besar. Sintesis sisi-sisi ini boleh digunakan bagi menghasilkan suatu kerangka konsep dalam falsafah teknologi yang berakar sumber dalam pandangan alam Islām.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The cognates of 'technology' come from the vernacular forms of the Latin *technica* and *technologia,* which in turn have their origins from Greek *tekhnologia*. According to the *Greek-English Lexicon* (1819 and 1901), the word *tekhnologia* (τεχνολογία) is derived from the combination of *tékhnē* (τέχνη), meaning, "art, skill, craft", and *logía* (λογία), meaning, "study of-."[1] *The Oxford English Dictionary* (1919) defines the term as commonly used in three instances: (1) "a discourse or treatise on an art or arts; the scientific study of the practical or industrial arts"; and by extension, "the practical arts collectively"; (2) "the terminology of a particular art or subject; technical nomenclature"; and (3), obsolete and rare, grammar. The second edition (1989) extended its meaning to include "a particular practical or industrial art".[2]

The American Century Dictionary (1891) defines technology as "that branch of knowledge which deals with the various industrial arts; the science or

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1 *A Greek-English Lexicon*, Henry George Liddell, D.D. and Robert Scott, D.D. (comps.), 8th ed., rev. ed., (Oxford: Clarendon Press, 1901), 1548. See also Carl Mitcham and Eric Schatzberg, "Defining Technology and the Engineering Sciences", *Handbook of the Philosophy of Science: Philosophy of Technology and Engineering Sciences*, Anthony Meijers (ed.), 16 vols.

2 Carl Mitcham and Eric Schatzberg, "Defining Technology and the Engineering Sciences", 9:31.

systematic knowledge of the industrial arts and crafts, as spinning, metal-working, or brewing." Technology also "comprises all that bewilderingly varied body of knowledge and devices by which man progressively masters his natural environment."[3] As a term, 'technology' was born from European discourses on technics (N. American: *technique*).[4] Technological ethicist Ian Barbour defines 'technology' as "the application of organized knowledge to practical tasks by ordered systems of people and machines", which clarifies engineering as a concomitant discipline.[5] 'Art' is used interchangeably with 'technology' refers to the application of science or scientific principle into work that possesses the capability to improve as more things become known i.e. as scientific knowledge advances.[6]

The nearest conceptual definitions to 'making of things' and the related 'industrial art' in the scientific tradition of Islām are the Arabic *ṣanaʿa* (صنع), *ṣinʿah* (صنعة) and *ṣināʿah* (صناعة), as can be found in al-Rāghib al-Isfahānī's *Mufradāt fī Gharīb al-Qurʾān*,[7] Ibn Manẓūr's *Lisān al-ʿArab*,[8] and Ibn Khaldūn's magnum opus *Muqaddimah*.[9] Abū Zayd ʿAbd al-Raḥmān ibn Muḥammad ibn Khaldūn (more commonly known as Ibn Khaldūn, 1332–1406 CE), the famous 15th century historian and philosopher who studied the ebb and flow of North African and Andalusian civilizations (Arabic: حضارة , *ḥaḍārah*), observes that *sināʿah*, the art of making things or more commonly known as industry, is resultant from man's intellectual ability to comprehend, organize and master the sciences.[10] Therefore, *sināʿah* is a scientific art. The Khaldunian conceptual scheme places craft or technology as an important aspect of a civilization which its loss signaled the

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3 T.K. Derry and T.I. Williams, *A Short History of Technology*, (Oxford: Clarendon Press, 1960), 3.

4 Carl Mitcham and Eric Schatzberg, "Defining Technology and the Engineering Sciences", *Handbook of the Philosophy of Science: Philosophy of Technology and Engineering Sciences*, 9:28.

5 Ian G. Barbour, *Ethics in an Age of Technology: The Gifford Lectures 1989–1991*, 2 vols. (London: SCM Press, 1992), 2:3.

6 Thomas Kuhn, *The Structure of Scientific Revolutions*, (Chicago: The University of Chicago Press, first published 1962), 160–161.

7 Al-Rāghib al-Isfahānī, *Mufradāt fī Gharīb al-Qurʾān*, (Mecca: Maktabah Nazār al-Muṣṭafā al-Bāz, 2009), 375.

8 Ibn Manẓūr, *Lisān al-ʿArab*, 9 vols., (Cairo: Dar El Hadith, 2003), 5:408.

9 Abū Zayd ʿAbd al-Raḥmān ibn Muḥammad ibn Khaldūn, *Muqaddimah*, ʿAbd Allāh Muḥammad Darwīsh (ed.), 2 vols. (Damascus: Dār Yaʿrib, 2003), 2:66.

10 Ibn Khaldūn, *Muqaddimah*, 2:166.

beginning of decline for the civilization.[11] The advancement of technology is also the advancement of urbanization, thus a reliable indicator of a civilization's health. Further precisions will be made in Chapter 3.

Technology, therefore, as widely understood is the practical application of science in industry or commerce. It is concerned with the making, usage, and knowledge of tools, machines, techniques, crafts, and systems in order to solve a problem or perform a specific function. In today's context, systems include software applications or methods of organization.

Technology can also be understood as an extension of the human faculties. The telescope increases the range of the human sight so it could perceive objects in the sky too distant for the naked eye to see. Both the loudhailer and the telephone have two-way amplification; amplifying the voice of a person speaking and enhancing the hearing of the person at the receiving end. In short, technology amplifies the human power and extends his reach.[12]

The application of science that results in technology eventually provides feedback of information and triggers further development in science in the search for better ways (or technics) of doing things, forming a kind of feedback loop, or what is called in philosophy of technology as 'reciprocal relationship' between science and technology.[13] In the discussion on philosophy of technology, this thesis finds it a useful position to take in a broad sense due to the reciprocal relationship between science and technology and that technological sciences today include many disciplines including mathematics, engineering, construction, medical, and information.[14]

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[11] See Ibn Khaldūn, *Muqaddimah*, 2:8–9.

[12] Lewis Mumford, *Technics & Civilization*, (New York: Harcourt, Brace & Company, 1934, repr., Chicago: The University of Chicago Press, 2010), 376.

[13] Hans Radder, "Science, Technology and the Science–Technology Relationship", *Handbook of the Philosophy of Science: Philosophy of Technology and Engineering Sciences*, 9:65.

[14] Ibid.

Based on the preliminary discussion above, the final and fundamental nature of things in religious reflections open the door for discussions that philosophy of technology must seek to address. Just as "recent approaches to the philosophy of science have shown that science is laden with philosophical presuppositions", this reciprocity must also imprint technology with philosophical presuppositions.[15] Therefore, this thesis realizes the importance of this reciprocal relationship because of the bearings that they have upon future manifestations of technology.[16] Furthermore, cultures have always proven to have impact upon the kinds of technology that are manifested, and Islām as a source of ethical and cultural values always determine "the choice of technology and the development and management of the technological culture."[17] There are many exhortations that can be found in the teachings of Islām to treat kindly fellow human beings and not to overburden others unnecessarily and since, assuming affirmation is present and that axiological elements in the worldview almost always get translated into action, it persuaded the Muslim to look elsewhere for sources of energy alternative to human muscle power to facilitate and accomplish work, thus giving legitimation to technological uses for religiously motivated purposes.

In addition to the axiological argument, this thesis also looks into the ontology of the issue, since it is simply deficient to discuss the philosophy of technology in Islām without also acknowledging the common elements in the belief system held by Muslims. Given that religion and culture also play a role in technological manifestations, with due respect to Arabists and Orientalists studying the historical period of Islām, the empirical and rational methods of analysis that they employ may be inadequate in dealing with issues such as technological imperatives, and this could lead to the divorcing of facts from the religious metaphysics that is the fountainhead of Islamic ethics; stripping bare any action and

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[15] See Val Dusek, *Philosophy of Technology: An Introduction*, (Oxford: Blackwell Publishing Ltd., 2006), 6.

[16] Hans Radder, "Science, Technology and the Science–Technology Relationship", 9:65. See also Val Dusek, *Philosophy of Technology*, 6.

[17] S.W.A. Husaini, "Energy: An Interpretative History of Islamic Thought, Engineering and Technology", *Journal of Islamic Science*, vol. 21, (Aligarh: The Muslim Association for the Advancement of Science & Centre for Studies on Science, 2005), 11.

observing only the convenient practical utility of doing things.[18] For instance, in describing scientists during the medieval period of Islām as just 'scientists', or engineers as just 'engineers', the impression given is that in their practices religious imperatives are not given thought or consideration. This is misleading and this thesis shall prove the case is in fact otherwise. In identifying the technological imperatives, it is important to consider metaphysical elements, therefore interpreting the history of science and technology in the medieval period of Islām cannot dispense with the context and a whole myriad of unseen mental elements that form the constituents of a 'worldview'.[19]

While there is an abundance of literature[20] acknowledging the contributions of Muslim scientists and technologists in the past, the debate is still open as to whether there is such thing as Islamic science or technology.[21] There are also several assertions that 1) science cannot be attributed to religio-cultural and traditional underpinnings 2) technology is neutral or free of value and 3) the sentiment that there is still lingering anti-scientific attitude among Muslims today.[22]

Yet, technology has aims that are not limited to just construction of material things or processes that have socially useful function; it also possess other functions as well, such as the medium in which culture is transferred from one generation to the next, or from one civilization to another. That being said, cultural influences also bear marks on technological progression, as do worldviews. In this respect, the relationship is also reciprocal, much like the relationship between science and

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[18] Ibid., 14. See also Ahmad Dallal, *Islam, Science, and the Challenge of History*, (New Haven & London: Yale University Press, 2010), 9–10; Neil Postman, *Technopoly: The Surrender of Culture to Technology*, (New York: Vintage Books, 1993), 31.

[19] S.W.A. Husaini refers to "social context" (op. cit., 15), but on the subject of worldview it is only proper that an even higher authority is referred to i.e. al-Attas and Açikgenç. See also Ahmad Dallal, *Islam, Science, and the Challenge of History*, 10–11.

[20] See for example George Saliba, *Islamic Science and the Making of the European Renaissance*, (The MIT Press, 2007); Dmitri Gutas, *Greek Thought, Arabic Culture: The Graeco-Arabic Translation Movement in Baghdad and Early 'Abbasid Society (2nd-4th/8th-10th centuries)*, (Routledge, 1998); Donald R. Hill, *Studies in Medieval Islamic Technology: From Philo to al-Jazari – from Alexandria to Diyar Bakr*, David A. King (ed.), (Germany: Johann-Wolfgang-Goethe University, 1998); Howard R. Turner, *Science in medieval Islam*, (University of Texas Press, 1995); Jim al-Khalili, *The House of Wisdom: How Arabic Science Saved Ancient Knowledge and gave us the Renaissance*, (New York: Penguin Press, 2010).

[21] For example, Jim al-Khalili argued, "science cannot be characterized by the religion of those who engage in it". See Jim al-Khalili, *The House of Wisdom: How Arabic Science Saved Ancient Knowledge and gave us the Renaissance*, (New York: Penguin Press: 2010), xxvi.

[22] Ibid., xxvii.

technology. In this reciprocal relationship, what is meant by technology is that which involves the production, acquisition and utilization of knowledge; insofar that observation and experimental science are integral to such organization, for example today in what is called 'design knowledge'.[23] For the intent and purpose of this thesis, the definition of science is accepted as:

> A body of knowledge (in the sense of discipline), which arises as a result of the process of determining a subject matter that is investigated by a scholarly developed method yielding theories[24]

The context chosen for this thesis is the Banū Mūsā brothers ('Sons of Mūsā'), namely Abū Jaʿfar Muḥammad ibn Mūsā ibn Shākir (800–873 CE),[25] Abū al-Qāsim Aḥmad ibn Mūsā ibn Shākir (803–873 CE) and al-Ḥasan ibn Mūsā ibn Shākir (810–873 CE), 9th-century Muslim scholars, scientists and engineers of Baghdad.[26]

Their written works numbered twenty, many were lost but the most well known was *Kitāb al-Ḥiyal*, 'the Book of Ingenious Devices.'[27] Their work is a fitting example how the worldview of Islām affects a person's view of nature, the appreciation of science becomes a study of the signs of God (*ayāt Allāh*)[28] present in that nature. As such, technology becomes the use of that science by Muslims whose minds affirmed as true (*taṣdīq*) the concepts (*taṣawwūr*) of Islām,

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[23] Hans Radder, "Science, Technology and the Science–Technology Relationship", *Handbook of the Philosophy of Science: Philosophy of Technology and Engineering Sciences*, 9:67.

[24] Alparslan Açıkgenç, *Islamic Science: Towards a definition*, (Kuala Lumpur: International Institute of Islamic Thought and Civilization (ISTAC), 1996), 35.

[25] For the sake of simplicity, this study will use mainly one system of calendar referring to Common Era (CE) and Before Common Era (BCE). The dates from the Islamic calendar are cited in important events and periods only as AH (after the *Hijrah*) and BH (before the *Hijrah*); 'circa' is abbreviated as 'c.' to indicate approximate dates or 'circa'; 'd.' is an abbreviation for 'died in'; 'r.' is an abbreviation for 'reigned'; 'fl.' is an abbreviation for 'floruit'.

[26] See "Banū Mūsā", *The Encyclopedia of Islam*, C.E. Bosworth, E. Van Donzel, W.P. Heinrichs, CH. Pellat (eds.) with collaboration of F.TH. Dijkema, P.J. Bearman, MME S. Nurit, 12 vols., new ed., (Leiden: E.J. Brill, 1993), 7:640; Salim Ayduz, "Banū Mūsā", *The Oxford Encyclopedia of Philosophy, Science, and Technology in Islam*, Ibrahim Kalin, Salim Ayduz, Caner Dagli (eds.), 2 vols., 1st ed., (Oxford: Oxford University Press, 2014), 1:87; Josep Casulleras, "Banū Mūsā", *Biographical Encyclopedia of Astronomers*, Thomas Hockey, Virginia Trimble, Thomas R. Williams (eds.), (New York: Springer, 2007), 92.

[27] Donald R. Hill (trans.), *The Book of Ingenious Devices (Kitab al-Ḥiyal)*, (Dordrecht: Reidel, 1979), 5–6.

[28] George Saliba, *Islamic Science and the Making of European Renaissance*, 175.

reinforcing within them that architectonic structure called 'worldview'[29]. Arising from this worldview are activities that conform to its truth and reality. For all intents and purposes, this thesis accepts the definition of worldview as:

> ...that vision of reality and truth, which, as an architectonic mental unity, acts as the non-observable foundation of all human conduct, *including scientific and technological activities* [emphasis mine].[30]

As such, a worldview that has undergone Islamization has influence on contemporary and future development of Muslim technology with positive effect on the environment, the ability to reshape and reconfigure lifestyles and the control over modes of production to suit the concerns and requirements of Islām and the Muslims. Technological imperative in Islām, therefore, is guided by principles insofar that technology does not transgress the limits of set by the religion in what is called the Sharīʿah, and at the same time secures the well-being (*maṣlaḥah*) as an expression of the acquisition of benefit and the repulsion of harm (*maḍarrah*) in pursuant of the higher objectives of the Sharīʿah (*maqāṣid al-sharīʿah*).[31]

1.2 Statement of Problem

It is becoming prevalent thought that science and technology can be treated as a neutral entity only when the sociocultural context and issues circulating the specific science or technology are removed.[32] The implication is that by doing so, a

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[29] Alparslan Açıkgenç, *Islamic Science: Towards a definition*, 10.

[30] Ibid., 29.

[31] Imran Ahsan Khan Nyazee, *The Methodology of Ijtihād*, (First published under *Perspective of Islamic thought series*, Islamabad: The International Institute of Islamic Thought, 1994. Malaysian edition, Kuala Lumpur: Islamic Book Trust, 2002), 213.

[32] See for example, W.E. Bijker, *Of Bicycles, Bakelites, and Bulbs*, (MIT Press, Cambridge, 1995) MA); R.T. Herschel and P.H. Andrews, 'Ethical Implications of Technological Advances in Business Communications', *Journal of Business Communications*, (Vol. 34, Issue 2, 1997), 160–170; B. Drake, K. Yuthas, J.F. Dillard, 'It's only words: Impact of technology on Moral Dialog', *Journal of Business Ethics*, (Vol. 23, Issue 1, 2000), 41; D.G. Johnson, 'Is the Global

relationship of social groups and power provided through the possession of technologies can be visibly seen. However, this assumption is difficult or impossible to prove given that a condition of sociocultural vacuum can never be realized. In lieu of that, this thesis proposes that prevailing worldview to be influential in the conception of a philosophy of technology that becomes the guideline for any technological development, especially in the environment of a civilization that is also a world power, such as the Islamic civilization that existed during the reign of al-Rashīd, al-Maʾmūn, al-Mutawakkil and al-Mustaʿīn– in which scholars were most active in translating works from other great civilizations including Greek and Persian and scientific discourses were celebrated across the empire.[33] This is especially given that within the Muslim civilization there has already emerged a scientific tradition.[34]

This thesis accepts the working definition of Islamic civilization as:

> ... a civilization that emerges among the diversity of cultures of Muslim peoples of the world as a result of the permeation of the basic elements of the religion of Islam which those peoples have caused to emerge from within themselves.[35]

Therefore, this thesis proposes that it is important to realize understand that Muslims of the past have developed solutions to problems related to elements that concerned them the most based on the worldview. This study may not be the first of its kind, as scholars have been attempting to establish causal link between Islamic thought and the development and growth of technological power.[36]

Information Infrastructure a Democratic Technology?', *Reading in CyberEthics*, R.A. Spinello, H.T. Tavani (eds.), (Sudbury: Jones and Bartlett Publishers Inc., 2001), MA.

[33] Such can be seen in the large number of translation work done by translators who have mastery over both languages Greek and Arabic, as in the case of Ḥunayn ibn Isḥāq who were under the employment of Banū Mūsā, and the polymath Thābit ibn Qurrah (d. 901 CE) who served under Caliph al-Muʿtaḍid (r. 892–902 CE). See also Al-Qiftī, *Ikhbār al-ʿUlamāʾ bi Akhbar al-Ḥukamāʾ*, Ibrāhim Šams-Al-Dīn (ed.), (Lebanon: Dar al-kotob al-ilmiyyah, 2005), 131–136; Ibn Abī Uṣaybiʿah, *ʿUyūn al-Anbāʾ fī Ṭabaqāt al-Aṭṭibbāʾ*, (Beirut: Manshūrāt Dar Maktabat al-Ḥayāt, 1965), 257–264.

[34] For the discussion on how a scientific tradition can emerge, please see Alparslan Açıkgenç's work *Islamic Scientific Tradition in History*, (Kuala Lumpur: Penerbit IKIM, 2014), 378–379.

[35] Syed Muhammad Naquib Al-Attas, *Historical Fact and Fiction*, (Kuala Lumpur: Universiti Teknologi Malaysia Press, 2011), xiv-xv.

[36] S.W.A. Husaini, op. cit., 2005, 12. See also Gunalan Nadarajan, *Islamic Automation: A Reading of al-Jazari's The Book of Knowledge of Ingenious Mechanical Devices (1206)*, academic paper

Therefore, what necessitated this development and growth in the form of creativity in feats of engineering is the prevailing worldview. In the case for Muslim engineering feats, the underlying philosophy of technology can occur with a worldview of Islām.[37]

Hence, questions such as the following are pertinent in this study: (1) What is Banū Mūsā's conception of technology and what are its aims? (2) What is Banū Mūsā's approach towards technology? (3) What are the variables, factors and causes that lead to technological development in the ʿAbbāsid era and the extent of Banū Mūsā's involvement in it? (4) What is the conception of knowledge during the medieval period and its relationship to technological development? (5) What sort of discourses on science happened during their milieu that may have formed Banū Mūsā's worldview influencing the formation of their technological ideas? (6) What are the intellectual connections between Muslim scholars of the past and Banū Mūsā that is reflected in their most significant contribution in technology?

Although there have been many books written on Banū Mūsā and other Muslim engineers they were largely on either translation of the book or the general history of development of science and technology during the so-called 'Golden Age' period of Islām; one that deals with the subject of philosophy behind the development of such technology from Muslim point of view is almost non-existent. This is because the present framework for the study of past technological development suffers what is also suffered in the history of science, namely, that the past is studied independently of the worldview and epistemic framework of the scientists and the technologists, leading to totally utilitarian assumptions that ultimately dismisses the existence of a philosophy of technology grounded in the worldview of Islām.

1.3 Objectives and Scope of Study

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presented at the REFRESH conference, First International Conference on the Media Arts, Sciences and Technologies held at the Banff Centre, Alberta, 2005.

[37] For an exposition on worldviews and mental structures, see Alparslan Açıkgenç, *Islamic Science: towards a definition*, 26–31.

The objective of this study is to examine and highlight Banū Mūsā ideas, on fine technology and its development, and to properly evaluate their contributions to the Islamic civilization. For this purpose, our study will be based on their treatises and monumental writings on automation and innovative engineering technologies.

Through analysis, some understanding of the Islamic concepts of technology, Islamic scientific tradition, power and energy can also be derived from the Banū Mūsā's unique outlook at life and philosophy of technology.

1.4 Significance of Study

Banū Mūsā's contribution to the development of technology is very significant to both Islamic and Western civilizations especially in the fields of mathematics and engineering. Waqar Ahmad Hussaini's summation that "a characteristic of Islamic civilization of the Middle Ages was the advances in mobilizing the sources of power and energy through the growing and more sophisticated uses of water and even wind power besides men and animals" emphasizes the importance of pioneering scientists and engineers during the medieval period as the crucial pivot where a civilization passed yet another stage in the development of power.[38]

Technology can also be the carrier of the culture in which it was borne, in the manner that it conveys information about those who have lived with them in the past, in addition to the mediation of language that negotiates ideas between worldviews. Also, by the same statement its philosophy can be obtained through the examination of its artifacts. In the words of Anderson Hunter Dupree:

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[38] S.W.A. Hussaini, "Energy: An Interpretative History of Islamic Thought, Engineering and Technology", *Journal of Islamic Science*, 12–14.

> The information system which is technology could not get very far without language, since the naming of things made efficient information exchange with the environment possible. Yet language is not the only carrier of technological information. Tools themselves transmit messages to their users even as energy flows through them to the environment. Society is also a carrier, for fathers, mothers, and masters pass on to sons, daughters, and apprentices information which they cannot verbalize and which is embedded in the skilled and practical eye-hand co-ordination of the artisan. No wonder that until the 20th century the best way to move technological information laterally in space in a short time was to transport skilled artisans.[39]

Many of the questions asked in philosophy of technology e.g. why and how a particular technology was conceived, cannot be answered without sound knowledge in the history of technology. For this reason, a number of philosophers of technology were also historians, and this can be found in the persons of Aristotle, Ibn Khaldūn, Jacques Ellul, Lewis Mumford, and Neil Postman, just to name a few. History is the language of philosophy, just as mathematics is the language of science.[40] It is through the indispensible effort of examining historical events and occurrences philosophers identify and describe phenomena as they unfold in history.[41]

Therefore, this study is also a preliminary examination on the development of fine technology (*al-ḥiyal*) in Islām and it is hoped that this it will help to arrive to a holistic definition of a philosophy of technology in Islām.

1.5 Research Methodology

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[39] A. Hunter Dupree, "The Role of Technology in Society and the Need for Historical Perspective", *Technology and Culture*, vol. 10, no. 4, (John Hopkins University Press, Oct., 1969), 528-534. See also Neil Postman, *Technopoly*, 14.

[40] Neil Postman, *Technopoly*, 13.

[41] Alparslan Açikgenç, *Islamic science: Towards a definition*, 17.

In order to understand the philosophy of a technology, one needs to examine the imperative; the reason a particular technology was conceived in the first place. This methodology is derived from the seminal work of the historian and philosopher of technology Lewis Mumford (1895–1990), *Technics and Civilization*,[42] and his later magnum opus the 2-volume *The Myth of the Machine*;[43] indispensible works on the historical development and philosophy of technology. It was in the course of reading these works as part of the literature review that Lewis Mumford's methodology of historiographical construction in bringing forth a philosophy of technology was found. Furthermore, Mumford put forth convincing argument on the medieval origins of modern technology in his *Technics and Civilization*, and based on this understanding, it is important to develop an understanding of the milieu first, before attempting to derive a philosophy of technology. Therefore, the methodology of this research includes utilizing available and established sources of history in order to construct a historiography and understand the milieu of Banū Mūsā, in the meantime examining the technological imperatives of their time and the motivations behind their work.

Therefore, historiographical tools are particularly useful for this study, which aims at acknowledging the fundamental elements of worldview that serve as pre-requisite for the conception of such a philosophy including the socio-psychological conditions, the scientific discourses and the discourses that revolve primarily around technology that were widespread during the time of Banū Mūsā.

In addition to using Syed Muhammad Naquib al-Attas's articulation on the worldview of Islām as the background of this study,[44] the research will also adopt semantic field analysis that he propounds.[45] In this thesis, the relevance of semantic field analysis can be seen since the Arabic language that Muslim scientists and philosophers used is built upon trilateral root system and by looking at conjugants

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[42] Lewis Mumford, *Technics and Civilization*, (New York: Harcourt, Brace & Company, first published 1934).

[43] Lewis Mumford, *The Myth of the Machine*, (New York: Harcourt Brace Jovanovich, vol. 1 published in 1967, vol. 2 published in 1970).

[44] See his magnum opus *Prolegomena to the Metaphysics of Islām: An Exposition to the Fundamental Elements of the Worldview of Islām*, (KL: ISTAC, 1995).

[45] As evident in many of his seminal works eg. *Islām and Secularism* (KL: ISTAC, 1993), *Prolegomena to the Metaphysics of Islām* (KL: ISTAC, 1995) and *The Concept of Education in Islam* (KL: ISTAC, 1999).

the attendant activities, the original meanings, and the ontology could be determined, especially with the utilization of *Lisān al-ʿArab* and other Arabic lexicons.

This study will also utilize descriptive and analytical methods for discussing the ideas of Banū Mūsā and their conception of technology and contributions in the field of mechanics, mechanical engineering, and fine technology. This will also be supported with an analysis of the available archival data and published materials, both primary and secondary, including on figures who have lived during the milieu of Banū Mūsā. In addition to that, this research will employ rational estimation with regards to establishing the causal link between the worldview and the concept of technology.[46]

The study will be based on primary and secondary sources. The primary sources include the existing earliest known manuscripts of *Kitāb al-Ḥiyal* (كتاب الحيل), the accounts of medieval biographers and historians, and works of translation by scholarly authority in the subject matter, namely Donald Routledge Hill and Ahmad Yusuf al-Hassan, and other experts in the history of medieval period and the development of engineering sciences and technology.[47]

With regards to previous work done by past scholars, Donald Hill (1922–1994) and Ahmad al-Hassan (1925–2012) both worked on available intact and fragmental manuscripts namely:

1. London, British Museum, Add. 23,391.
2. Paris, Bibliotheque Nationale, Catalogue Von G. de Slane, No. 2468, p. 437.
3. Oxford, Bodleian Library, No. 954, p. 95 (fragment manuscript, introduction part only).

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[46] According to Professor Syed Muhammad Naquib al-Attas in his recent work *Historical Fact and Fiction* (Kuala Lumpur: Penerbit UTM Press, 2011, xiv), "In view of this dearth of historical materials, much of our interpretation and explanation of past events will have to depend largely upon rational rather than empirical methods. Rational estimation must find credence from the empirical evidence of past facts." In proving this thesis's theory that worldview necessitated creativity in feats of engineering, it resolves to use this method.

[47] S.W.A. Husaini, "Energy: An Interpretative History of Islamic Thought, Engineering and Technology", *Journal of Islamic Science*, 13.

4. New York Public Library. Indo-Persian, Spencer Collections, MS 2. Risālā-i-Hakīm Muḥammad.
5. Topkapi Saray A.3474.

Donald Hill and Ahmad al-Hassan also worked with German translations and works pertaining to medieval engineering practices; the fruits of labor of Franz Hauser and Eilhard Wiedemann (fl. 1909). From the list above, Donald Hill judged the Topkapi Saray manuscript to be the best and most complete copy.[48] Since Hill and al-Hassan have worked extensively on editing and translating the manuscripts, with Topkapi Saray given the utmost attention, therefore it is not necessary for this study to acquire all the abovementioned manuscripts. In lieu of this, during the course of this research, a digitized copy of the manuscript Topkapi Saray A.3474 from Topkapı Palace Museum in Istanbul was obtained on 13th June 2013 for the purpose of verification and also visual identification and interpretation of motives and symbolic elements in the work. A number of folios from A.3474 will be illustrated in this study.

The secondary sources include published materials that deal with the issue of technological development, utilizing Banū Mūsā's writings and essays as sources in relevant libraries if necessary, and also references from philosophers and historians of science and technology.

As mentioned before, this study adopts historiography as a tool to examine the motivations of historical characters and also to explain the rise of the engineering sciences during their times. As mentioned before in the statement of problem, this includes putting forth an argument that bases itself on the idea that worldview can influence technological development and progression, and subsequently manifest this influence in the culture of a group of people, a community and ultimately a civilization.[49]

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[48] Donald R. Hill, "XII: The Banū Mūsā and their 'Book of Ingenious Devices'", *Studies in Medieval Islamic Technology: From Philo to al-Jazari – from Alexandria to Diyar Bakr*, David A. King (ed.), (Great Britain: Ashgate Variorum, 1998), 46–47.

[49] Lynn White Jr., *Medieval Technology and Social Change*, (Oxford: Oxford University Press, 1962), 130. Lewis Mumford, and later Neil Postman would also hold the opinion that ideological

As a disclaimer, this study examines not all but only some aspects of Banū Mūsā's activities and contributions. As stated before, it is intended to look into some of the fundamental elements of Islamic worldview that have formed at least part of their motivations, therefore the study is not exhaustive in nature.

1.6 Delimitation of Study

The difficulty is in the fact that there is a huge gap of time existing between Banū Mūsā and today (more than 1,000 years), and most of the twenty works produced by them regarding their field of expertise have been lost. Problems that may also be encountered include in procuring hard copies of the manuscripts including *Kitāb al-Ḥiyal*.

While no doubt extremely useful for deriving a philosophy of technology, this thesis does not utilize the analysis of artifacts left behind by Banū Mūsā simply due to the constraints of time and resources, aside from the concern that such a study maybe is more suitable for a doctoral or post-doctoral research wider and in-depth scope.

Although scholars such as Donald Hill and Ahmad al-Hassan, who have passionately dedicated significant portion of their lives studying Banū Mūsā in a more painstaking manner, held strong belief that Banū Mūsā had actually constructed and operated their devices during their lifetime, they also indicated that the artifacts may have not survived the passage of time, as the same fate that had

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and mythical functions control the outbursts of a society's energy or more specifically the technological development and the resources mustered to achieve it. See Lewis Mumford, *The Myth of the Machine: Technics and Human Development*, 2 vols., (New York: Harcourt Brace Jovanovich, 1966), 1:168; Neil Postman, *Technopoly*, 22–23 and 25. Therefore, for the intent and purpose of this thesis, these functions are treated as cultural elements that make up a worldview.

befallen the devices made by their successor Badīʿ al-Zamān Abū al-ʿIzz ibn al-Razāz al-Jazarī (commonly known as al-Jazarī, 1136–1206 CE).[50]

1.7 Organization of Study

Chapter 1 has briefly introduced the background of this study, which is on technology and the origination of the term. It also briefly explained the direction of this study with regards to comparing the significations of the conceptual terms from two civilizations that are central to the discussion, namely Greek and Muslim, while raising the issues pertinent to discussions in philosophy of technology. It also raised the pertinent questions, which will shape the entire direction of this study based on the scope of study and the research methodology being employed.

Chapter 2 concerns with historiographical reconstruction centered on the milieu of Banū Mūsā and their life work, which include the discussion on early Islamic civilization and the ʿAbbāsid society in which they have lived and worked. It also looks into the translation movement that was initiated by Caliph al-Maʾmūn and the establishment of important centers of research that had acted as catalysts for scientific and technological development in the milieu. In examining the milieu, the scientific conceptual schemes that may have influenced Banū Mūsā can be known. The legacy of Banū Mūsā insofar that their work have influences on later figures who followed in their footsteps is also examined in this chapter.

Chapter 3 examines the genesis of technological ideas, taking cue the development from ancient times into the ʿAbbāsid period. It examines the diffusion of science and scientific thoughts into the Muslim world from Greek, Persian and Eastern civilizations as described in Chapter 2. This investigation involves looking

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[50] Donald R. Hill and Ahmad Y. al-Hassan, "Engineering in Arabic-Islamic Civilization", *Ingeneria, Storia Della Scienza, Enciclopedia Italiana*, vol. 3, (Capitolo LI, 2002), 647–666. See also Donald R. Hill, *Islamic Science and Engineering*, (Edinburgh: Edinburgh University Press, 1993), 122.

into Greek philosophers' conception of technology and identifying conceptual commensurables in Muslim scientific thought.

Chapter 4 focuses on textual analysis of Banū Mūsā's seminal work *Kitāb al-Ḥiyal*. It briefly introduces the work and examines the key terms used and analyzes the semantic fields of each term. The terms *ḥiyal* (حيل) and *sinʿah* (صنعة), which represent the key ideas in Banū Mūsā's system of thought, are examined and explained, utilizing Arabic lexicons including Rāghib al-Isfahānī's *Mufradāt fī Gharīb al-Qurʾān*, Ibn Manẓūr's *Lisān al-ʿArab* and al-Tahānawī's *Kashshāf Iṣṭilaḥāt al-Funūn* and referring to authoritative works such as al-Khuwārizmī's *Mafātīḥ al-ʿUlūm* and Ibn Khaldūn's *Muqaddimah*. At the end of the chapter, several interpretative analyses of symbolic representations based on the motifs in *Kitāb al-Ḥiyal* will also be attempted.

Chapter 5 concludes the thesis by summarizing the significant contributions made by Banū Mūsā in the field of engineering and its development. It ends the discussion with suggesting the direction for future research into Islamic technology.

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