SCIENCE, TECHNOLOGY AND THE 19th CENTURY STATE: THE ROLE OF THE ARMY

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Edited by

KONSTANTINOS CHATZIS and EFTHYMIOS NICOLAÏDIS

NATIONAL HELLENIC RESEARCH FOUNDATION
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SCIENCES, TECHNOLOGIES ET CONSTITUTION DE L'ÉTAT AU XIX^{e} SIÈCLE : LE RÔLE DE L'ARMÉE

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Avant-Propos

Le présent volume est le deuxième ouvrage qui résulte d'une collaboration entre *l' Institut de Recherches Néohelléniques* (IRN*)* de la *Fondation Nationale de la Recherche Scientifique de Grèce* et le *Laboratoire Techniques, Territoires et Sociétés* (LATTS), unité commune à plusieurs institutions françaises de l'enseignement et de la recherche[1]. Le volume qui l'avait précédé dans le cadre de cette collaboration, intitulé *Science, Technology and the 19th century State*, vieux déjà de trois ans, réunissait une série de contributions qui tentaient d'explorer les relations cultivées durant le XIXe siècle entre un État (grec, français, anglais, portugais, en l'occurrence) qui se veut rationnel, d'un côté, les sciences et les technologies, instruments de la "rationalisation" recherchée, de l'autre. Le volume que voici, intitulé *Sciences, technologies et constitution de l'État au XIXe siècle : le rôle de l'armée*, garde la thématique générale de son prédécesseur tout en la précisant, puisqu'il se focalise sur un acteur particulier : l'armée. Si l'association de l'armée avec l'État se fait naturellement et sans surprise, –des guerres entre États parsemant l'histoire de l'humanité, et, de ce point de vue, le XIXe siècle ne constitue nullement une exception–, la connexion des militaires avec les "sciences et les technologies" mérite peut-être un petit commentaire. La collusion entre l'armée et la science (et la grande industrie) est de "notoriété publique" pour ce qui concerne les grandes puissances durant la période de la guerre froide. Mais cette alliance entre l'armée, d'un côté, les sciences et les technologies, de l'autre, loin d'être un phénomène récent, plonge ses racines très loin dans le temps. Sans avoir à remonter jusqu'à Archimède, notons qu'elle se développe de façon intense depuis la Renaissance et marque aussi le XIXe siècle ; elle

1. LATTS : unité mixte de recherche CNRS 8134, École Nationale des Ponts et Chaussées, Université Paris XII Val-de-Marne et Université Marne-la-Vallée.

concerne les pays du "centre" tout comme ceux qui appartiennent à la "périphérie". Dans les premiers, plusieurs savants fabriquent dans un cadre militaire de nouveaux savoirs scientifiques et technologiques qui, loin de concerner uniquement les seuls champs de bataille, vont vite s'échapper de leur lieu de naissance pour s'insérer dans le flux de la production scientifique et technologique de leur époque. Dans les pays de la "périphérie", l'armée figure très souvent parmi les cibles privilégiées des politiques de "modernisation" et va s'illustrer comme importateur de connaissances, de savoir-faire et d'objets inventés et utilisés d'abord dans les pays développés. Rien d'étonnant à ce que, dans ces pays de la "périphérie", des militaires se trouvent souvent très impliqués dans la mise en place des structures éducatives modernes ou assurent des tâches et des missions "non militaires" (prise en charge du secteur des travaux publics, par exemple).

Le présent volume réunit des communications présentées lors d'un colloque organisé conjointement par le IRN et le LATTS à Hermoupolis (Syros) en juillet 2000. Si la plupart des interventions portent sur les pays respectifs des deux institutions qui se trouvent à l'origine de la rencontre, à savoir la Grèce et la France, d'autres régions et pays du monde, comme l'Egypte, la Roumanie ou le Japon, sont également concernés, par le biais de l'action de missions techniques françaises notamment. Comme les recherches présentées dans le volume sorti en 2000, les articles qui forment le présent ouvrage ne se rangent pas sous une théorie générale qui tenterait d'expliciter le rôle de l'armée dans le commerce entre les sciences, les technologies et la constitution de l'État au XIXe siècle. De façon plus modeste, les auteurs de ce recueil se penchent sur des épisodes particuliers de ce commerce, en explorant le rôle joué par telle institution ou tel groupe militaire, voire tel officier. Nous espérons toutefois que le réseau de chercheurs construit à l'occasion de la collaboration entre le IRN et le LATTS pourra procéder bientôt à de véritables études comparatives, susceptibles de déboucher sur des enseignements à portée plus générale au sujet des relations entre les sciences et les technologies, d'un côté, la construction de l'État moderne, de l'autre.

Huit textes composent le présent recueil.

Nathalie Montel se penche sur la création de l'arsenal d'Alexandrie au début des années 1830, décidée par Méhémet-Ali dans son effort général de modernisation de l'Egypte et confiée à un ingénieur français du Génie maritime, Charles Lefébure de Cerisy. L'originalité de l'approche adoptée par l'auteur consiste en l'utilisation de l'arsenal d'Alexandrie comme un miroir dans lequel se reflète non pas l'Egypte mais la réalité française de l'époque en matière de construction navale militaire.

Anousheh Karvar décrit la façon dont la France aida la Roumanie et le Japon à réorganiser leurs armées respectives pendant la deuxième moitié du XIXe siècle, période riche en réformes pour ces deux pays, engagés dans le processus de construction d'un État à la fois national et centralisé.

Patrice Bret a choisi de traiter de la question de l'organisation de la recherche militaire française entre les années 1760 et 1830. Il montre que celle-ci, à travers la création de plusieurs institutions militaires, se trouve à l'origine même de la recherche publique en France.

Konstantinos Chatzis étudie l'organisation du corps du Génie et les multiples rôles assurés par ce dernier dans la Grèce du XIXe siècle. "Arme savante" créée en 1829, le corps du Génie remplit, jusqu'aux années 1880, des fonctions et des tâches qui relèvent, en réalité, des domaines de l'ingénieur des ponts et chaussées (aménagement des villes, travaux publics...) alors que ses membres s'illustrent également dans la transmission en Grèce des connaissances et savoir-faire élaborés en Occident.

Dans leur texte, Yannis Antoniou et Michalis Assimakopoulos décrivent le long processus de l'apparition et de l'"acclimatation" en Grèce de la figure de l'ingénieur moderne, processus qui s'étale sur une période qui va de l'indépendance du pays (1830) aux premières années du XXe siècle.

La contribution de Dimitris Vogiatzis est consacrée à la technologie militaire utilisée par l'armée grecque pendant le XIXe siècle, période durant laquelle des formations régulières "à l'occidentale" et des troupes "à l'ancienne" coexistent en son sein.

La question traitée par Andreas Kastanis dans sa contribution est celle de l'introduction et de l'enseignement de la géométrie descriptive en Grèce au XIXe siècle. D'inspiration française, cet enseignement est dispensé à l'Ecole militaire et à l'Université d'Athènes dès les années 1830.

Le rôle joué et la place occupée par les officiers de marine grecs dans le paysage scientifique de la Grèce du XIXe siècle font, enfin, l'objet de la contribution de George Vlahakis.

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(INR, Fondation Nationale de la Recherche Scientifique)

Forward

The present volume is the second book resulting from the collaboration between the Institute for Neohellenic Research (INR) of the National Hellenic Research Foundation and the Laboratoire Techniques, Territoires et Sociétés (LATTS), an entity common to many French education and research institutions[1]. Within the framework of this collaboration, another volume has preceded the present one three years ago, entitled *Science, Technology and the 19th century State*, bringing together a number of contributions, which attempted to explore the relationship during the 19th century between a state (Greece, France, Britain and Portugal, in this case), which thinks of itself as rational, on one hand, and on the other, sciences and technologies, instruments of a studied 'rationalization' on the other. This volume, titled *Sciences, technologies et constitution de l'Etat au XIXe siècle: le rôle de l'armée* [*Sciences, Technologies and the Establishing of the State in the 19th century: the Role of the Military*], holds to the general theme of the previous volume since it focuses on a particular agent, the army. If the association of the army to the state comes naturally and without any surprise –war between states is endemic throughout the history of humanity and, from this point of view, the 19th century is no exception– the relationship between the military and 'sciences and technologies' is worth a commentary. The collusion between army and science (and big business) is of common knowledge, in as much as it concerns the Great Powers during the Cold War. Yet, this alliance between army, on one hand, and sconces and technologies, on the other, is not a recent phenomenon at all, since its origins go way back in time. Without going as far back as to Archimedes, it develops intensively since the Renaissance and marks

1. LATTS : unité mixte de recherche CNRS 8134, École Nationale des Ponts et Chaussées, Université Paris XII Val-de-Marne et Université Marne-la-Vallée.

the 19th century as well; it affects the countries of the 'centre' as well as those of the 'periphery.' In the first ones, a number of scientists develop, within a military framework, a new scientific and technological knowledge, which far from concerning solely the battlefields, leaves its original place to incorporate into the flux of the scientific and technological production of the time. In the 'periphery' countries, the army is often a privileged target for 'modernizing' politicians and it will make its mark as an importer of knowledge, know-how and objects that were first invented and utilized in developed countries. Thus, it is not surprising, that in those 'periphery' countries, the military are often involved in the establishing of modern educational structures or that they undertake 'non military' tasks and missions, such as, for example, taking over public works).

The present volume consists of papers presented in a congress organized jointly by the INR and the LATTS in Hermoupolis (Syros), in July 2000. Although most of the papers relate to the two countries to which the above-mentioned institutions belong, namely, Greece and France, other regions and countries are concerned, such as Egypt, Romania or Japan, in particular through the action of French technical missions. As was the case of the volume published in 2000, the articles forming the present volume are not set under a general theory that would attempt to explain the role of the military in the relationship between sciences, technologies and the construction of the state in the 19th century. In a more modest fashion, the authors of this collection deal with particular episodes of this relationship, exploring the role of such institution or of such military group, or even of such officer. Nevertheless, we hope that the network of researchers born out the collaboration between the INR and the LATTS will soon be able to initiate real comparative studies, that eventually will produce new knowledge, of a wider scope, about the relationship between sciences and technologies on one hand, and the construction of the modern state, on the other.

The present collection comprises eight texts.

Nathalie Montel deals with the creation of the Alexandria arsenal, in the beginning of the 1830's, which was decided by Muhammad Ali in his general effort to modernize Egypt and assigned to a French naval engineer, Charles Lefébure de Cerisy. The originality of the author's approach consists in seeing the Alexandria arsenal as a mirror, reflecting not Egypt but the French reality of the time concerning military shipbuilding.

Anousheh Karvar describes how France helped Romania and Japan to reorganize their armies in the second half of the 19th century, a period rich in reforms for both countries, which were involved in the construction of a national and centralized state.

Patrice Bret deals with the question of the organization of the French military research between 1760 and 1830, showing that, through the creation of numerous military institutions, it is the origin of French public research.

Konstantinos Chatzis studies the organization of Engineer Corps and the multiple roles it held in 19th century Greece. An 'army of scholars' created in 1829, the Engineer Corps fills, until the 1880's, functions and tasks that in reality belong to the civil engineers' domain, while its members excel in transmitting in Greece Western knowledge and know-how.

Yannis Antoniou and Michalis Assimakopoulos describe the lengthy process of the advent and 'acclimatization' of the modern engineer in Greece, a process that spans from the country's independence (1830) to the beginning of the 20th century.

Dimitris Vogiatzis' contribution concerns the military technology used by the Greek army during the 19th century, when regular 'western' military formations and 'old fashioned' troops coexisted.

Andreas Kastanis deals with the introduction and teaching of descriptive geometry in Greece during the 19th century. Of French inspiration, this subject was taught in the Military Academy and the University of Athens since the 1830's.

Finally, the role and place held by Greek marine officers in the Greek scientific scene of the 19th century are dealt by George Vlahakis.

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NATALIE MONTEL

La Construction Navale Militaire Française au Prisme de l'Égypte

La création de l'arsenal d'Alexandrie au début des années 1830

Avec l'étude de la création d'un arsenal à Alexandrie au début des années 1830, on se trouve confronté à un thème devenu classique de l'histoire des techniques, thème que l'on désignait, il y a quelques années, sous le nom de transfert de techniques[1]. Aujourd'hui, on préfère l'évoquer en parlant d'échanges ou d'interactions entre connaissances scientifiques et techniques appartenant à des aires culturelles différentes, afin d'éviter la vision trop réductrice d'une relation univoque entre un premier pays dit " émetteur " et un second considéré comme " récepteur "[2].

La création d'un arsenal à Alexandrie relève en effet de ce type de situation : décrétée en 1828 par Méhémet-Ali (1769-1849)[3], vice-roi d'Égypte (1805-1849), elle est confiée à un ingénieur français du Génie maritime, Charles Lefébure de Cerisy (1789-1864)[4]. En décidant d'établir un arsenal moderne dans le port d'Alexandrie, l'intention du souverain égyptien est de faire du pays qu'il gouverne une puissance navale, de le doter d'une flotte capable de rivaliser avec les plus grandes et en mesure de s'opposer, le cas échéant, à l'escadre turque. Pour comprendre la décision du vice-roi, il est nécessaire de la situer sommairement dans son contexte. Il convient d'abord de rappeler qu'elle s'inscrit dans le cadre plus général d'un vaste plan de

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1. *L'acquisition des techniques par les pays non-initiateurs. Actes du colloque de Pont-à-Mousson, 28 juin - 5 juillet 1970*, Paris, Éditions du CNRS, 1973, 624p.

2. Voir notamment Patrick Petitjean, Catherine Jami et Anne-Marie Moulin (ed.), *Science and empires : historical studies about scientific development and european expansion*, London, Kluwer academicN publishers, 1992, 411p. Sur l'approche privilégiant la diffusion de modèles, voir le numéro spécial de la revue *History and Technology*, 1995, n° 2-3 : " Techniques, frontiers, mediation. Transnational diffusion of models for the education of engineers ".

3. Dans sa graphie arabe : Muhammad-'Ali.

4. Dénommé Cerisy dans ce qui suit.

développement agricole, industriel et commercial, engagé en Égypte depuis le début des années 1820, puis que ce programme de développement va de pair avec un accroissement de la puissance militaire terrestre du pays et l'organisation périodique de campagnes de conquêtes territoriales[5]. L'ambition de Méhémet-Ali est de fonder une puissance politique de premier ordre, mais aussi de constituer un État indépendant, en se libérant de la tutelle turque, ou, pour le moins dans un premier temps, d'acquérir une certaine autonomie vis-à-vis du Sultan. La possession d'une marine de guerre apparaît très tôt aux yeux du vice-roi comme " une condition première et indispensable "[6] dans la voie de son indépendance. Dès 1824, dans le but de constituer une flotte, il entreprend de commander des frégates à plusieurs arsenaux européens (français et italien notamment), mais ces premières expériences d'achats de navires de guerre à l'étranger sont sources de nombreux déboires et de diverses déconvenues, relatives notamment au délai de fabrication et au coût de revient[7]. Elles lui font notamment comprendre que, comme le dit un contemporain, " pour être indépendant, il lui fallait des tacticiens nationaux et un matériel fabriqué en Égypte "[8]. C'est pourquoi il décide de créer un arsenal moderne sur la côte égyptienne. Pour sa réalisation, il choisit de s'en remettre à Cerisy, qu'il connaît déjà, celui-ci s'étant occupé de la construction des frégates commandées à la France. La mission de l'ingénieur français est d'envergure puisqu'il s'agit de donner à l'Égypte les moyens de fabriquer des vaisseaux de guerre[9] aussi performants que ceux des puissances européennes[10].

5. La première conquête est celle du Soudan au cours des années 1820-1822. Un gouvernement égyptien est installé dans la ville de Khartoum, nouvellement fondée. En 1824, la Crête se soulève lors de la guerre d'indépendance grecque et elle est soumise par le corps égyptien, qui en garde possession. Dix ans plus tard, en 1831-1832, c'est au tour de la Syrie d'être conquise.

6. Georges Douin, *La mission du baron de Boislecomte : l'Égypte et la Syrie en 1833,* Le Caire, Institut français d'archéologie orientale, 1927, p. 118.

7. G. Douin, *Les premières frégates de Mohamed Aly (1824-1827)*, Le Caire, Société royale de géographie, 1926, 127p.

8. A. Colin, " Lettres sur l'Égypte : industrie manufacturière ", *Revue des deux mondes*, 1838, tome 14, p. 518.

9. En tête de la hiérarchie des navires composant les flottes de combat se trouvent les vaisseaux, portant de 80 à 120 canons, puis les frégates, de moindres dimensions, plus rapides et équipés de moins de canons, suivies par les corvettes et les bricks, qui jouent essentiellement un rôle de liaison.

10. Les navires de guerre construits en Italie et en France font partie de la flotte

Inverser la perspective

En présence de ce type de situation, trois séries d'interrogations sont habituellement développées. Une première série de questions concerne la politique étrangère de la France. Quelles sont en effet les intentions du gouvernement français, lorsqu'il autorise l'un de ses ingénieurs de la Marine royale à travailler pour le compte d'un pays faisant partie de l'empire ottoman, quand il aide, par conséquent, un vassal à s'armer contre son suzerain ? La deuxième série de questions touche à l'analyse des conditions et facteurs propices à l'"assimilation" par l'Égypte des techniques les plus récentes de la marine européenne que l'ingénieur français amène avec lui et tente d'enraciner dans le pays. Corrélativement, c'est la réussite ou l'échec du projet confié à Cerisy qu'il s'agit d'examiner minutieusement[11], considéré, bien souvent, dans la perspective d'une évolution de l'Égypte vers une " modernité " pensée comme universelle. Enfin, c'est sur les modalités pratiques des processus de transmission et d'acquisition de savoirs et savoir-faire qu'il est d'usage d'examiner en pareil cas. Et, dans une telle perspective, il est nécessaire de scruter la trajectoire de Cerisy, vecteur principal et médiateur central de la tentative de transmission de techniques, mais aussi de s'interroger tour à tour sur les compétences respectives des hommes qui l'accompagnent et l'épaulent dans on action[12], sur le modèle d'arsenal dont il s'inspire pour créer celui d'Alexandrie, sur la diversité des savoir-faire impliqués, contenus en particulier dans les machines ou objets techniques transportés à cette occasion, enfin de chercher à mieux connaître les dispositifs éducatifs

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turco-égyptienne coulée dans la baie de Navarin le 6 juillet 1827 par une escadre navale française, anglaise et russe.

11. Sur l'analyse de l'échec du programme d'industrialisation de l'Égypte, voir Jean Batou, " L'Égypte de Muhammad-'Ali. Pourvoir politique et développement économique ", *Annales ESC*, mars - avril 1991, n°2, pp. 401-428.

12. Sur ce point, voir notamment : Georges Durand-Viel, *Les campagnes navales de Mohammed-Aly et d'Ibrahim*, Paris, Imprimerie nationale, 1937, tome 2, p. 16 ou Gabriel Guémard, *Une oeuvre française : les réformes en Égypte, d'Ali-Bey El Kébir à Méhémet-Ali, 1760-1848*, Le Caire, Imprimerie Paul Barbey, 1936, p. 428. Cerisy demande que plusieurs ouvriers de Toulon qu'il désigne nominalement le rejoignent en Égypte, notamment trois maîtres charpentiers, un maître perceur et un contremaître des boussoles, mais aussi " dix ouvriers charpentiers de première classe, sachant tracer à la salle des gabarits, et six perceurs habiles ".

qui accompagnent l'opération : les structures d'enseignement technique mises en place sur le terrain pour former des hommes susceptibles de prendre la relève[13], les missions scolaires et les élèves envoyés en France en formation[14], l'importation et la traduction des ouvrages technique français[15], l'instauration d'écoles pour l'apprentissage de la langue française[16], etc.

L'approche développée ici est sensiblement différente : elle se propose en effet d'inverser la perspective habituelle, de la retourner, en considérant ce moment particulier d'un échange technique entre la France et l'Égypte comme une circonstance exceptionnelle permettant d'examiner la situation française, et non égyptienne. La construction navale française au prisme de l'Égypte : tels sont donc l'objet et le point d'observation retenus pour cette étude[17]. Dans l'histoire de cette expérience singulière que constitue le séjour professionnel de Cerisy à l'étranger, ce qui sera analysé c'est ce qu'elle peut nous apprendre sur

13. Il est explicitement mentionné dans le contrat d'engagement de l'ingénieur du Génie maritime, qu'il se chargerait " de former une école de constructeurs de maistrance, et d'organiser des ateliers d'instruction ". Est ainsi développé, lié à l'arsenal d'Alexandrie, le complexe scolaire de Ra's al-Tin. Sur ce thème voir en particulier Antoine-Barthélemy Clôt-Bey, *Aperçu général sur l'Égypte*, Paris, Fortin, Masson et Cie, 1840, tome 2, p. 240. et G. Douin, *La mission..., op. cit.*, p. 138.

14. Pour plus d'informations, voir Jean Bernardini, *Le port de Toulon et sa marine de 1815 à 1830*, Toulon, Blanchard, 1970, p. 92 : " des Égyptiens se trouvaient, presque en permanence, en stage à l'arsenal de Toulon. En juin 1827, un effendi et cinq jeunes égyptiens y étudient " l'art des constructions navales ". Ils travaillent comme apprentis sans solde, alternativement dans tous les ateliers du port. Après Navarin, le préfet maritime estima prudent de leur refuser l'entrée de l'arsenal. Mais le ministre ordonna, le 17 décembre 1827, de les recevoir à nouveau " ; René Cataui, *Le règne de Muhammad Ali d'après les archives russes en Égypte*, Le Caire, 1934, tome 1, p. 361 : lettre de Pezzoni à Nesselrode, le 18 novembre 1829 ; G. Durand-Viel, *Op. cit.*, tome 2, p. 42.

15. Concernant les sciences navales, Anouar Abdel-Malek signale notamment l'envoi en Égypte par le directeur des quais de Toulon d'un lot d'ouvrages, à l'instigation du consul de France Drovetti, et la commande par le vice-roi, en 1827, de livres sur les nouveaux navires construits à Londres. Anouar Abdel-Malek, *La Formation de l'idéologie dans la renaissance nationale de l'Égypte (1805-1892)*, Paris, Sérifloc, 1969, p. 132.

16. Thomas-Xavier Bianchi, " Catalogue général des livres arabes, persans et turcs imprimés à Boulac en Égypte depuis l'introduction de l'imprimerie dans ce pays ", *Journal asiatique*, 1843, 2, pp. 24-61.

17. Ce choix est redevable au livre de Jacques Proust, *L'Europe au prisme du Japon, XVIe-XVIIIe siècle, entre humanisme, contre-réforme et lumières*, Paris, Albin Michel, 1997, 316p.

la France. Il s'agit donc d'envisager cet épisode comme une occasion potentiellement révélatrice de certains traits caractéristiques des arsenaux français, un moment susceptible de voir se briser le silence qui entoure les situations ordinaires et de fournir à l'historien des informations inédites. Lorsque, comme c'est le cas de Cerisy, on cherche à imiter un modèle, à reproduire, certes en les adaptant, des façons de faire, il n'est pas rare que la démarche s'accompagne d'une réflexion critique sur le modèle dont on s'inspire et qu'on livre des informations qui d'ordinaire sont tues. L'hypothèse de départ de ce travail est donc que la construction d'un arsenal à l'étranger par un professionnel français peut mettre en lumière certains aspects demeurés dans l'ombre de la situation de la construction navale militaire française.

L'intérêt d'une telle démarche est double. Il est d'abord de modifier le point d'observation traditionnel, en proposant d'examiner la situation française de l'extérieur, à la lueur d'un événement exceptionnel. Mais il est aussi, et peut-être surtout, de ne pas tomber dans le piège du franco-centrisme, d'éviter de considérer ces moments de rencontres entre deux aires culturelles comme des relations univoques et de les analyser uniquement en tenant compte de points de vue français. Ce risque est encore plus grand quand, comme c'est le cas ici, les sources sont de langue française. Considérant par ailleurs que la position d'un point de vue intermédiaire ou entre-deux ne peut être qu'illusoire, il m'a semblé préférable d'analyser, à travers la relation franco-égyptienne, le partenaire français, en l'occurrence d'étudier le milieu de la construction navale en France.

L'étude du séjour égyptien de Cerisy (avril 1829-mai 1835) éclaire notamment trois points particuliers de la situation de la construction navale militaire française. Le premier concerne le statut professionnel et social de l'ingénieur du Génie maritime français sous la Restauration. Le deuxième a trait aux contraintes qui pèsent sur ce milieu technique. Enfin, c'est le lien étroit qui unit administration et technique dans les arsenaux français que l'expérience égyptienne de Cerisy souligne.

Une situation professionnelle frustrante

Cerisy débarque à Alexandrie en avril 1829. Ingénieur du Génie maritime, âgé de quarante ans, il se voit offrir par le vice-roi une situation exceptionnelle, à laquelle il n'aurait jamais pu prétendre en restant dans son pays. _ l'aune de la position qui lui est offerte par le souverain égyptien, il est possible de réévaluer sa carrière en France.

Une brillante position offerte par le souverain égyptien

Après deux années de scolarité à l'École polytechnique, de 1807 à 1809, Cerisy opte pour le corps du Génie maritime[18] et va, pendant un an, suivre les enseignements de l'école de Brest. En 1810, il est affecté au port de Toulon, où il passe l'essentiel de sa vie professionnelle. Il connaît un déroulement de carrière très classique, gravit régulièrement les échelons hiérarchiques pour atteindre, après dix années de services, le grade de sous-ingénieur de première classe de son corps, grade qu'il occupe encore en 1828[19], lorsqu'il signe son contrat d'engagement avec le vice-roi. Le nombre des ingénieurs de chaque grade, fixé par l'arrêté du 24 messidor an IX (13 juillet 1801), ne permet qu'à un très petit nombre d'élus d'accéder aux sommes de la hiérarchie. Le contrat de trois ans signé par Cerisy stipule explicitement que les fonctions qu'il sera amené à remplir en Égypte seront assimilables au grade d'ingénieur en chef de la marine. Cette embauche représente donc une promotion considérable pour l'ingénieur français, qui passe ainsi du grade de sous-ingénieur à celui d'ingénieur en chef, sans avoir eu à gravir les trois échelons d'ingénieur ordinaire prévus par la hiérarchie de son corps. En même temps qu'un grade que son âge n'aurait pu lui faire obtenir dans l'administration française, le vice-roi offre à Cerisy des appointements sans commune mesure avec ce qu'il pouvait espérer gagner un jour. En 1829, un sous-ingénieur de 1ère classe est payé 2 700 francs par an[20], tandis que son contrat mentionne un salaire annuel

18. La première organisation du corps des ingénieurs constructeurs de la marine remonte à 1765. L'ancienne École des ingénieurs constructeurs de la marine devint école d'application de l'École polytechnique le 22 pluviôse an IV (10 février 1796). Sur l'histoire du Génie maritime, voir, par exemple, *École polytechnique. Le livre du centenaire (1797-1894)*, Paris, Gauthier-Villars et fils, 1894, tome II : services militaires, pp. 161-248.

19. Le contrat d'engagement de Cerisy est reproduit dans Jean-Baptiste Vivielle, " Un ingénieur français au service de Méhémet-Ali, vice-roi d'Égypte. Louis-Charles Lefébure de Cerisy ", *Revue maritime*, 1926, 1er semestre, p. 181.

20. Vincennes. Service historique de la Marine (noté SHAM dans ce qui suit). CC7, dossier administratif de Lefébure de Cerisy.

de 19 000 francs[21], soit un montant sept fois supérieur. De surcroît, il est prévu que l'Égypte pourvoie à ses frais d'habillement, de nourriture et de logement et lui accorde, en outre, 4 000 francs pour ses " frais de route ". C'étaient là les bases initiales du contrat financier, mais le montant du salaire de Cerisy est révisé à la hausse à plusieurs reprises. En mars 1833, l'intéressé écrit qu'il s'attend à ce que ses appointements soient augmentés de 12 000 à 15 000 francs[22]. À en croire certaines sources, il aurait finalement perçu 60 000 francs par année passée en Égypte[23]. À son salaire annuel, s'ajoutent de surcroît les nombreux présents que lui fait le vice-roi. Ainsi, à chaque vaisseau mis à l'eau, Cerisy se voit récompenser d'une tabatière en diamants tandis que sa femme reçoit en cadeau un châle en cachemire, des présents qu'il évalue à 15 000 ou 18 000 francs[24]. En plus de ses marques de gratitude en nature, le roi manifeste sa satisfaction pour le travail accompli en lui décernant des décorations. Le 27 mars 1833, Cerisy se voit conférer le grade de général de brigade et est fait bey[25]. Deux mois plus tard, avec le grade d'amiral, il reçoit de nouvelles décorations en diamants. Il en éprouve une certaine fierté : " c'est très flatteur pour moi, car je suis le premier Européen à qui pareille faveur a été accordée "[26], écrit-il. Bien que gardant une certaine distance avec ce type de distinction honorifique[27], il s'avoue néanmoins satisfait

21. J.-B. Vivielle, *Op. cit.,* p. 180.

22. " Correspondance de Charles Lefébure de Cerisy avec Louis-Charles Beaucousin-Delignières ", *Société d'émulation d'Abbeville. Bulletin trimestriel*, n°3 et 4, 1922, p. 164 : lettre du 28 mars 1833.

23. Vincennes. SHAM. CC7, dossier administratif de Lefébure de Cerisy.

24. " Correspondance... ", *op. cit.,* p. 152 : lettre du 3 mars 1831.

25. J.-B. Vivielle, *Op. cit.,* p. 189.

26. " Correspondance... ", *op. cit.,* p. 165 : lettre du 3 mai 1833.

27. Dans une lettre que le consul de France, Mimaut, envoie à Mme de Cerisy à l'occasion de la naissance de son second enfant, on apprend que les cadeaux du vice-roi sont perçus par l'ingénieur du Génie maritime avant tout comme des symboles. Sachant bien ce qui ferait réellement plaisir à son mari, Mimaut écrit : " je vous prie d'inviter M. de Cerisy à m'envoyer l'instruction que je lui ai demandée pour lui faire faire par les préfets Mamours de son Altesse la collection d'insectes qu'il désire. C'est le moyen, si vous le voulez, de faire substituer aux vilaines choses que je viens d'être obligé de nommer [un second schall de même qualité et une nouvelle tabatière enrichie de diamans] une aussi grande quantité qu'on pourra le souhaiter de scarabées, de moucherons et de cousins ". Toulon. Service historique de la Marine. 23S08 (fonds Duroch), pièce 423 : lettre de Mimaut à Mme de Cerisy, 19 avril 1831.

d'être traité avec " grande considération " et flatté des témoignages de reconnaissance du vice-roi, les considérant comme un encouragement à poursuivre le travail engagé. En creux, c'est le peu d'égard manifesté par son ancien employeur, l'État français, qui apparaît. Et pourtant, lorsqu'il travaillait à l'arsenal de Toulon, son zèle avait été remarqué, comme en témoignent les appréciations portées à son sujet par les inspecteurs chargés de le noter. Ils décrivent un homme passionné, un travailleur acharné qui n'hésite pas à sacrifier son temps libre. L'un d'entre eux rapporte :

> *"Il a introduit plusieurs perfectionnements dans les ateliers en fer. Cet officier est particulièrement adonné dans ses moments de loisir à ce genre de travail dans lequel il excelle et dont il a transmis les résultats aux ouvriers sous ses ordres"*[28].

Deux ans plus tard, un courrier signé du ministre témoigne de la satisfaction de ses supérieurs pour l'activité déployée par Cerisy dans la réparation d'une corvette, et, en 1826, il reçoit une nouvelle lettre de félicitations de la direction du Génie maritime pour la façon dont il s'est occupé de l'école de maistrance de Toulon[29], assortie cette fois d'une gratification de 1 500 francs[30]. Mais cela reste bien maigre et, surtout, aucune promotion n'est en vue qui lui permettrait d'accéder à davantage de responsabilités.

L'Égypte : un exutoire pour les ingénieurs français

Dans les lettres que Cerisy envoie à son ami d'enfance abbevillois, l'ingénieur se confie à son correspondant, lui expose ses pensées, son point de vue sur les événements qu'il vit et lui fait part de ses sources d'étonnement[31]. Les objets qui fixent l'attention de Cerisy sont bien souvent ceux pour lesquels existe une différence importante entre les

28. Vincennes. SHAM. 6DD147, dossier n°864 : rapports de tournées de l'inspecteur général du Génie maritime au ministre, 20 octobre 1820. Je remercie Dominique Brisou de m'avoir signalé ce document.

29. " Toulon. Service historique de la Marine. 23S08 (fonds Duroch), pièces 426 et 428.

30. Vincennes. SHAM. CC7, dossier administratif de Lefébure de Cerisy.

31. Au total, vingt lettres, qui s'étalent du 9 février 1829 au 26 avril 1835 : " Correspondance... ", *op. cit.*, pp. 141-179.

deux milieux, l'ancien et le nouveau, celui dont il vient et celui dans lequel il s'installe, celui qu'il connaît et celui qu'il découvre. Il est ainsi naturellement amené à les comparer, fournissant ainsi à l'historien le moyen d'être renseigné à la fois sur l'un et sur l'autre. Ainsi, par exemple, une différence de taille entre sa nouvelle et son ancienne position, pointée par Cerisy, réside dans la proximité qu'il entretient avec son employeur. L'ingénieur exerce en effet ses fonctions en contact étroit avec le vice-roi, ce qui a notamment pour conséquence de permettre des prises de décisions rapides, auxquelles il n'est guère habitué. _ la différence de la situation qui prévaut en France, où chaque proposition doit gravir les échelons successifs de la hiérarchie avant d'atteindre les bureaux de l'administration centrale qui siège à Paris où la décision se prend et qu'ensuite la réponse suive le même cheminement en sens inverse, les décisions sont presque immédiates. L'ingénieur discute de ses projets ou des options possibles directement avec Méhémet-Ali, qui s'intéresse personnellement à l'arsenal et n'hésite pas à se rendre sur le théâtre des travaux pour en accélérer le cours[32]. Autre motif de satisfaction pour l'ingénieur français et autre contraste saisissant avec la situation qu'il connaît dans son pays : les conditions de travail. En Égypte, les crédits ou la main d'œuvre ne font jamais défaut lorsqu'il les réclame. Cerisy vit et travaille dans l'entourage du souverain égyptien, un peu à la manière des ingénieurs italiens de la Renaissance.

En réalité, plus que le grade, l'argent et les honneurs ou les conditions de travail, ce sont la possibilité d'accomplir une œuvre, l'opportunité de mettre son talent, son énergie et son savoir-faire au service d'un projet ambitieux, l'occasion de réaliser de grands travaux qui attirent l'ingénieur français en Égypte. Ces motivations, il les exprime dans la lettre qui accompagne sa demande d'autorisation de partir en Égypte faite à sa hiérarchie où il explique qu'il borne toute son " ambition à l'exécution de travaux remarquables "[33]. S'il traverse la Méditerranée, c'est sans conteste pour saisir l'occasion de montrer ce dont il est capable professionnellement. La tâche qui l'attend est de grande ampleur, l'arsenal d'Alexandrie étant à créer de toutes pièces. L'exaltation que ressent Cerisy à l'idée de diriger la conception de

32. R. Cataui, *Op. cit.*, tome 1, p. 361 : lettre de Pezzoni à Nesselrode, 18 novembre 1829.

33. Vincennes. SHAM. CC7, dossier administratif de Lefébure de Cerisy.

l'arsenal et d'en organiser la production rappelle les nombreux projets qui, pour une raison ou une autre, dorment dans les cartons et les armoires des bureaux de l'administration française. Quand elle se présente à lui, il saisit donc la chance qui lui est donnée de mettre en pratique son savoir.

L'énoncé de telles motivations renvoie au peu d'intérêt et à la faible importance des responsabilités que les ingénieurs du Génie maritime de son grade se voient confier à cette époque mais aussi au manque de perspectives qui s'offre à eux s'ils restent dans l'administration. Il faut en effet atteindre un grade élevé de la hiérarchie pour espérer conduire de grands travaux, mais surtout les chances de se voir confier la responsabilité de la construction d'un nouvel arsenal sont quasiment nulles, les infrastructures existantes étant, à cette époque, jugées suffisantes pour satisfaire les besoins. Dans le meilleur des cas, il ne peut être question que de l'agrandissement ou de la modernisation d'un arsenal existant. Cette situation suscite chez nombre d'ingénieurs du Génie maritime des frustrations et des rancœurs, dues non seulement au fait qu'ils s'estiment sous-employés et corrélativement sous-payés, mais surtout au sentiment que leurs talents demeurent inexploités et leurs mérites méconnus.

De retour en France, Cerisy n'acceptera plus de reprendre des missions dans son administration d'origine et il s'en explique :

> *" En quittant volontairement la position brillante que m'accordait le vice-roi d'Égypte, c'était pour jouir d'un repos qui me devenait nécessaire et je serais en contradiction avec moi-même si j'acceptais en France des fonctions bien inférieures à celles que je remplissais en Égypte depuis sept ans "*[34].

Il prend donc sa retraite à l'âge de quarante-huit ans. Il aurait aimé être reconnu dans son propre pays pour ses travaux en Égypte, mais il n'en est rien. Aigri de constater qu'en dépit des promesses faites à son départ, la France à son retour ne tint guère compte de l'état de ses services pour Méhémet-Ali et déçu de ce que son pays ne lui propose pas un poste à la mesure des aptitudes démontrées par son expérience égyptienne, il préfère se retirer[35] pour se consacrer à son autre passion, sa collection d'insectes.

34. *Ibidem*. Lettre du 19 août 1837.

35. Selon ses propres termes : " envoyer promener le Génie maritime ". " Corres-

L'Égypte fait ainsi partie des pays[36] qui offrent à la France du XIX^{e} siècle un exutoire aux ingénieurs qu'elle forme[37], mais auxquels celle-ci ne peut donner des missions d'envergure et des responsabilités importantes. Elle procure à des ingénieurs français animés du désir de se rendre utile et de réaliser de grands travaux l'opportunité de sortir des situations étriquées dans lesquelles ils sont confinés, leur ouvrant de nouvelles perspectives professionnelles. Ce faisant, elle permet d'éviter des sentiments de frustration, ou, pour le moins des déceptions, voire de l'amertume et des rancœurs de la part de ces ingénieurs employés par l'État et qui ne trouvent pas de travaux à réaliser en rapport avec les compétences qu'ils estiment avoir, mais aussi à la mesure de ce que les promesses tacites faites lorsqu'ils étaient élèves à l'École polytechnique leur avaient laissé entrevoir. Que des pays comme l'Égypte soient effectivement les seuls susceptibles de fournir aux ingénieurs du Génie maritime un terrain d'expression de leurs savoir-faire est un constat que fait également en 1850 le ministre de la Marine Charles Dupin, qui déclare :

> *" Si l'on veut juger ce que valent et ce que peuvent les officiers de notre Génie maritime, ce n'est pas dans nos anciens ports, où leur génie est arrêté par des rivalités collatérales, ce n'est pas là qu'il faut les voir à*

pondance... ", *op. cit.*, p. 150 : lettre du 25 juin 1830.

36. On pourrait également citer le cas du Japon, où l'ingénieur de la Marine François-Léonce Verny (1837-1908) conçoit, dirige et participe à la construction, à partir de 1865, du chantier naval de Yokosuka, ou l'expérience des chantiers navals de Fuzhou en Chine. Pour une étude comparative de ces deux expériences, voir Yamada Keiji, *Fabriquer des objets fabriqués. Les techniques françaises de construction navale dans le mouvement d'occidentalisation en Chine et dans la restauration Meiji*, document de travail, traduit par F. et M. Macé, journée d'études sino-japonaises, 6 mai 1995, 14p.Pour un développement du cas japonais à partir de sources françaises, on se reportera à Anousheh Karvar, *La formation des élites scientifiques et techniques étrangères à l'École polytechnique aux 19e et 20e siècles*, Thèse nouveau régime d'épistémologie, d'histoire des sciences et des techniques sous la direction de Dominique Pestre, Université de Paris VII, 1997, pp. 142-186. On pourra également consulter sur cet arsenal : Élysabeth de Touchet, " La création de l'arsenal de Yokokusa : la naissance de corps d'ingénieurs et d'ouvrier d'État au Japon ", *Le mouvement social*, n°193, octobre-décembre 2000, pp. 9-27.

37. Le thème de la colonie, terre d'asile pour les élites, est abondamment cinquante ans plus tard. Sur ce point voir : Yvan-Georges Paillard, " Une issue coloniale à la crise des ' élites ' de la fin du XIXe siècle ? ", *Le mouvement social*, n°138, janvier-mars 1987, pp. 45-59.

l'épreuve : c'est au-dehors, dans ces situations où tout est à créer d'ensemble. Tel on a vu il y a peu d'années M. de Cerisy créer comme par magie le matériel de la Marine égyptienne, tel on avait vu 20 ans plus tôt Tupinier régénérer la Marine vénitienne "[38].

Des perfectionnements techniques bridés

Cerisy connaît en Égypte une liberté ignorée de lui jusque-là. Sa latitude d'action est immense. Son but, il ne s'en cache pas, est de faire de l'arsenal d'Alexandrie un établissement modèle, intégrant les enseignements les plus récents des procédés français mais aussi anglais[39]. Le sentiment de liberté qu'il éprouve le conduit même à suggérer à l'un de ses amis resté en France de venir le rejoindre, lui expliquant non sans une certaine naïveté : " c'est, je crois, le vrai pays de la liberté, car on n'y fait que ce que l'on veut. Point de garde, point d'impôt, point de jury, point d'émeutes "[40]. Par comparaison, les contraintes subies en France lui sautent aux yeux.

Sur le plan technique, il profite de la liberté qui lui est laissée pour créer un arsenal fabriquant des navires conformes à ses convictions et vues personnelles en matière d'architecture navale. Cerisy introduit ainsi, sur les navires qu'il construit en Égypte, deux importantes modifications par rapport aux pratiques qui ont cours en France. La première a trait à la forme des carènes (coques de navires), la seconde à l'artillerie embarquée. L'amélioration des techniques liées à la construction navale dans le premier tiers du XIX^e siècle est encore essentiellement inspirée par la pratique. En particulier, la forme des carènes, fruit des expériences passées, échappe largement au calcul. Motif de débats et de réflexion à la fin du siècle précédent, la question de la meilleure forme à donner aux coques de navires fut tranchée par l'adoption de profils types, établis par l'architecte naval Sané (1740-1831)[41]. Des ordonnances fixaient ainsi les dimensions principales à

38. *École polytechnique...*, *op. cit.*, pp. 201-202.

39. Paris. Archives nationales, dossier de Légion d'honneur de Cerisy n°154 0027. D'août 1823 à mai 1824, Cerisy est en mission en Angleterre, où il visite les principaux ports militaires et de commerce du pays.

40. " Correspondance... ", *op. cit.*, p. 164 : lettre du 28 mars 1833.

41. Jean Bernadini, *Le port de Toulon et sa marine de 1815 à 1830, la reconstitution de la flotte française en Méditerranée*, Aix-en-Provence, La pensée universitaire, 1969, p. 140.

adopter pour chaque type de navires construit dans les arsenaux français. Les principes édictés par Sané devinrent une norme de laquelle il n'était guère possible de s'écarter. Et pourtant, l'expérience avait depuis fourni de nouveaux enseignements ; elle avait notamment démontré que la diminution de largeur traditionnellement opérée dans la partie supérieure des navires ne se justifiait pas. Prévue initialement pour procurer aux bateaux un moyen de défense en cas d'abordage, en ménageant un large espace vide entre les deux vaisseaux ennemis dont les coques se touchent, cette disposition avait en pratique montré sa faible utilité, les abordages étant peu fréquents et ne se produisant presque jamais de côté, mais par l'avant ou l'arrière du navire. Tenant compte de ces observations, Cerisy décida d'adopter, pour les coques des vaisseaux construits à Alexandrie, un profil en largeur qui ne se rétrécissait pas au-dessus de la ligne de flottaison. Une telle disposition offrait le double avantage de donner aux vaisseaux une plus grande capacité mais aussi davantage d'espace pour la manœuvre des canons embarqués[42].

La seconde innovation introduite par Cerisy concerne l'artillerie. Pour les bâtiments de guerre de la marine égyptienne, il établit une uniformité de calibre des canons, disposition maintes fois réclamée en Europe[43], mais pas encore entrée en vigueur. Plusieurs sortes de canons cohabitaient sur les navires de guerre : des canons longs, des canons courts et d'autres, appelés caronades. À chaque type de canon correspondaient des boulets de diamètre différent. On imagine le type de difficulté qui pouvait résulter d'une telle diversité au moment des batailles navales. Cerisy décida que les vaisseaux qui sortiraient de l'arsenal d'Alexandrie seraient équipés de canons différents mais lançant des boulets tous de même calibre. Ainsi, les " vaisseaux de 100 " embarquent 32 canons de 30 longs à la première batterie, 31 canons de 30 courts à la deuxième et 34 caronades de 30 sur les gaillards.

Dans la construction des navires de guerre égyptiens, Cerisy met donc en pratique les améliorations que son expérience dans les ports de France et ses observations tirées de ses visites dans les arsenaux anglais lui faisaient considérer comme préférables aux usages établis. Ces perfectionnements, longtemps réclamés par les constructeurs

42. *Annales maritimes et coloniales*, 1937, tome 2, pp. 1224-1225.
43. A.-B. Clôt-Bey, *Op. cit.*, p. 243.

français, n'avaient pu, en dépit de leur simplicité, être éprouvés en France. Cerisy trouve en Égypte un pays propice à l'application d'idées nouvelles, un espace de liberté et un laboratoire lui permettant de tester en grandeur réelle certains procédés qu'il n'avait pu expérimenter en France. En négatif, cette situation révèle un milieu français de la construction navale où les perfectionnements, pourtant reconnus comme nécessaires par les hommes de l'art, ont du mal à s'imposer, où les habitudes et les règlements font figure de freins et d'obstacles à la concrétisation des améliorations.

Il convient également de noter que les solutions adoptées en Égypte seront ensuite reproduites en France, appliquées aux bâtiments français[44]. Et c'est d'ailleurs bien là ce que recherchait Cerisy. L'ingénieur français et saint-simonien Charles Lambert, qui travaille également en Égypte à cette époque, note dans son journal à propos de son confrère de l'arsenal : " il veut forcer la France par l'exemple "[45]. Cette réflexion traduit bien l'état d'esprit dans lequel agit l'ingénieur du Génie maritime. Ne pouvant les introduire directement en France, il fait la démonstration de l'intérêt et du caractère bien fondé de certaines de ses propositions en les mettant en application en Égypte, espérant ainsi indiquer la marche à suivre et le sens du progrès. La France tire partie de ces essais, puisqu'elle adopte finalement les solutions qui ont fait leurs preuves de l'autre côté de la Méditerranée. La possibilité d'expérimentation qu'offre l'Égypte renvoie par opposition l'image d'une France où les innovations sont freinées, les initiatives bridées, où les résistances au changement sont fortes du fait notamment de l'existence d'un carcan administratif qui étouffe les idées nouvelles, en bref l'image d'un milieu technique routinier et quelque peu sclérosé.

Techniques et administration : deux facettes indissociables de la conception et de l'activité des arsenaux

Dernier point que l'expérience égyptienne met en relief, c'est la diversité des professions et des savoir-faire mobilisés au sein de l'arsenal, mais aussi la part d'organisation qui accompagne le fonctionnement de ce

44. *Ibidem*, p. 246.

45. Paris. Bibliothèque de l'Arsenal, Fonds Enfantin, FE 7828/12 : Lambert, *Journal du 4 février 1834 au 10 janvier 1835*, ms, note du 30 août 1834.

type d'établissement et la fabrication régulière de navires.

Peu de temps après son arrivée, Cerisy dresse le plan de l'arsenal à construire, mais aussi " fait les projets et les plans pour les colis, les magasins, les ateliers divers, les hangars, les machines ", " trace l'organisation de l'administration de la marine ", " rédige les marchés de fourniture "[46]. IL fait face à un ensemble de besoins intimement liés, endossant tour à tour des rôles qui, en France, sont distincts, " tout à la fois directeur général d'arsenal, directeur des constructions, directeur du port, directeur d'artillerie, directeur des ponts et chaussées, directeur d'administration, maître ouvrier de toutes les professions diverses, enfin apprenti de tous les états "[47]. L'arsenal est un véritable complexe industriel, qui se nourrit de savoir-faire diversifiés et où se rencontrent des activités à la fois économiques, techniques et administratives. Pour donner une idée de la multiplicité des techniques convoquées à l'intérieur de l'arsenal d'Alexandrie, en même temps que de la diversité des ateliers directement nécessaires à la construction navale, on peut se reporter au bilan des travaux réalisés que brosse en 1832 Clôt-Bey, médecin français au service personnel de Méhémet-Ali :

> *" Les principaux travaux opérés sur cette plage sablonneuse sont : quatre cales en maçonnerie et les avant-cales prolongées en mer pour les vaisseaux de 1er rang, trois cales pour frégates et bâtiments inférieurs, le magasin général pour le dépôt de toutes les munitions navales, la corderie avec ses machines pour le commettage*[48] *; les ateliers de forges, de la serrurerie, de la taillanderie*[49]*, de mécanique, de la fonderie, de la ferblanterie, de la plomberie, de la vitrerie, des instruments nautiques, de la poulierie, de la voilerie, de la garniture, de la tonnellerie ; les ateliers pour les chaloupes et canots, pour les cabestans, les gouvernails, le charronnage ; la salle de gabarits, une salle des modèles devant refermer tous les objets qui entrent dans l'armement des vaisseaux pour l'instruction des officiers, des hangars pour le dépôt et la conservation des bois de construction, les machines à curer, u ponton*[50] *de carénage "*[51].

46." Correspondance... ", *op. cit.*, pp. 146-147 : lettre du 26 juillet 1829.

47. *Ibidem*, p. 149 : lettre du 25 juin 1830.

48. Terme de corderie désignant la confection d'un cordage par la réunion de bris de torons tordus ensemble.

49. Fabrication des outils et fers tranchants.

50. Construction flottante formant plate-forme.

51. A.-B. Clôt-Bey, *Op. cit.*, p. 242.

On constate ainsi que les techniques de la construction navale sont solidaires d'un ensemble important de techniques industrielles, dans lesquelles entre en jeu un grand nombre de matières premières auxquelles s'attaches des savoir-faire spécifiques et des métiers très différents. Une grande partie des objets entrant dans la fabrication des navires est produite dans des chantiers et ateliers compris dans l'enceinte même de l'arsenal. Mais la construction navale s'appuie également sur un tissu industriel extérieur, qui lui est lié à des titres divers et qui en est plus ou moins éloigné géographiquement. Elle fait appel à un réseau de maisons de commerce qui facilite les approvisionnements en matières premières mais aussi en fournitures diverses. Côté matières premières, la structure du navire de guerre des années 1830 demande essentiellement du bois, mais aussi des éléments métalliques qui permettent de renforcer de nombreux points de l'ossature, des plaques de cuivre pour le doublage des coques et des toiles pour les voiles. Spécialistes de l'architecture navale, les ingénieurs de la Marine à l'époque de Cerisy se doivent d'être tout à la fois habiles charpentiers et bons mécaniciens. La pénurie de bois est un handicap fort pour l'Égypte auquel il est remédié en faisant venir du bois de chêne du golfe Adriatique[52], d'Ancône ou d'Albanie, des bois de mâture de la région du Danube et de Suède, d'autres de Toscane[53]. Les fers viennent d'Angleterre et de Russie[54], tandis que les ancres, les chaînes et les canons sont également des produits importés[55]. Mais Cerisy s'efforce de développer dans le pays des fabriques utiles au fonctionnement de l'arsenal. Une manufacture de toile à voile est ainsi organisée à Rosette, où se multiplient également les ateliers de forges et auxquels il est fait appel dans les moments de forte demande de l'arsenal[56]. Au Caire, des établissements sont formés où les ouvriers du Pacha fabriquent des toiles à voile, mais aussi des clous de toute espèce, des feuilles de cuivre doublage ou encore des plombs laminés[57]. Cerisy organise aussi l'instruction d'ouvriers cordiers qui,

52. R. Cataui, *Op. cit.,* tome 1, p. 414 : lettre du 23 avril 1831.

53. G. Durand-Viel, *Op. cit.,* tome 2, p. 115.

54. G. Douin, La *mission..., op. cit.*, p. 120.

55. Edmond Jurien de la Gravière, *La marine aujourd'hui*, Paris, Hachette, 1872, p. 240.

56. *Ibidem*, p. 253.

57. J.-B. Vivielle, Op. cit., p. 186 : lettre écrite par Cerisy d'Alexandrie au ministre

dans les villages, confectionnent les fils de caret nécessaires au gréement des vaisseaux et emploie dans les corderies de la marine de guerre le chanvre cultivé depuis peu dans la plaine du Caire[58].

Moyen de satisfaire des intérêts militaires, la création d'un arsenal constitue aussi un élément moteur du développement d'un véritable tissus d'entreprises locales et contribue à introduire des savoir-faire techniques nouveaux, qui, à l'instar du travail des travaux, peuvent être utilisés dans d'autres secteurs. L'arsenal maritime d'Alexandrie ne tarde pas à devenir le plus important centre industriel du pays, d'où sortent des instruments de précision pour la navigation, mais aussi des machines de génie civil, notamment des dragues pour le chantier du barrage du Nil[59], une machine à receper les pieux sur le modèle de celle qui existait à Toulon[60], ou encore une embarcation spécialement conçue pour le transport de l'obélisque de Louxor[61], donné à la France par Méhémet-Ali et installé sur la place de la Concorde à Paris.

On conçoit aisément que pour coordonner l'ensemble des activités à l'intérieur comme à l'extérieur de l'arsenal, assurer la complémentarité des travaux d'un aussi grand nombre de corps de métiers, satisfaire à la gestion des approvisionnements aussi bien que du personnel, en même temps qu'à la fabrication programmée d'une flotte complète, il était nécessaire de disposer d'un système d'organisation et d'administration efficace. Gérer, administrer et organiser, est également affaire de savoir-faire. Et dans ce domaine, comme dans les autres, c'est le système français qui sert de référence et que Cerisy s'efforce de reproduire. Il conçoit l'organisation de l'administration de la Marine égyptienne d'après celle qui existe en France[62]. Des manuels français sur le sujet sont traduits en turc. Les règles de l'organisation de la marine et de l'arsenal sont mises en place en étroite collaboration avec Osman bey Nourredin, haut fonctionnaire égyptien formé en Europe.

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de la Marine, le 9 décembre 1831.

58. G. Durand-Viel, *Op. cit.*, tome 2, p. 114. G. Guémard, *Op. cit.*, p. 347.

59. Émile Barrault, *Occident et Orient. Études politiques, morales, religieuses pendant l'année 1833-1834 de l'ère chrétienne, 1249-1250 de l'hégyre*, Paris, Dessessart, 1835, p. 444. G. Guémard, *Op. cit.*, p. 320.

60. Bibliothèque de l'Arsenal. Fonds Enfantin. FE 7828/12. Lambert, *Journal du 4 février 1834 au 10 janvier 1835*, note du 19 juin 1834.

61. Vincennes. SHAM. CC7, dossier administratif de Lefébure de Cerisy. Lettre du consul de France Mimaut à Cerisy, 20 décembre 1837.

62. G. Durand-Viel, *Op. cit.*, tome 2, p. 17.

En dépit de cette aide précieuse, les difficultés liées à ces questions d'organisation et d'administration restent les principales pierres d'achoppement des efforts de Cerisy[63], celles qui présentent le plus de résistance et qui seront en partie causes de son départ. Il est également à noter qu'une fois Cerisy parti et remplacé à la tête de l'arsenal, c'est le système administratif que l'ingénieur français a tenté de mettre en place que l'on s'empresse en priorité d'abandonner[64]. Les difficultés rencontrées par Cerisy mettent en lumière une dimension importante du système technique français de la construction navale, une composante dont on parle peu : la dimension administrative et organisationnelle, qui est conçue comme étant à la fois complémentaire et indissociable des procédés mis en œuvre. Pour construire un navire, il ne suffit pas de disposer de charpentiers, de forgerons, d'écoles et de bons fournisseurs, il apparaît également indispensable de posséder des connaissances et compétences en matière d'organisation et de gestion, des secteurs particulièrement développés dès cette époque dans l'administration militaire française.

Par ses lettres, Cerisy entend informer son correspondant abbevillois sur sa vie et son expérience professionnelle à Alexandrie au début des années 1830. Les nécessaires comparaisons qu'il introduit pour se faire comprendre, comme les choix des sujets sur lesquels il s'exprime ou les objets de son étonnement à l'occasion de la découverte de ses nouveaux environnement et conditions de travail renseignent aussi, directement ou indirectement, sur sa situation antérieure. C'est cet aspect de son témoignage qui a été exploité ici, en complément des informations livrées par les témoignages ou les sources de nature administrative dont on pouvait disposer. En particulier, il permet de saisir le décalage qui existe alors entre les aspirations professionnelles de l'ingénieur du Génie maritime et le travail qui lui est demandé, mais aussi de mettre en lumière l'existence d'obstacles s'opposant à l'adoption de perfectionnements techniques. Il souligne enfin l'intrication des aspects organisationnels et techniques dans la conception française des arsenaux de marine.

63. *Ibidem*, p . 147.
64. *Ibidem*, p. 150.

ANOUSHEH KARVAR

MODERNISING THE STATE BY REORGANIZING THE ARMY : 19th CENTURY ROMANIA AND JAPAN

Throughout the 19th century, France, with its state corps and its complex civilian and military engineer training was a good technocratic model of recruitment for civil servants on the basis of scientific and technical merit and expertise. The civilian and military profile of the French *École polytechnique* graduates was the result of a perfect integration of scientific structures in the state command. This result served as an example for many states in construction.

The goal being to guarantee supremacy in case of military confrontation, the application of science in the fields of defence and territorial development became a state affair. The engineer and the officer were the main actors of state modernisation.

In this paper, I will describe the way France aided Romania and Japan during the second half of the 19th century. During this period, Romania achieved independence after two and half centuries of ottoman domination while Japan entered in a new era after the Meiji revolution.

On the French side, the officers sent abroad in mission to the Romanian and Japanese governments were greatly influenced, in their action, by the international political atmosphere.

The strong foreign policy during the Second Empire took advantage of Romania's and Japan's demand to increase its economical expansion. The military, scientific and technical activity of the French officers was able to develop in a climate of mutual understanding. With their help, many infrastructures were achieved, training schools for technical executives were constructed and contingents of young people were sent in French engineering schools. These arrivals were taken in charge by their native countries and were supported by the French diplomacy.

But the French officers were also affected in their action by the aftermaths of international conflicts. After 1870-71 war, France entered in a phase of isolationism : France's welcoming policy towards the foreign students sent in military schools changed after its defeat against Germany. The hardening of the attitude of the French ministry of war can be explained by the progress of the French armament in artillery, and therefore by the "confidential" value of the teaching given in military schools.

In the meanwhile, the diplomats and military *attachés* sent in mission in these countries insisted on the advantage of instructing young foreigners in France. This instruction could be used according to them as an effective mean to control the elites. A note on the admission of foreign officers in French military schools illustrated this point of view : " *the foreign officers who have received instruction and education can be considered as genuine agents of French influence*"; another note : "*the systematic closing of our military schools to foreign officers deprives our diplomatic and military representatives of a serious mean of action and is a harm to the French interests*"[1].

In the 1880s, with the impulse of men on the field, this way of considering the foreign students, that is to say, as future elites and not as factors of institutional trouble, redefined favourably the political behaviour to their regard. The diplomacy began to put pressure on the ministry of War in order to encourage the reintegration of foreign officers in French military schools.

Until the First World War, the French ministry of War's position was characterised by a row of restrictive and liberal policies. At the same time, modifications which occurred on the international scene such as the demand to diversify the sources of foreign aid, were favourable to the increase of German influence in the armies of both Romania and Japan.

Romania

In 1856, the treaty of Paris freed the two principalities of Moldavia and Valachia from ottoman domination and for the time being and waiting for a future independence, placed them under the collective protection of great European powers.

The Romanian movement of national unification, definitely inspired by France, was in its major part the work of a first generation of

1. Army Staff Papers, September 1896, Archives du Service historique de l'armée de terre : 7N665, Officiers étrangers.

Romanian students exiled in Paris after the repression led by the Russians and the Ottomans of the national and liberal movement in 1848. After independence was eventually achieved, France was promptly designated as administrative and political model and was in charge of the training of future executives of the Romanian state.

The organisation of the army, the creation of a court of expenses and of a state council inspired by the code of Napoleon were part of the conquest of the administrative and military apparel by the sons of great Moldavian and Valaquian landowners (*boyards*) trained for the most in Paris.

In 1857, France received its first demand of military assistance: it consisted in sending officers to instruct the troops, organise the Supply Corps but also reconvert the military schools of Bucharest and Iasi. It was also planned in this context to send an important number of young men to make studies in *Saint-Cyr* and in the *École polytechnique*, and also to help young lieutenants from Romanian military schools finish their training in schools such as the *École d'État Major*, *École de l'Artillerie et du Génie de Metz* or in *École de Cavalerie de Saumur*.

The conflict between Russia and Turkey from 1877 to 1878 prepared the proclamation of independence in Romania and prince Charles of Hohenzollen who replaced prince Cuza in 1866 became king Carol the First. The participation of Romania in this war on the sides of Russia stood as an initiatory experience in the modernisation of the army. The young romanian officers who had made their studies in the *École polytechnique*, and then in the *École de l'Artillerie and du Génie* found this war was an opportunity to prove their abilities and their supervision qualities.

This transformation of the Romanian army was carefully observed by military *attachés* and French officers during their visits in the country. The report of a French staff officer mentions still in 1874 the lack of officers in the command of an army that was still new and artificial and where all posts were occupied by a small aristocracy. Ten years later, another military reports spoke of the considerable progress which had been made since the war and where young officers trained in France had been able to show their value : "*Today (1884), the polytechnician officers are still put aside but in a couple of years, their arrival in superior ranks is the guarantee of the suppression of privileges and of the progress according to a specific hierarchy*"[2].

2. Captain Blanche's Report, April 12, 1884. Archives du Service historique de

Nevertheless, the Romanian state remained a fragile and unfinished construction and was subject to many political and economical rivalries of European powers. The French military reports emphasised on the uncertain relationship of this young nation with Austria, Russia and Germany. In the prospect of a coming European war, the reports say : *"It is for us to change the balance by helping (the Romanians) access our schools"*[3].

However, the territorial division imposed by Russia to Romania at the end of the war between Russia and Turkey in 1877 was not to the benefit of Romania and relations between the two countries had ever since been tense. Besides, the Romanian monarch, because of German ascendants was rather in favour of Germany in his international policy. Thus, in 1883, Romania signed a treaty of defensive alliance against Russia with Austria-Hungary. Romania took part the same year to the Triple-Alliance set up by Germany, Austria-Hungary and Italy a year earlier. Romania became thence open to German diplomatic influence.

Pro-French political circles in Romania expressed their misgivings to this moving closer with Germany but the French diplomacy had adopted a policy of caution in the Balkanic countries since the defeat of 1870 and did not attempt anything to recover its situation.

Consequently to its new international orientation, Romania trained most of its military executives in German, Austrian and Italian military academies.

How was this diversification of military assistance sources in Romania seen by foreign observers in general ? And by the French military *attachés* especially ?

They positioned the individuals on the political scene, both foreign and domestic, according to the country where they had been trained. A *Times* article from February 1892 described the members of the "junimist" party as Germanophils, because : *"They have been educated for the most part in German Universities, and have always sung the praises of Teutonic learning and culture"* in contrast with the general movement of the members of the liberal party who considered a trip in Paris as an essential part of building of a political career : *"the young gentlemen who go abroad to complete their education generally*

l'armée de terre : 7N1451, Roumanie 1834-1895.

3. Army Staff Papers, September 1896, Archives du Service historique de l'armée de terre : 7N665, Officiers étrangers.

go to Paris, and return home enthusiastic Francophils" [4].

This way of thinking did not take in account the inherent paradox to a cultural nationalism based on imported ideologies. This paradox made the young Romanian intellectual's nationalist movement burst in 1848 in different political parties who struggled between the affirmation of a national culture and the assimilation of imported values from across occidental Europe, and not only from France.

The French military *attachés* insisted on re-establishing the former image of 1848 generation who was unanimously influenced by French culture. They asked from the French government to take in charge the destiny of the new generation of the post-independence period and give it a French orientation. This generation was strongly divided on many issues such as the definition of its moral unity, relationship with the West and with the working-class people in society. The military *attachés* put forward the rivalries between France and Germany to justify their demand.

These same *attachés* were indignant at the counter-examples that they encountered here and there: officers trained in France but who were ungratefully attracted by Germany. To their eyes, the francophil feelings of these men were under the influence of the germanophil Romanian monarch. This situation had to be quickly remedied by France.

Despite all these tensions, Romania seemed to possess an army satisfying the bureaucratic needs of modern state. Two reports: the first written in 1899 by Emile Bernard, lieutenant in a territorial infantry and editor in the ministry of War, the other written by the Romanian military commission for the Universal Exhibition in Paris draw out a detailed assessment of the military organisation of this country :

— The army was made out of three major elements : the active army, the militia, and the massive recruitments.

— The military conscription was obligatory and personal.

— The grade (or brevet) of officer was the property of the officer who had obtained it after studies in a military school in his country or in a foreign country.

— The promotion from one grade to another was achieved by an exam after having reached a minimum length of service.

— From the grade of colonel, the promotion could be made

4. This article is attached to Captain Sailly's Report of July 2, 1892. Ibid.

according to the hierarchy's demand.

— Romania possessed a full range of military schools : academies, schools for sub-officers, officers, artillery and military engineering schools, Cavalry schools, Superior school of War,...[5]

Japan

In 1850, Japan was still part of the countries with whom Europe had not yet established intensive economical relations. The distance and the cost of transport to Japan on the European side, and the isolationist policy carried out in Japan since 1603 by the *Shogun* Tokugawa on the Japanese side, had both foiled the exchanges between merchants and missionaries. The United Sates, the closest geographically speaking country, acted as pioneers in 1853. American military vessels under the command of commodore Perry besieged the Japanese coasts and required the opening of the ports to foreign exchange. Under military constraint, Japan had to review its policy : the first "treaties of friendship and of commercial exchange" were signed between 1854 and 1858 with the United States, Holland, Russia, Great Britain and France.

Confronted with a military threatening West, Japan kept in mind China's defeat in 1842 in the War of Opium. It accelerated the modernisation of its army, especially the naval fleet. In this context, the *Shogun* Tokugawa planned to build up a shipyard near Tokyo and asked the French government for technical advice. The choice of France for the foundation of the first major Japanese shipyard was prepared since a couple of years i/ by the French diplomats working in Japan; ii/ by a favourable linguistic comprehension prepared for a couple of time by Frenchmen such as l'abbé Mermet de Cachon who created in 1865 a Japanese interpreting school known as the *Collège français de Yokohama* [6]; iii/ by a group of Japanese Francophils who consolidated the alliance between France and Japan and thus, helped in many projects such as Franco-Japanese College, naval building sites, French military missions in Japan.

5. L'Armée roumaine en 1900. Notice publiée pour l'Exposition universelle de paris par la commission militaire roumaine, 1900.

6. The students who came out of this school became interpreters in the Japanese administration or in French military missions.

On the field, the first achievement of Fraçois-Léonce Verny, a French polytechnician and naval engineer who was designated for the mission, consisted in supplying Japan with its first modern shipyard. The project also included the construction of a repair workshop which was meant on one hand to keep in good order the ships that Japan had bought to other countries and on the other, to train a group of Japanese workers for different jobs necessary to the functioning of the shipyard.

The first stage of building the shipyard was accompanied by the creation in 1867 of a technical school with two distinct branches. The first one, a full-time school, was destined to train shipbuilding engineers, chosen within the *Samurai* class. The programme was inspired by the courses given in the *École polytechnique* and the *École d'application du Génie maritime*. Professors were appointed among the French personnel of the shipyard, assisted by Japanese interpreters. The second offshoot was part-time school for training foremen, compulsory for all shipyard workers aged fifteen and above. They were taught Japanese language, the metric system, the Arabic numerals, along with the practical training they had under the supervision of the French foremen.

When Japanese frontiers were opened to commercial trade with European countries, in 1853, France and Britain followed opposite foreign policies leading to conflicting alliances. France associated itself with the Tokugawa Shogun and Britain with the rebels who seized power and restored the Meiji Emperor in 1868. Allied with the rulers, the British succeeded in imposing their model and material on the Japanese navy.

For these political reasons, the Japanese government did not bring logistic support to the ambitious project of training engineers. A dozen of its best students were sent to France to complete their training at the *École du Génie maritime*, while the others were transferred to the British Naval School in Tokyo.

Paradoxically enough, the system of industrial apprenticeship initiated in the Yokosuka shipyard has had a much more lasting success. It spread throughout Japanese industry by means of the numerous workers it produced.

The balance of alliances threatened the continuation of work on the site of Yokosuka. In spring 1868, the French staff was invited to withdraw from Yokosuka and go to the port of Yokohoma. F.-L. Verny and the minister L. Roches led a double offensive and managed to obtain the permission to continue their naval mission a couple of years more. In 1877, one year after Verny's departure to Japan, the shipyard was entirely ran by a Japanese staff who was assisted by a few American experts.

During the transitory 10 years period (1868-1877), an organisation of compromises was established by the Japanese government for two different reasons: first, it consistsed in obtaining a narrow control on the finances of the shipyard. After great expenses due to the setting up of new infrastructures, Japan's economy seemed to be weakened.

Second, Japan sought to obtain political independence regarding other foreign powers for projects that concerned its own national sovereignty. Verny considered these as *"premature aspirations of independence"* against which he must resist. He then sent a French emissary to the Japanese government. In a letter to the minister of the Marine dated of August the 5th 1875, he distinguished two tendencies among the Japanese: *"Some accept frankly the participation of foreigners to replace the learned people which they lack of and develop the production of their country and the instruction of the youth. Others accept the service of foreign organisations only for a short period of time"*[7].

The exchanges of this French officer with his administration beholds altruism mingled with a certain moral connotation especially when he justified the immaturity of the Japanese to take in charge their own affairs or else, when he pleaded in favour of the instruction of workers and executives. For him, Japan was not yet an adult nation and was incapable of exploiting its resources by its own.

In the first moments of Yokosuka project, a collusion occured between the Christian mission in which our lazarist polytechnician felt totally invested and the Second Empire for which he stood out as the official missionary. But, just as for its military assistance in Romania, France politically abandoned the project of the shipyard in the 1870s.

With the Third Republic and the forthcoming colonial era, the right of civilisation of the civilising nation lost its religious attributes to become a more offensive laic and republican project. In the case of the French naval mission in Japan, the attempts to reorganise according to

7. « Mes relations avec les autorités françaises et japonaises pendant ma mission au Japon, 1865-1876 », Lyon, December 10, 1876. Private papers and correspondence of Léonce Verny (Aubenas, France).

this new strategy came too late and did not succeed in maintaining French influence in these countries. We can read in official reports : *"The mission at the head of which is placed L. Verny is a civilising mission that profits to the people who had the fortunate inclination to turn towards us. This mission profits to France who can, by the mean of this project, establish its influence and extend itself on a political, commercial and industrial point of view. It would be a pity to put it to an end..."*[8].

The administration conferred to the polytechnician engineer the status of an agent at the service of political and economical interests of the colonial state, that of a new type of missionary endowed with technical knowledge.

The way this technical knowledge was acculturated depended certainly on the environment in which it was implanted in terms of modernising strategy and political options but also on the scientific and technical profile of the actors of this transplantation.

The illustration comes from the comparison between a Japanese project and the project led by a French ship lieutenant, P. Gicquel at Fuzhou in China, at the same period of time. Verny, as a polytechnician engineer, was conscious of the fact that a long period of formation was necessary before becoming knowledgeable professional. He put forth the *making-of* instead of the made object and thus the building up of small ships and repair workshops. Furthermore, Verny considered technique as an economical action. According to him, economical efficiency was a major actor to sustain and develop the making-of and therefore *profit* from these reparations.

Giquel, a ship lieutenant was an officer in the navy. He insisted on training to read fabrication plans and plans for the construction of models. The building site of Fouzhou rapidly became operational in the fabrication of copies. The Chinese project was based on the *making-of*. But as Giquel was a technician, he was not able to control the *costs*.

For Verny, the formation of the local staff was a long process which required a strong theoretical instruction, especially in mathematics. It could only be given out to a social elite. As soon as they had finished their complementary training, we find back his students, at the Naval Military Engineering School in France and at teaching posts in the

8. Archives du Service historique de la Marine : dossier Verny : BB3 864.

future Faculty of Engineering of the University of Tokyo.

The shipyard of Fouzhou also consisted of several training centres. But it included a more practical complementary training where pupils learnt *"enough mathematics to construct a ship from any given plan"* and *"to be aware of the functioning, of the dimensions and of the role played by the different parts in order to be able to draw and reproduce each separate structure..."*[9].

In the meantime, at the naval mission, the French government sent three military missions in Japan orientated to train the executives of the army in the infantry, the cavalry and artillery and the military engineering (1866-1868), (1874-1879), (1884-1888). I will not describe these missions further in detail but they followed the same scheme of implantation and achievement as the military missions in Romania and as the naval mission in Japan.

The choice of France for the instruction of its troops which was first dictated by the interplay of political alliances under the shogun government was perpetuated at the beginning of the Meiji era. A delegation was first sent in Europe to observe the different military systems. They then decided of a decree which put an end to the eclectic choices taken until then by the fiefs in an effort to centralise their troops and to create a united army.

Alike to the Romanian case, the foreign officers trained by French missions took part in a war that put in application their instruction. It was a campaign against the insurrection of the *Samurais* in the South West of the country that came to an end on September 1877 after the victory of the army of Emperor at Satsuma.

At the same time as the process putting an end to the naval mission in Yokosuka, the Japanese authorities took in measures to diversify their sources of assistance and to gain autonomy. A second trip of the high command of the Japanese army in Europe in order to visit the military organisation of the great nations, was marked by the adoption of the Prussian model.

Throughout all the reports sent in France and throughout the private letters of French officers, we can draw a quite positive report out of the

9. P. Giquel, L'Arsenal de Fou-Tchéou, Shang-haï, Imprimerie A.H. De Carvalho, février 1874.

French missions carried out in Romania and Japan. The slight misgivings that were suggested intervened always at a time when these missions met difficulties to extend their trip in these countries. We can legitimately think that the military assistance given by France in a matter of organisation, regulation and instruction allowed Japan as well as Romania to supply themselves with a modern and professional army. The most important part of this assistance was probably the instruction given to these foreign students in their countries, in France and for some in the French *École Polytechnique*.

In Romania's case just as in Japan's, the recruitment on the basis of specialised knowledge took place of recruitment among traditional aristocratic classes: *Boyards* for Romania and *Samurais* for Japan. The military career development seemed to be established on the basis of merit and length of service.

In both countries, the army, still under construction, consolidated its training in the initiatory experience of war and proved out to be helpful for the national cause : 1877-1878 war against the Ottomans and the 1877-78 insurrection of *Samurais*.

The transplantation of the imported French model and of the techniques would not have been such a success in Romania and Japan if it had not been sustained by a genuine political impulse. It would not have been a success if it had not been part of a set of large structural reforms leading to the construction of national and central state.

PATRICE BRET

L'ÉTAT, L'ARMÉE ET L'ORGANISATION DE LA RECHERCHE MILITAIRE EN FRANCE (1763-1830)

Introduction

Entre la dernière décennie du règne de Louis XV, après la Guerre de Sept Ans, et le règne de Charles X, à la fin de la Restauration, la France met en place une pensée, des pratiques et des institutions de ce que l'on nommerait aujourd'hui recherche-développement. Dans ce processus de structuration de l'intervention de l'État et de sa gestion de l'innovation, les questions d'armement, matériel et munitions, tiennent une place centrale et jouent un rôle moteur[1].

Ce processus peut être vu comme continu par-delà les changements de régime issus de la Révolution, mais les événements politiques jouent pourtant un rôle considérable dans l'évolution du paysage institutionnel de l'invention et de la recherche. Deux faits majeurs marquent en effet la période : d'une part, bien sûr, la Révolution française, dans ses aspects politiques, économiques, sociaux et juridiques ; d'autre part, la guerre, souci omniprésent pour les gouvernants, qu'ils l'aient faite, qu'ils la conduisent ou qu'ils la préparent. En effet, les guerres révolutionnaires et impériales –presque continuelles sur le territoire national ou à ses frontières et sur ses côtes, toujours sous

1. Les éléments exposés ici sont développés dans notre ouvrage *L'État, l'armée, la science. L'invention de la recherche publique en France, 1763-1830*, Rennes, Presses universitaires de Rennes (coll. Carnot), 2002, qui analyse notamment les programmes concernant les poudres et salpêtres, la rationalisation de la conception et de la fabrication des armes, le développement des obus et des fusées de guerre. Notre thèse de doctorat d'histoire (*La pratique révolutionnaire du progrès technique. De l'institution de la recherche militaire en France (1775-1825)*, Université Paris I / Panthéon-Sorbonne, 1994, 4 vol.) analysait en outre les programmes concernant le territoire et les communications (cartographie, aérostation, télégraphe). En l'absence de références, nous renvoyons à ces ouvrages.

menace britannique, entre 1792 et 1815– ne sont pas seules en cause : toutes proportions gardées et phénomène national mis à part, la Guerre de Sept Ans (1756-1763), qui ouvre la période, a pesé presque aussi lourd dans les esprits que la défaite de 1870 à la fin du XIXe siècle ; la guerre d'indépendance des États-Unis (1778-1783) en constitue la revanche contre l'Angleterre, mais son poids financier, terriblement lourd, participe au déclin de l'État monarchique ; enfin, dans des circonstances fort différentes, il ne faut pas omettre les expéditions de la Restauration, lieux d'expérimentation d'armes nouvelles, en Espagne (1823), en Morée (1828) et à Alger (1830).

Quelle a été la place des militaires dans cette construction d'une nouvelle gestion de l'innovation, qui allait poser les fondements intellectuels, politiques et institutionnels de la recherche publique en France ? Pour simplifier et ne pas occulter le poids de la Révolution dans ce processus continu, nous distinguerons trois étapes chronologiques entre lesquelles ruptures et continuités font bon ménage : le modèle académique ou colbertiste de l'Ancien Régime, héritier d'une tradition séculaire ; le modèle révolutionnaire ou jacobin, qui commence vraiment sous la Convention girondine pour connaître son apogée sous la Convention montagnarde ; le modèle technocratique –dans lequel les militaires jouent le rôle principal– qui s'installe ensuite lentement du Directoire à la Restauration.

1. L'expertise académique et la rationalisation des armes savantes[2]

Les linéaments et le fonctionnement d'une politique de l'invention technique sous l'Ancien régime sont mieux connus depuis les travaux récents de Philippe Minard sur l'inspection des manufactures et de Liliane Hilaire-Pérez sur l'invention en France et en Angleterre –qui met l'accent sur la capacité d'innovation des artisans et sur la diversité de ses modalités– et ceux qui ont été entrepris autour de l'Académie royale des sciences, notamment sur les prix et les commissions d'expertise[3].

2. Pour les références de cette partie, voir P. Bret, *L'État, l'armée, la science..., op. cit.*, chap. I.

3. L. Hilaire-Pérez, *L'invention technique au siècle des Lumières*, Paris, Albin Michel, 2000 ; Ph. Minard, *La fortune du colbertisme. État et industrie dans la France*

Une académie omnipotente menacée dans ses fonctions

Une politique de l'invention oscille entre deux objectifs contradictoires : protéger l'invention (forme de politique de la propriété intellectuelle) ou la diffuser (forme de politique de développement économique). L'État colbertiste choisit de pousser à l'innovation, c'est-à-dire d'abord à diffuser, moyennant des gratifications, et exceptionnellement à protéger par un privilège exclusif à condition qu'il y ait rapidement une réalisation concrète. Deux structures sont fondées sur ce principe de base.

La première, d'ordre intellectuel, est l'*Académie royale des sciences*, fondée en 1666 et dotée d'un règlement en 1699. S'occupant non seulement de sciences, mais également de techniques, elle constitue ainsi, pour Lavoisier, un « tribunal libre » qui garantit à la fois l'inventeur, l'entrepreneur et le consommateur. Les questions militaires y tiennent une place non négligeable et nombreux sont, tout au long du siècle, les académiciens ordinaires, honoraires ou associés libres d'origine militaire qui sont particulièrement intéressés par les questions d'armement, tels le lieutenant-général d'artillerie Deschiens de Ressons, le chevalier d'Arcy, le marquis de Montalembert, les ingénieurs militaires Fourcroy de Ramecourt, Borda et Coulomb, etc. Pour décerner son approbation, nécessaire à l'obtention d'un privilège de fabrication, elle nomme pour chaque projet présenté une commission spéciale chargée d'en rendre compte à la compagnie savante par un rapport sur lequel celle-ci se prononce. Outre ce mode d'intervention par expertise, l'Académie est le lieu d'une politique d'orientation ou d'incitation à la recherche, par l'instauration de prix fondés par l'État ou par des particuliers. Lancée en 1714 par le prix

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des Lumières, Paris, Fayard, 1998. Voir aussi Mathilde Lardit, « Les concours de l'Académie royale des sciences », mémoire de maîtrise (Paris I), 1997 ; P. Bret, « La prise de décision académique : les procédures et pratiques de choix et d'expertise à l'Académie royale des sciences », in É. Brian et C. Demeulenaere-Douyère (dir.), *Règlement, usages et science dans la France de l'Absolutisme*, Paris, Tec & Doc, 2002, pp. 321-362 ; L. Hilaire-Pérez, « Académiciens et inventeurs au XVIIIe siècle : l'examen des inventions et le crédit de l'innovation », *ibid.*, pp. 309-320 ; Pascale Mafarette-Dayries, « L'Académie royale des sciences et les grandes commissions d'enquête et d'expertise à la fin de l'Ancien régime », in P. Bret et M. Dorigny (dir.), *Sciences et techniques autour de la Révolution française*, Paris, Société des études robespierristes, 2000, pp. 121-135.

Rouillé de Meslay, cette forme d'intervention se développe notamment dans les deux dernières décennies de l'institution.

La seconde structure, d'ordre administratif et économique, est le *Bureau du commerce*, créé en 1722 auprès du Contrôle général des finances. Plus proche des milieux entrepreneuriaux et de la réalité de la production, le Bureau du commerce illustre par une vision plus libérale de l'économie, les contradictions internes au système. A lui et aux intendants qui le relaient sur le terrain reviennent l'impulsion et la gestion de la politique de l'innovation fort éloignée du colbertisme originel. A côté du corps des inspecteurs des manufactures, le Bureau du commerce dispose d'experts attitrés choisis au sein de l'Académie des sciences.

Outre ces deux structures, le secrétaire d'État à la Guerre nomme également des commissions particulières qui font leurs propres épreuves sur les polygones des écoles régimentaires d'artillerie ou dans le laboratoire de la Régie des poudres à l'Arsenal. Il innove, même, en chargeant Bossut, dans les années 1760, et Du Buat, vingt ans plus tard, de recherches expérimentales en hydraulique, tandis que Monge et Clouet font la synthèse de l'eau par l'étincelle électrique quelques jours avant Lavoisier et plus rigoureusement que lui. Ainsi naît une tradition de recherche qui intéresse parfois la communauté scientifique plus encore que l'armée. Dans ce cadre militaire, quoique de façon moins systématique, le recours aux académiciens constitue à nouveau une garantie : en 1781, par exemple, Lavoisier participe à l'examen de la poudre du Sieur Elcan avec un de ses collègues de la Régie des poudres et deux officiers d'artillerie–le service producteur et le service utilisateur étant ainsi associés à l'expertise.

Constitution d'un nouveau paysage : apparition des comités techniques permanents

D'une façon ou d'une autre, le jugement académique reste la caution suprême. Mais le travail académique, développé depuis les années 1730, connaît dans les années 1770-1780 une telle croissance qu'il devient nécessaire d'opérer une réduction des questions relevant de la compétence de l'Académie et de réorganiser ses méthodes de travail.

Une réduction artificielle du travail est obtenue par le refus systématique du charlatanisme et le renvoi de certaines questions à des sociétés spécialisées. Ainsi sont désormais rejetées sans examen les questions scientifiques et techniques insolubles ou incontrôlables, telles que la quadrature du cercle, le mouvement perpétuel ou les « secrets » de fabrication non dévoilés, tandis que d'autres sont renvoyées à de nouvelles instances d'expertise, la Société royale de médecine (1778), pour les « remèdes secrets » (médicaments, cosmétiques, etc.), et, de manière moins systématique, la Société d'agriculture de Paris (1761), promue au rang de société *royale* en 1788.

Plus importante encore est la réorganisation du travail d'expertise. Elle consiste en un renforcement, une spécialisation et une pérennisation des commissions. D'une part, le nombre des commissaires augmente : alors que les commissions à deux membres dominent traditionnellement, celles de trois membres et plus passent de 13% en 1764-1773 à 49% en 1784-1793, tandis que les diverses classes (astronomie, chimie, anatomie, etc.) sont elles-mêmes parfois érigées en commissions d'expertise. D'autre part, à côté des commissions « spéciales » ordinaires, traditionnellement établies pour l'examen d'un projet unique, de grandes commissions permanentes apparaissent pour examiner désormais tous les projets relevant de questions d'intérêt public, hôpitaux, abattoirs, aérostats, etc. Dans le vocabulaire académique, elles prennent parfois le nom de comité. Cette continuité dans le travail, qui renforce de fait leur compétence, institue ainsi dans le système des structures plus opérationnelles que les structures organiques de l'Académie, même après la réforme de 1785, qui voit l'apparition de deux nouvelles « classes » au sein de la compagnie. Initiateur des grandes commissions et auteur de cette réforme, Lavoisier s'est également attaché avec moins de succès à rationaliser les procédures d'expertise, notamment par la normalisation du rapport des commissions et du jugement académique.

Cette gestion collective des questions d'invention, qui puise sans doute aussi dans les pratiques du Bureau du commerce, rejoint une tendance de l'administration royale, dont témoigne l'existence éphémère du Comité de la guerre (1781-1784), du Conseil d'administration de la guerre (1787-1788), auprès du Secrétariat d'État à la guerre, ou du Conseil d'administration de l'agriculture ou Comité d'agriculture (1785-1787), auprès du Contrôle général des finances. La composition de ce dernier est significative de cette évolution : le noyau initial de cette institution ministérielle est exclusivement formé d'académiciens des sciences autour de Lavoisier. Avec la Révolution, la monarchie constitutionnelle poursuit cette ligne de gestion collective des questions techniques, restructure en 1790 la direction technique des armes savantes en créant le *Comité central des fortifications*, mis sur pied dès 1791, et le *Comité central d'artillerie*, réellement établi en 1795 seulement.

Approche scientifique dans les questions techniques du domaine militaire

Un autre phénomène majeur est l'approche scientifique qui prévaut de plus en plus dans la gestion de toutes les questions techniques. On peut considérer qu'il se manifeste principalement en trois formes de rationalisation qui touchent à la fois les aspects humains, matériels et fonctionnels du secteur technique de l'État.

La rationalisation des personnels chargés des questions techniques relevant de l'État se fonde sur un enseignement scolarisé à la fois théorique et pratique, phénomène bien connu des historiens, et sur des exigences croissantes de compétences, concrétisées par la reconnaissance du mérite par le biais du concours d'entrée. Amorcée dès le milieu du siècle avec les premières grandes écoles d'ingénieurs –celle des Ponts et chaussées en 1747 et, surtout, celle du Génie en 1748– cette forme de rationalisation est à nouveau développée avec plus ou moins de succès, dans le contexte de la Guerre de Sept Ans, puis après l'indépendance des États-Unis, pour d'autres catégories d'ingénieurs ou de personnels dont le statut se rapproche du leur : c'est le cas entre 1760 et 1766 pour les constructeurs de vaisseaux, les géographes et les mines, définitivement pour les mines et les poudres en 1783. Sans épouser la même structure centralisée, malgré vaines quelques tentatives dans le troisième tiers du siècle[4], les écoles d'artillerie et les différentes écoles de marine (hydrographie, gardes de la marine), dont l'origine remonte à la fin du XVIIe et au début du XVIIIe siècle, connaissent également, par l'usage des manuels et le système des examinateurs, une homogénéisation et une élévation du cursus scientifique, ainsi qu'une reconnaissance du talent[5].

4. L'École royale de Marine au Havre (1773-1775), l'École royale des élèves à La Fère (1756-1766) puis Bapaume (1766-1772) pour l'Artillerie.

5. Voir Bruno Belhoste, *La formation d'une technocratie. L'École polytechnique et ses élèves de la Révolution au Second Empire*, Paris, Belin, 2003.

La rationalisation des matériels doit d'abord s'inscrire dans la ligne des efforts d'uniformisation des rangs des navires et des calibres d'artillerie, accomplis entre 1715 et le début des années 1730, qu'illustrent le vaisseau de 74 canons et le système de Vallières. Mais, une nouvelle fois, la Guerre de Sept Ans a été à l'origine des grandes réformes, qui ne trouvent leur application définitive que sous le règne de Louis XVI, tant pour l'armée royale, avec le nouveau système d'artillerie de Gribeauval et le fusil 1777, conçu sous son égide par Honoré Blanc, que pour la marine royale, sous l'égide de Borda, avec les essais de standardisation des mâtures de Briqueville et les « plans-types » de navires de Sané. La volonté d'uniformisation, jointe à la recherche accrue de la précision et l'utopie productiviste analytique, ont donné lieu aux premiers essais en grand de pièces interchangeables[6].

Enfin, moins lisible, parce qu'elle n'a pas directement donné naissance à des institutions ou des objets aisément identifiables, mais qu'elle les a seulement accompagnés dans l'ombre, la rationalisation des pratiques est sans doute plus importante encore. Composée d'éléments divers, touchant aussi bien aux modes de production (procédures de contrôle de qualité, etc.) qu'à ceux de la comptabilité, elle se caractérise principalement par le développement de véritables programmes de recherche-développement, à commencer par celui de l'artillerie de Gribeauval. La création de la Régie royale des poudres et salpêtres par Turgot en 1775 et l'appel à Lavoisier pour la co-diriger, présentent un exemple de l'approche scientifique et de la rationalisation d'un secteur entier, à la fois administratif et industriel. En quelques années, un secteur stratégique aux structures archaïques et aux pratiques empiriques se transforme en un secteur public moderne[7] : les commissaires des poudres, qui formaient des dynasties de petits notables locaux deviennent des fonctionnaires-savants auxquels s'ouvre une véritable perspective de carrière, des ingénieurs chimistes avant la lettre, qui se plaignent d'être militarisés et transférés

6. Voir notamment Kenneth L. Alder, *Engineering the Revolution: Arms and Enlightenment in France, 1763-1815*, Princeton, N.J., Princeton University Press, 1997 ; Sylviane Llinares-Créteur, « La normalisation dans la marine de guerre française au XVIIIe siècle », in Robert Bélot, Michel Cotte, Pierre Lamard (dir.), *La technologie au risque de l'histoire*, Paris, UTBM-Berg International Editeurs, 2000, pp. 363-378.

7. Par des modes de formation adaptés et différents moyens d'incitation financière, la rationalisation touche aussi en amont la petite industrie, privée mais contrôlée, des salpêtriers.

de poste en poste à la manière des ingénieurs militaires. Muni d'une solide formation théorique et pratique uniforme au sein de chaque corps, les commissaires des poudres deviennent interchangeables, comme le sont les membres des autres corps, ingénieurs, artilleurs ou marins, comme le deviennent aussi les diverses pièces d'un canon de campagne ou d'une platine de fusil. Le port d'un uniforme, qui leur est octroyé en 1787, consacre ce phénomène.

De cette période de la fin de l'Ancien Régime, trois points forts doivent être retenus : l'intervention de l'État, dans la tradition colbertiste ; l'émergence de structures d'examen collectives et spécialisées, nées au sein de l'Académie des sciences ; l'approche scientifique des problèmes conduisant à une rationalisation et des tentatives de standardisation. Toutefois, bien sûr, il faut se garder de voir un mouvement uniforme et linéaire, doté d'une forte cohérence. Ainsi, Gribeauval et Lavoisier, deux des principaux artisans de cette modernité, s'opposent en 1781 sur la fabrication de la poudre : l'artilleur consommateur préfère s'en tenir aux textes réglementant la fabrication, datant de 1684, quand le savant fabricant a prouvé expérimentalement les faiblesses ou les vices des procédés en usage.

2. Le modèle révolutionnaire de « l'application des sciences à la guerre » [8]

La Révolution hérite de ce paysage en devenir, que l'inertie du système d'Ancien Régime pouvait difficilement laisser s'épanouir. Elle bénéficie aussi de sa propre dynamique (tous les champs du possible sont ouverts) et de l'urgence impérative (la guerre et la « patrie en danger »), qui pousse à l'innovation pour accélérer les procédés, fût-ce au détriment de la qualité réglementaire (procédés révolutionnaires). Mais elle agit dans une grande instabilité avec peu de moyens.

Consécration du mérite par excellence, l'initiative est désormais l'apanage des savants qui jouent un rôle primordial en investissant le politique, d'abord par conviction personnelle dans la nécessité de réformer l'État et la société, puis comme recours pour le service de la patrie. Ils en profitent pour poser les bases d'une intégration de la science à la société.

8. Pour les références de cette partie, voir P. Bret, *L'État, l'armée, la science…*, *op. cit.*, chap. II.

La direction occulte des savants

A une époque où il n'existe pas de politiciens par profession, il n'y a pas lieu de distinguer les savants qui font de la politique de leurs collègues d'autres origines professionnelles. Le mathématicien Monge, ministre de la Marine, les chimistes Guyton et Fourcroy ou les ingénieurs militaires Carnot (également mathématicien) et Prieur de la Côte-d'Or (également chimiste), membres du Comité de salut public sont tous tout à la fois des savants et des politiques. Dans leurs fonctions politiques, ils utilisent d'ailleurs moins leurs compétences d'experts et leurs connaissances scientifiques, qu'une approche scientifique des problèmes et leur connaissance des réseaux de savants et d'« artistes » pour mettre en place la fameuse « mobilisation des savants » de l'an II, qu'il convient de relire hors de tout discours idéologique pour y distinguer, à la manière des historiens de la Première Guerre mondiale, une auto-mobilisation ou mobilisation spontanée venue d'en bas et une mobilisation par le haut, organisée et imposée par le pouvoir. Dans les deux cas, il faut souligner la formidable mise en œuvre de ces réseaux scientifico-techniques, tel le réseau bourguignon de Guyton de Morveau issu de l'académie de Dijon, dont il était chancelier, du Club patriotique de Dijon, qu'il avait fondé en août 1789, et des *Annales de chimie*, jeune revue dont il était l'un des fondateurs regroupés autour de Lavoisier pour la diffusion de la révolution chimique.

Deux étapes liées à la situation politique nationale (Convention girondine puis montagnarde) et à la situation militaire (aggravation de la menace intérieure et extérieure durant l'été 1793) peuvent être distinguées.

La première ne serait que l'ébauche imparfaite de la seconde, si elle n'était aussi de forte portée symbolique à l'origine de la mobilisation des savants : à ce seul titre, elle mérite bien d'être considérée comme primordiale. Le 9 avril 1793, en effet, sous la présidence de Guyton, la première décision de la première séance du Comité de salut public, créé trois jours plus tôt, est de former une « commission de quatre citoyens instruits en chimie et en mécanique, chargés spécialement de rechercher et d'éprouver les nouveaux moyens de défense ». Sont aussitôt nommés les chimistes Berthollet et Fourcroy, le mécanicien Perier (tous trois membres de l'Académie des sciences) et l'ingénieur militaire Lafitte-Clavé. Mais la tâche était certes trop grande pour une commission si faiblement constituée, dont tous les membres avaient d'autres occupations pour la défense nationale elle-même –à commencer par Lafitte-Clavé, aussitôt promu inspecteur général du Génie.

Aussi, dans une seconde étape, cette commission presque mort-née donne naissance à deux structures qui correspondent à ses deux fonctions distinctes, l'initiative et la recherche-développement. L'initiative et la gestion politique reviennent à la *Section des armes* du Comité de salut public, composée de savants groupés autour de Prieur de la Côte-d'Or. Elle prépare les arrêtés sur les questions d'armement, dont les minutes sont de la main de Guyton (quand Prieur est au Comité) ou de Prieur (quand Guyton est au Comité), de Berthollet, de Monge, etc. C'est l'organe de la mobilisation des savants, qui rédige les instructions techniques, élabore les procédés révolutionnaires, dispense les cours révolutionnaires, crée l'École polytechnique et les écoles d'application. Là s'organise la production et se prépare la politique de recherche à plus long terme. Quant à la seconde structure, bientôt établie à Meudon, elle s'attache à la direction et la gestion technique des programmes de recherche-développement : il s'agit en fait de donner un cadre institutionnel aux divers programmes lancés par le ministère de la Marine –avant même la création de la commission du 9 avril, qui n'eut qu'à les superviser– et par le Comité de salut public.

La recherche sous contrôle : Meudon et les premiers « laboratoires »

L'automne 1793, au lendemain de la « levée en masse », marque, en effet, une étape décisive dans ce processus d'institutionnalisation de la recherche. En un mois, le Comité de salut public crée à Meudon, sous sa surveillance directe, deux établissements secrets, l'un pour les épreuves d'artillerie, l'autre pour les épreuves aérostatiques.

Dans le premier sont développés les programmes de recherche-développement des boulets incendiaires et des boulets creux, de la poudre de muriate suroxygéné de potasse, et testés d'autres inventions, notamment des fusées de guerre et les boulets à bague. Le contrôle du Comité de salut public se renforce encore au printemps, lorsque la commission travaillant à Meudon est transformée en commissariat et que la fabrication des boulets incendiaires et creux pour la marine commence. Si l'établissement disparaît au printemps 1796, le centre d'épreuves d'armes de Meudon est reconstitué en décembre 1797, quoique la commission ne soit plus alors qu'une sorte de commission d'expertise mixte. Au demeurant, ces changements de titre et de nature masquent une stabilité du personnel qui illustre une tendance à la pérennité de l'institution.

Le centre d'épreuves aérostatiques, dont les premiers travaux permettent au printemps 1794 la mise en place opérationnelle de l'aérostation militaire, devient dès le mois de novembre suivant l'École nationale aérostatique. Là se poursuivent la recherche et la fabrication, qui connaissent leur apogée au printemps 1796. D'école technique élémentaire, l'École nationale aérostatique devient alors une école d'application de l'École polytechnique, dont le cursus est lié à l'École des géographes.

A côté des deux centres de Meudon travaillent deux laboratoires nationaux et deux ateliers pilotes.

Ces derniers sont créés au printemps 1794. L'un d'eux, l'*Atelier de perfectionnement des armes portatives* de la rue Marc, est d'ailleurs une sorte de laboratoire de recherche pour la production. Placé sous la surveillance directe de deux savants engagés, Hassenfratz et Vandermonde, et sous la direction technique de Mégnié le jeune, il est chargé en mai 1794 de poursuivre la rationalisation des opérations techniques de la fabrication des fusils, initiée par Honoré Blanc à Saint-Etienne (1782) puis à Vincennes (1786), sous l'autorité de Gribeauval, pour obtenir des pièces interchangeables. Là sont élaborées de nouvelles procédures techniques pour la fabrication des platines de fusils (emploi de machines-outils, estampage de certaines pièces), dans le cadre d'une division du travail qui emprunte parfois à des pratiques artisanales (la serrurerie picarde). Mais au-delà de cette production, une véritable révolution des pratiques industrielles est en vue dans l'esprit des savants. Le second atelier, l'*Atelier de précision de la Grosse artillerie*, rue de Lille, sous la surveillance de Jumelin et la direction de Mercklein, est moins directement novateur à l'origine, puisqu'il est simplement chargé de centraliser la fabrication des instruments de contrôle des calibres d'artillerie pour accroître la standardisation. Son travail futur est préparé par un Bureau du système métrique sous la direction du colonel Grobert, chargé de l'application du système de poids et mesures à l'artillerie.

Enfin, deux laboratoires nationaux se partagent la recherche concernant les poudres et les alliages destinés à l'Artillerie. Le premier est créé de toute pièce au siège de l'Administration des armes, quai Voltaire, sous l'autorité de Guyton, qui le fait équiper en février 1794, non seulement des instruments et ustensiles nécessaires à un laboratoire de chimie, qui sont prélevés sur les cabinets des émigrés et condamnés, mais aussi d'instruments nouveaux de sa conception, tel le « pyrochrone », avec lequel il compare la vitesse d'inflammation de la poudre[9]. Le second n'est autre que la laboratoire des essais de l'Hôtel de la Monnaie, construit spécialement en 1776, où le ci-devant académicien Jean Darcet commence une série de travaux sur les bronzes d'artillerie, que son fils poursuivra sous la Restauration[10].

La veille technologique : les structures d'appel à invention

A côté de cette recherche étroitement contrôlée par le pouvoir politique et scientifique, diverses institutions, spécifiques ou non, assurent une sorte de veille technologique et encouragent la démocratisation de l'invention.

La première, qui ne se limite certes pas aux questions militaires, a été mise en place par l'Assemblée législative : il s'agit du *Bureau de consultation des arts et métiers*. Dans cette institution initialement conçue comme une structure démocratique de l'expertise, l'Académie des sciences parvient vite à retrouver son influence, non seulement en y obtenant la moitié des sièges, mais aussi parce que l'expertise du Bureau est principalement destinée à l'attribution de récompenses nationales. De fait, celui-ci forme autant un bureau d'assistance sociale aux inventeurs qu'un « tribunal » de l'invention à la manière de l'Académie. Mais, en faisant appel à l'ensemble des inventeurs, invités à solliciter une récompense, il acquiert aussi une fonction patrimoniale et devient un réservoir d'idées –le versement des archives du Bureau

9. P. Bret, « Contrôle de qualité, expertise et recherche expérimentale à la fin du XVIIIe siècle : de l'éprouvette d'ordonnance à la mesure de l'inflammabilité », in *Instrumentation, expérimentation et expertise des matériaux énergétiques (poudres, explosifs et pyrotechnie) du XVIe siècle à nos jours* (Actes des Troisièmes Journées scientifiques Paul Vieille), Paris, CRHST-A3P-CEA/DAM, 2001, pp. 29-59.

10. P. Bret, « Des essais de la Monnaie à la recherche et à la certification des métaux : un laboratoire modèle au service de la guerre et de l'industrie (1775-1825) », *Annales historiques de la Révolution française*, nÆ 320 (avril-juin 2000), pp. 137-148.

de consultation au Conservatoire des arts et métiers est d'ailleurs symptomatique à cet égard.

De son côté, l'Administration centrale des armes s'adjoint une structure d'appel à invention spécialisée dans les inventions pour la guerre, d'abord la *Commission des armes*[11], puis, en novembre 1793, le *Jury des armes et inventions de guerre*, qui distribuait également de modiques récompenses aux inventeurs.

Ainsi, la tradition colbertiste s'est fondue dans une nouvelle tradition jacobine, qui l'a développée en hiérarchisant le paysage de la recherche militaire : à une structure centrale (la commission du 9 avril, puis la Section des armes du Comité de salut public) reviennent la gestion de la recherche et la définition des grandes options, en étroite liaison avec le pouvoir central ; aux centres de recherche de Meudon, aux ateliers pilotes et aux laboratoires nationaux –qui, à la différence des commissions d'expertise traditionnelles, tendent à former des structures permanentes– revient le développement des programmes d'initiative étatique ; à des structures d'expertise plus ou moins spécialisées reviennent la gestion de l'invention (stimulation par des récompenses, comme naguère les prix des académies) et la veille technologique (filtrage et remontée des informations) ; enfin, cette dernière est aussi assurée par les nombreux relais politiques (sociétés populaires) et administratifs actifs durant la Révolution, qui diffusent en outre les instructions du Comité de salut public.

3. Les corps savants et le gestion technocratique de la recherche[12]

Une inflexion majeure se produit avec la Convention thermidorienne, surtout à partir du printemps 1795, qui marque la fin de l'effort de guerre révolutionnaire lancé en 1793. Cette inflexion s'accentue sous le Directoire, pour s'affirmer et se poursuivre à travers les régimes sous le Consulat, l'Empire et la Restauration : le primat du politique et scientifique, à son apogée sous la Convention montagnarde, s'efface

11. Ne pas confondre avec la *Commission des armes et poudres* créée en février 1794 et devenue en avril l'une des douze commissions exécutives remplaçant les ministères.

12. Pour les références de cette partie, voir P. Bret, *L'État, l'armée, la science...*, *op. cit.*, chap. III.

désormais pour faire place, d'abord à un contrôle bureaucratique au niveau ministériel –les ministères sont rétablis en novembre 1795– puis à une reprise en main technocratique par les corps savants, qui laisse néanmoins subsister une tension interne entre les bureaux ministériels et les corps et se développer une inertie au sein même des corps.

Le retour des corps savants

A l'issue des guerres révolutionnaires et malgré les défections dues à l'émigration, les corps savants sont en effet mieux organisés et plus puissants que sous l'Ancien Régime.

D'une part, ces corps sont dotés d'organes collégiaux de gestion et d'expertise, avec les comités centraux, désormais consolidés par une certaine expérience et par la professionnalisation de l'armée. C'est notamment le cas du Comité central de l'artillerie, envisagé dès 1790, créé effectivement en 1795 et bientôt renforcé après un démarrage difficile. Avec les archives du Dépôt central de l'artillerie, qu'il supervise, il conserve la mémoire de l'innovation[13].

D'autre part, les armes savantes se développent à partir du Directoire en profitant de l'affaiblissement du pouvoir politique, de la place accrue d'une armée professionnalisée qui pèse sur le politique et du renforcement de l'esprit de corps dans le moule de Polytechnique. La création de cette école permet de ne plus aller chercher les savants ailleurs que dans les corps savants. Et lorsqu'on le fait, ces savants eux-mêmes sont polytechniciens, tel Gay-Lussac, qui travaille avec l'Artillerie et les Poudres à partir de 1818.

A la différence de ces organes des corps, nés de la Révolution mais bien intégrés à l'appareil militaire, les créations révolutionnaires trop marquées par le politique et le scientifique sont supprimées : l'Atelier de précision de la Grosse Artillerie en mars 1797, l'établissement de Meudon en janvier 1800, au lendemain du 18 Brumaire, avec la Commission des épreuves d'armes. Ce dernier est abandonné au profit du parc de Vincennes, mieux contrôlé par l'Artillerie. En revanche,

13. P. Bret, « Genèse et légitimation patrimoniale d'une invention : les archives de l'Artillerie à l'origine d'une innovation cruciale dans la Marine au XIXe siècle », in Anne-Françoise Garçon et Liliane Hilaire-Pérez (éds), *Les chemins de la nouveauté : inventer, innover à l'épreuve de l'histoire (XIIe-XIXe siècles)*, Paris, Éd. du CTHS, sous presse.

parce qu'il correspond évidemment à un besoin nouveau, le premier est rétabli dès 1800, mais dans le cadre ordinaire de l'Artillerie et sous son contrôle unique : le nouvel Atelier de précision deviendra le bureau d'études de l'Artillerie jusqu'au milieu du XXe siècle, donnant naissance au Laboratoire central de l'armement et à ses avatars ultérieurs, dans un contexte techno-scientifique et industriel fort différent. Ainsi, les corps ont désormais une totale maîtrise de leur recherche.

Outre leur organisation centrale, les corps savants disposent aussi désormais d'une revue, qui remplace les traditionnels manuels normatifs tels que l'*Aide-mémoire à l'usage des officiers d'artillerie* rédigé par le général Gassendi (cinq éditions de la Révolution à 1819). Sous différentes appellations et avec une périodicité variable, cette revue devient l'organe essentiel, tant pour la cohésion sociologique et intellectuelle du corps, que pour l'orientation et la diffusion de la recherche. À l'instar du *Journal de l'École polytechnique*, fondé en 1795, les corps de chacun des ministères créent leurs propres journaux : le *Journal des mines* dès 1794 (*Annales des mines* à partir de 1815) et les *Annales des ponts et chaussées* en 1831 pour les grands services civils de l'Intérieur ; les *Annales maritimes et coloniales* en 1816 pour la Marine dans son ensemble, avant l'éclosion des journaux spécialisés de ses corps sous la monarchie de Juillet ; le *Mémorial de l'officier du génie* en 1820 (après une première parution en 1803-1804), le *Mémorial du Dépôt général de la guerre* en 1825 (rééditant et poursuivant le *Mémorial topographique et militaire* de 1802-1805) et le *Mémorial de l'Artillerie* en 1826, enfin, pour la Guerre.

La publication de ce dernier journal –décidée par le ministre, baron Damas, deux mois après la création du *Mémorial du Dépôt général de la guerre* et de l'École centrale de pyrotechnie militaire– est caractéristique de la nouvelle politique de l'innovation. N'ayant rien d'un annuaire ni d'un aide-mémoire, le *Mémorial de l'Artillerie, ou Recueil de mémoires, expériences, observations et procédés relatifs au service de l'artillerie ; rédigé par les soins du Comité, avec l'approbation du ministre de la Guerre* est ouvert aux recherches dans tous les domaines touchant à l'arme. À la différence des journaux créés antérieurement, le *Mémorial de l'Artillerie* est fondé à la fois pour la promotion des recherches effectuées par les officiers dans les établissements de l'Artillerie et pour l'orientation et la diffusion de la recherche. En donnant suite à une décision ministérielle de mars 1819, prise sur proposition du général Valée, mais restée sans exécution, le baron

Damas crée aussi un prix annuel sous la forme d'un concours ouvert à tous les officiers et ordinairement doté de trois médailles d'or (une d'une valeur de 1500 francs et deux de 1000 francs). Les travaux couronnés sont destinés à être publiés dans le *Mémorial* s'ils ne risquent pas de « répandre des connaissances qu'il serait utile à l'état de tenir secrètes ».

L'État reconnaît ainsi la pratique de la recherche au sein même d'un corps savant et l'encourage le plus largement possible, tout en privilégiant l'expérience et en manifestant une méfiance certaine vis-à-vis d'une recherche trop largement guidée par la théorie. Avec les comités centraux et les revues spécialisées, un nouveau modèle technocratique s'est mis en place pour gérer l'innovation technique.

Une phase transitoire marquée par la dualité civil / militaire

Pour autant, le recours aux civils reste un complément indispensable, et la période révolutionnaire et impériale est marquée par la dualité civil / militaire, soit par la composition des commissions, soit par la collaboration entre laboratoires.

En effet, le modèle révolutionnaire des commissions mixtes n'est pas totalement abandonné. Napoléon Bonaparte, Premier Consul puis Empereur, le restaure à l'occasion. C'est notamment le cas avec la Commission de perfectionnement des poudres (1802), dont les membres proviennent de cinq institutions scientifiques et techniques différentes, militaires ou civiles, avec la grande Commission de topographie (1802), représentant huit institutions, et surtout avec la Commission des fusées incendiaires (1810), dont les membres scientifiques –Monge, Berthollet, Guyton-Morveau– appartenaient en 1793 à la commission des aérostats. La différence essentielle est qu'il ne s'agit plus ici de commissions pérennes, comme la Révolution les avait finalement établies, mais de commissions ayant un objet particulier déterminé à résoudre : étudier le perfectionnement des poudres, définir les conventions de la cartographie française, établir les normes d'un système français de fusées de guerre. Parfois pourtant, notamment dans ce dernier cas, la tendance à la pérennité devait finalement l'emporter avec la formation de plusieurs structures intermédiaires jusqu'à la création de l'École centrale de pyrotechnie militaire en 1824. Comme à Meudon quelques années plus tôt, la stabilité du personnel crée la pérennité de 1810 à 1824 par-delà la diversité des institutions : le capitaine Jacquier, qui travaille pour la commission de 1810, est placé à la tête de la compagnie d'artificiers créée à Bourges en 1815 et transférée à Toulouse en 1818 ; il est membre de la Commission des artifices créée dans cette ville cette année-là et rétablie à Metz en 1821, qui dispense déjà un enseignement pyrotechnique ; et son second, le capitaine Munier, devient sous-directeur de l'École de pyrotechnie en 1824.

Les laboratoires, en revanche, sont des institutions permanentes. Sans parler des laboratoires de chimie de Polytechnique, mis en place à partir de 1795 –l'école, militarisée en 1804, est dotée d'une grande pile voltaïque quatre ans plus tard pour la recherche fondamentale– plusieurs laboratoires participent à la recherche appliquée et à l'expertise pour le compte des autorités militaires. Si celui de l'Administration des armes a disparu avec la cette institution révolutionnaire, le laboratoire des essais de la Monnaie collabore avec l'Artillerie depuis cette époque : Jean Darcet puis son fils travaillent ainsi à la conception et l'expertise des alliages. En 1815, une grande expertise réclamée par la Commission des bouches à feu nécessite même la collaboration du laboratoire du Conservatoire des arts et métiers et d'un atelier privé parisien. Quelques années plus tard, Darcet fils et Gay-Lussac siègent dans cette commission avec des artilleurs. Sous l'Empire, Vauquelin travaille pour les Poudres au « laboratoire des recherches chimiques du Muséum d'histoire naturelle ». Mais sous la Restauration, à partir de 1818, les corps disposent désormais de leurs propres laboratoires : celui de l'Arsenal, où Gay-Lussac travaille pour les poudres ; celui de l'École d'artillerie de la Garde à Vincennes, où travaille Brianchon ; ceux du Dépôt central de l'artillerie –l'un pour la chimie (devenu en 1886 le Laboratoire de chimie de la Section technique de l'Artillerie), l'autre pour l'électricité– et des écoles régimentaires d'artillerie à Douai, Metz, Strasbourg et Toulouse. Avec les laboratoires d'essais, qui sont systématisés dans les installations industrielles (poudreries, raffineries, fonderies) pour le contrôle de qualité, c'est un ensemble, certes assez disparate, d'une vingtaine de laboratoires au moins qui existe dans les années 1820.

La synthèse entre les formes mixtes provisoires et les formes pérennes est faite avec la création, également en 1818, du Comité consultatif des Poudres et salpêtres, au lendemain du remplacement de la Régie des poudres par une direction générale rattachée à l'Artillerie.

Au prix de quelques changements minimes de titre, cet organisme voit se succéder tout au long du siècle trois académiciens, qui y siègent avec des artilleurs de 1818 à 1907 : Gay-Lussac, Pélouze, Berthelot. Le recours révolutionnaire aux savants s'est ainsi institutionnalisé, particulièrement dans ce secteur des poudres, où la tradition de collaboration avec les savants est plus ancienne et plus forte qu'ailleurs : elle remonte à Lavoisier, en 1775, passant par Fourcroy en 1792 et Chaptal en 1794.

Le creuset messin : Metz, capitale de la recherche expérimentale militaire

Une autre forme de synthèse s'opère à Metz. Avec trois écoles dépendant de l'Artillerie et une académie locale, cette ville est devenue au XIXe siècle le centre de la recherche dans le domaine militaire.

La recherche messine est dominée par l'École d'application du génie et de l'artillerie, et par la figure de Poncelet, officier du Génie, nommé en mai 1824 professeur du cours de mécanique appliquée aux machines, qui commence effectivement l'année suivante. Il y amène Morin, officier d'artillerie, qui lui est adjoint en 1829 avant de lui succéder de 1835 à 1839. À l'occasion de la réorganisation de l'arsenal de Metz, Poncelet aborde l'étude des roues hydrauliques, incurvant les aubes pour accroître le rendement des roues de courant. Le mémoire qu'il présente à l'Académie des sciences sur le sujet lui vaut le prix Montyon de mécanique en 1825. Soucieux de diffuser son invention, il en tire bientôt une *Instruction pratique sur la manière de procéder à l'établissement des roues à aubes courbes.* La référence à la tradition de recherche du corps du Génie est explicite : le 21 juillet 1827, demande est faite de continuer les expériences faites soixante et quarante ans plus tôt à Mézières par Bossut et Dubuat sur l'écoulement de l'eau par un pertuis. La fonderie de Douai, équipée d'une machine à vapeur de 12 chevaux en 1825, devient le lieu d'expérimentation privilégié pour les recherches de Poncelet et Morin sur les rendements et la sécurité de ces machines, l'objet même des premiers travaux de ce dernier, couronnés par le prix du concours organisé sur le sujet par le Comité central d'artillerie, puis le prix Montyon de mécanique en 1838. Directement utiles pour les machines des différentes usines dépendant de l'Artillerie, mais dépassant largement en intérêt les seuls militaires, ces recherches intéressent l'industrie dans son ensemble[14].

Ce n'est pas le cas des recherches en balistique, qui concernent plus directement le corps. Elles conduisent à la création d'une commission permanente, la Commission des principes du tir, créée en 1833, dans laquelle s'illustrent Piobert et Didion et qui traverse la monarchie de Juillet.

Plus encore que l'École d'application, dont la fonction première reste l'enseignement, l'École centrale de pyrotechnie militaire créée en 1824 représente fort bien la normalisation des formes de la recherche révolutionnaire et impériale. Appelée à jouer un rôle durable dans le domaine –à Metz jusqu'en 1870, puis à Bourges pendant un siècle (1967)– elle constitue l'aboutissement des tâtonnements révolutionnaires et du programme napoléonien sur les fusées de guerre, lancé en 1810. Théorique et pratique à l'image des écoles d'ingénieurs, elle est d'abord plus proche des Écoles d'arts et métiers par le niveau de son recrutement. Le contenu de l'enseignement reste en effet élémentaire, mais l'aménagement de la partie théorique et la conception originale de la partie pratique permettent de répondre aux besoins de la formation des artificiers. L'École gagne ainsi peu à peu en importance, voire en prestige, et connaît un développement inattendu, au point d'attirer des officiers d'autres armes. La fonction de recherche devient essentielle : absente dans l'ordonnance fondatrice, elle est en bonne place dans le règlement, et la pratique la renforce, au point que la recherche expérimentale est finalement considérée comme l'objectif principal de l'école par son directeur Cailly, selon lequel le « but que l'on s'est proposé en la créant [est de] *se livrer uniquement au perfectionnement* d'une branche de l'arme où il reste sans contredit bien des découvertes encore à faire ».

Parallèlement, les officiers de l'École centrale de pyrotechnie militaire participent pleinement à la vie sociale et savante de la ville

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14. Bruno Belhoste et Louis Lemaire, « J.-V. Poncelet, les ingénieurs militaires et les roues et les turbines hydrauliques », *Cahiers d'Histoire et de Philosophie des Sciences,* 29 (1990), pp. 33-89 ; Claudine Fontanon, « Arthur Morin (1795-1880). Un ingénieur militaire au service de l'industrialisation », *ibid.*, pp. 90-118 ; Kostas Chatzis, « Jean-Victor Poncelet et la "science des machines" à l'École de Metz », in Bruno Belhoste et Antoine Picon (dir.), *L'École d'application de l'artillerie et du génie de Metz (1802-1870). Enseignement et recherches*, Paris, Musée des Plans-reliefs, 1996, pp. 32-43.

aux côtés de leurs collègues professeurs de l'École régimentaire d'artillerie et de l'École d'application de l'artillerie et du génie. Ensemble, ils contribuent à la renaissance de l'Académie de Metz, participant à ses travaux et dispensant les cours industriels destinés aux ouvriers, fondés sous ses auspices à l'initiative de Bergery, professeur de mathématiques à l'École régimentaire d'artillerie. Metz devient ainsi un centre d'enseignement et d'édition majeur en matière de sciences appliquées et de techniques. Par cette heureuse configuration, Metz réussit où Toulouse, avec sa seule école régimentaire, a échoué peu auparavant, malgré les travaux de Tardy et Piobert et ceux de la première Commission d'artifices en 1818-1819.

Dans le sillage de l'École d'application, la place de Metz tout entière est donc devenue un complexe très original tout à la fois ouvert sur l'industrie et le monde ouvrier, et antichambre de deux académies : non seulement l'académie locale, qui accueille Bergery, Munier, Woisard ou Bardin, mais aussi l'Académie des sciences, dont la section de mécanique accueille ensuite successivement Poncelet (1834), Piobert (1840), Morin (1843) et, comme correspondants seulement, Didion (1873) et Boileau (1875). Elle est le centre de la recherche théorique et expérimentale sur les poudres et explosifs, la balistique, la mécanique des fluides, les moteurs hydrauliques et à vapeur, et toutes les questions de frottements[15]. Les besoins de l'expérimentation en font aussi un lieu d'élaboration de procédures expérimentales et un lieu de conception d'instruments de mesures adaptés : frein dynamométrique, chronomètres, dynamomètres, pendules balistiques, gravimètres, etc.

Dans cette ville de province qui regroupe un grand nombre d'officiers des armes savantes et trois écoles tournées en partie vers la recherche, les liens entre ces hommes d'une même génération sont sans doute plus étroits qu'ils ne le seraient à Paris, assurant une synergie plus grande. Frères d'armes dans le Génie et surtout dans l'Artillerie, presque tous ont été formés à l'École polytechnique et cooptés au sein de l'Académie de Metz. Mieux, ils sont bien souvent d'origine messine (Poncelet, Paixhans, Boileau) ou du moins mosellane (Didion, Munier) - les deux Lyonnais Morin et Piobert font presque figure d'exception. Un tel cadre

15. G. Piobert, *Traité d'artillerie théorique et pratique* (1836) ; J.-V. Poncelet, *Mémoire sur les roues hydrauliques verticales à aubes courbes mues par dessous* (1825, rééd. 1827) ; id., *Cours de mécanique appliquée aux machines* (1826) ; A. Morin, *Compte-rendu d'une mission dans les fonderies de l'artillerie* (1828).

est particulièrement propice au développement de la pratique du travail collectif, au point que Piobert, Morin et Didion présentent en commun un *Mémoire sur les lois de la résistance de l'air sur les projectiles* au concours de mathématiques de l'Académie en 1838[16].

Deux types de recherche expérimentale ou appliquée, opposés dans la pratique, voire dans les objectifs, se côtoient ainsi à Metz. Le premier type, développé autour de l'École d'application, consiste en une recherche largement extravertie, inscrite dans la tradition des recherches de Bossut, Dubuat, Borda ou d'Arcy (moteurs hydrauliques, frottements, balistique). L'expérience y est d'abord un élément nécessaire à la construction et surtout à la validation de la théorie. Les résultats, aussitôt réinvestis dans l'enseignement, font l'objet de mémoires abondamment diffusés au sein même des armes savantes, par le *Mémorial de l'Artillerie*, et en dehors d'elles. Plus que les enjeux de carrière militaire, pour laquelle la recherche semble être plus souvent un frein qu'un tremplin, au début du siècle au moins, priment alors les enjeux de carrière scientifique et académique de ces *ingénieurs savants*. Malgré des procédures expérimentales bien établies, le second type, intéressant surtout l'École de pyrotechnie, correspond à une recherche plus empirique, bien souvent encore incapable d'appréhender les fondements scientifiques d'un objet physico-chimique complexe (pyrotechnie). Ce défaut de bases théoriques donne ici à l'expérience un statut privilégié dans le développement opérationnel des inventions : il s'agit d'une recherche fermée, au caractère militaire plus prononcé. Sans réel enjeu scientifique, elle est principalement destinée au service de l'Artillerie, tandis que la recherche sur les moteurs intéresse aussi l'industrie civile. Avec des retombées moindres sur l'enseignement, elle donne plus rarement lieu à publication, dans les *Mémoires de l'Académie de Metz*, à laquelle Munier présente sa *Théorie du mouvement du tir des fusées* en 1830.

Conclusion

De même que les créations scolaires du XVIIIe siècle, de l'École des Ponts et chaussées et de celle du Génie à l'École polytechnique, ont

16. G. Piobert, A. Morin et I. Didion, *Mémoire sur les lois de la résistance de l'air sur les projectiles* (1839).

durablement marqué le paysage de l'enseignement français par le système des grandes écoles, de même, les créations d'établissements militaires, de l'Atelier de précision à l'École centrale de pyrotechnie militaire ont durablement marqué le paysage de la recherche militaire française. Mieux, ces institutions ont même été à l'origine de la recherche publique en France.

Ainsi, prenant le relais d'un mouvement initié dans la sphère de l'État et les milieux scientifiques sous la monarchie et la Révolution, les militaires ont contribué, dès le début du XIXe siècle, à dresser et à stabiliser le paysage institutionnel de la recherche militaire pour un siècle et demi. Alors qu'à l'étranger l'initiative reste principalement privée[17], en France, durant la Révolution comme sous l'Empire et sous la Restauration, l'initiative revient au pouvoir qui met en place, d'une part des commissions de recherche collective faisant appel aux savants puis aux polytechniciens, d'autre part des comités d'examen d'invention. Six caractères peuvent définir ce nouveau modèle adopté par les militaires : 1) l'initiative de l'État de longue tradition colbertiste, renforcée par le « centralisme jacobin » ; 2) la rationalisation et la standardisation des procédés et des produits, fruit de la rencontre de l'esprit encyclopédique et de l'esprit analytique ; 3) la science garante de la technique, dans la tradition académique ; 4) le lien entre formation et recherche, concrétisé par l'installation de laboratoires dans les écoles, dans le cadre d'une nouvelle tradition polytechnicienne qui plonge ses racines dans l'école de Mézières et l'école des Poudres ; 5) la recherche collective, issue du passage des commissions d'expertise académique aux équipes de recherche en laboratoire, nouvelle tradition savante refondée autour de Lavoisier sur la tradition avortée des origines de l'Académie des sciences ; 6) enfin, l'exploration de « nouveaux moyens de défense » hors du système dominant (aérostation, télégraphe). Ce dernier point est certainement celui envers lequel les militaires, tenants d'un certain conservatisme, ont été le plus réticents[18].

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17. Le cas des fusées de Congreve en Angleterre et de Schumacher au Danemark est exemplaire à cet égard : initiateurs de leur invention, ils sont portés par leurs liens personnels avec leurs cours royales respectives – le premier, fils du directeur du Royal Laboratory de Woolwich, est un intime du Prince de Galles, futur George IV ; le second est aide-de-camp du roi Frederik VI.

18. Selon les époques, cette frilosité est d'ailleurs partagée par les gouvernants.

Ce modèle, qui essaime partiellement à l'étranger après Waterloo pour s'adapter aux situations nationales[19], se pérennise et se renforce ensuite jusqu'à la première guerre mondiale. Pourtant, loin d'être un facteur de développement décisif à long terme, sa précocité et son organisation fermée sont sans doute à l'origine de son évolution trop lente, marquée par une grande stabilité et une relative inefficacité de 1840 à 1870, puis par un renouveau à partir des années 1880, au lendemain de la défaite de 1870-1871. Des difficultés inhérentes au système entravent particulièrement le fonctionnement des instances de recherche : faute d'autonomie et de distinction suffisante des laboratoires de recherche, le poids de la hiérarchie et des expertises pour le service est un lourd handicap. Ce problème récurrent, soulevé par Poincaré et Le Chatelier après l'affaire de l'explosion du cuirassé Iéna en 1907 et par les directeurs du Laboratoire de chimie de la section technique de l'artillerie de 1914 à 1917[20], ne sera réellement résolu qu'au XXe siècle.

Voir P. Bret, « Quand la poudre défie le métal. L'affaire des poudres brisantes (1826-1830) », in Jean-François Belhoste et Denis Woronoff (dir.), *Armes et Poudres* (colloque de Varaignes, 13-14 octobre 2000), à paraître.

19. Notamment en Suède, en Pologne, en Russie, souvent par l'entremise de polytechniciens (comme Bazaine en Russie) ou d'officiers formés par des polytechniciens (comme Bem, élève de Livet de l'École du génie et d'artillerie de Varsovie).

20. P. Bret, « La guerre des laboratoires : Poincaré, Le Chatelier et la Commission scientifique d'étude des poudres de guerre (1907-1908) », in Simone Mazauric (dir.), « Actes du colloque Henri Poincaré (Nancy, avril 2002) », *Philosophia Scientiae* (Nancy), sous presse, et « Managing the scarcity of chemical expertise: The laboratories of the French Artillery and Powder Service at war », in Roy Mac Leod et Jeffrey Johnson (eds), *Revisiting the 'Chemists' war', 1914-1923: Modern War, Munitions, and National Systems*, (colloque de Bologne, 13-16 juin 2002), Dordrecht, Kluwer, sous presse.

KONSTANTINOS CHATZIS

DES INGÉNIEURS MILITAIRES AU SERVICE DES CIVILS : LES OFFICIERS DU GÉNIE EN GRÈCE AU XIX^{e} SIÈCLE

Introduction

Le présent travail a comme objet les officiers du Génie en Grèce au XIXe siècle, avec une attention particulière portée à la période 1829-1878. " Arme savante " créée en 1829, le corps du Génie remplit jusqu'aux années 1870 incluses des fonctions et des tâches qui relèvent, en réalité, des domaines de l'architecte et de l'ingénieur civil (l'ingénieur des ponts et chaussées, selon la nomenclature française relative aux ingénieurs). Ayant le *quasi* monopole en matière d'aménagement des villes, de travaux publics, voire de construction des bâtiments publics, les officiers du Génie dispensent également une partie substantielle de l'enseignement technique de la période. Il faut attendre 1878 pour que cette situation atypique, où des militaires assurent des missions civiles, cesse d'exister avec la création d'un corps d'ingénieurs civils dépendant du Service des travaux publics du Ministère de l'intérieur. A partir de cette date, le corps du Génie devient une organisation au service exclusif de l'armée. Mais si à partir de 1878 la séparation entre ingénieurs militaires et ingénieurs civils est consommée sur le plan institutionnel, plusieurs ex-officiers du Génie continuent à œuvrer au service des civils tout au long du XIXe siècle, en intégrant par exemple le nouveau corps d'ingénieurs du Ministère de l'intérieur.

Cette note comprend *trois parties*. Dans un premier temps, nous exposons rapidement l'organisation du corps du Génie ainsi que l'évolution de ses effectifs, de sa création aux années 1880. Nous présenterons ensuite les différents types d'action menés par les officiers du Génie durant cette période. La troisième partie échange les " vues panoramiques " des parties précédentes contre deux " gros plans " consacrés à deux officiers du Génie, Emmanuel Manitakis et

Nicolaos Solomos : à travers l'action et les textes de ces deux ingénieurs, nous aborderons la question du " profil " de l'officier grec du Génie au XIXe siècle, question qui reste évidemment ouverte. La conclusion place, enfin, ce travail dans une thématique plus générale, celle de l'étude de l'État grec au XIXe siècle.

Partie I : Le corps du Génie, structures et hommes

Le 6 janvier 1828, Jean Capodistrias, qui sera le gouverneur de la Grèce jusqu'à son assassinat perpétré en septembre 1831, débarque à Nauplie. Il y trouve un accueil plus qu'enthousiaste et un pays ravagé par la guerre d'indépendance nationale, entamée en 1821, frappé aussi par les conflits internes aux insurgés. Dans un contexte de crise, il entreprend les premières mesures pour la constitution d'un État organisé, capable d'assurer l'issue victorieuse de la guerre et le relèvement de la société grecque.

La réorganisation de l'armée fait partie de ses préoccupations immédiates (Papageorgiou 1986). Parmi les différentes mesures prises, figure la création, en juillet 1829, du corps du Génie dont l'appellation officielle est " Corps des officiers des fortifications et d'Architecture (*Soma ton epi tis ochiromatopoïïas kai architectonikis axiomatikon*) ". Le nouveau corps se voit chargé d'une double mission, militaire et civile à la fois. Outre l'élaboration et la réalisation de tous les travaux relatifs aux fortifications et aux bâtiments militaires, ses membres doivent assurer également des missions qui relèvent ordinairement de l'architecte et de l'ingénieur civil (des ponts et chaussées) : ponts et routes, construction des bâtiments civils, relevés topographiques, urbanisme et aménagement des villes...

L'organisation du corps du Génie est l'œuvre d'un ingénieur français, le colonel du Génie Théodore A. Garnot, membre de la mission militaire française en Grèce. Sur sa proposition, le nouveau corps est composé de vingt membres, dont douze officiers : à sa tête on trouve un lieutenant-colonel, celui-ci dirigeant un chef (commandant) de bataillon, quatre capitaines, trois lieutenants, trois sous-lieutenants et huit conducteurs[1].

" L'organigramme " du nouveau corps étant défini, il fallait le remplir. Dans un premier temps, Garnot, promu à l'occasion

1. Une comparaison des salaires perçus par les officiers du Génie avec ceux des officiers d'autres corps montre qu'il s'agit d'un corps d'élite (Papageorgiou 1986, pp.

lieutenant-colonel et placé à la tête du corps, trouve six personnes pour l'épauler, cinq grecs et un suisse, de Vaud, nommé capitaine (Kardamitsi-Adami 1988, pp. 70-71). Quant aux grecs choisis, ils étaient tous passés par l'Europe. *Théodore Vallianos*[2], nommé chef de bataillon, déjà officier du Génie de l'armée russe, se trouve en Grèce dès mai 1822. *Dimitris Stavridis*[3], entré au nouveau corps comme lieutenant, ingénieur diplômé de l'École polytechnique de Vienne en 1827, est aussi l'un de ces nombreux grecs de la diaspora qui, lorsque la révolution éclate, se rendent en Grèce pour mettre leurs compétences au service de la patrie. *Stéphane d'Isay* (Stephanos Isaïas), nommé sous-lieutenant, diplômé de l'Université de Padoue (diplôme d'ingénieur architecte), est en Grèce depuis mai 1828. Les deux autres grecs, *Emmanuel Manitakis* et *Ioannis Kallergis* (nommés sous-lieutenant), sont de culture française. D'après leurs notices biographiques envoyées à Capodistrias, ils ont étudié les sciences à Paris et ensuite l'art de l'ingénieur à Metz, probablement à l'École

192-194 ; Kardamitsi-Adami 1988, pp. 65-66).

2. Sur Vallianos (1796-1857), voir : *Megali Elliniki Eggyklopaideia*, vol. 6, 1928, p. 577 ; TEE 1976, pp. 115-122 ; Kardamitsi-Adami 1988, pp. 71-72. Vallianos est né en Russie de père grec et de mère russe. Il commence ses études d'ingénieur militaire en 1814, et en 1821 obtient le grade de capitaine. Il se rend de sa propre initiative en Grèce en 1822. Il participe, entre autres, aux batailles de Patras et de Missolonghi, et assure le renforcement des fortifications dans plusieurs villes ainsi que l'élaboration et la construction de plusieurs ouvrages de génie civil. Il est peut-être l'ingénieur le plus actif durant l'époque de la révolution. Alors qu'il est nommé directeur du corps du Génie en 1832, un an plus tard, Vallianos est obligé d'accepter le poste de Consul à Salonique, après s'être brouillé avec les bavarois. Sa disgrâce va durer jusqu'à la fin de sa vie. En marge de la hiérarchie militaire, chrétien fervent, il va traduire de russe en grec plusieurs ouvrages à contenu religieux.

3. Dimitris Stavridis (1803-1866) est né à Agchialos (ville de Trace). Orphelin de père, Stavridis est placé sous la protection de son oncle, qui l'amène avec lui à Vienne. En 1820, il est inscrit à la faculté de médecine de cette ville, avant d'opter pour des études d'ingénieur, toujours à Vienne. Stavridis participe à la construction de l'orphelinat d'Egine, et construit plusieurs bâtiments publics, dont des écoles ; il assure la mise en application du plan de Tripoli. Il est nommé inspecteur à l'École militaire en novembre 1829, professeur de " mathématiques pratiques " dans cette école en 1832. En 1839, il y enseigne l'architecture et la géométrie descriptive. En 1843, il est sous-commandant de l'École et, en 1855, il en devient le commandant. De 1856 à sa mort, survenue le 28 juillet 1866 (il est alors colonel), Stavridis assure la direction du corps du Génie (Voir : Journal *Aion* 14 août 1866 ; Kardamitsi-Adami 1988, pp. 72-73; Kastanis 1995, pp. 185-186).

régimentaire d'artillerie. Notons qu'une fois rentrés en Grèce, Manitakis et Isaïas vont compléter leur formation théorique sur le terrain, en travaillant comme aspirant-ingénieurs sous les ordres des ingénieurs français de l'expédition de Morée (Kardamitsi-Adami 1988, pp. 70-74).

Renforcés par quelques nouvelles recrues[4], ces premiers ingénieurs du corps du Génie, aidés par les rares autres ingénieurs au service de l'État grec ainsi que par les ingénieurs de l'expédition française[5] –parmi lesquels figure un officier d'origine grec, Stamatis Bulgaris[6]–, vont œuvrer à la reconstruction du pays durant l'ère du gouverneur Capodistrias. Comme nous pouvons le constater, ce sont des ingénieurs déjà formés, sans liens préalables et organiques avec l'armée grecque. Mais très vite, le corps du Génie va trouver un vivier dans lequel il pourra puiser régulièrement ses futurs membres. En effet, en même temps qu'il opère la réorganisation de l'armée, Capodistrias fonde en 1828, à l'aide d'un autre français, le polytechnicien et officier de l'Artillerie Henri Pauzié, une École militaire pour la formation des futurs officiers, dont les ingénieurs du Génie (Kastanis 1995).

L'arrivée du jeune Othon de Bavière en 1833, premier roi de Grèce (1833-1862), s'accompagne d'une nouvelle réorganisation de l'armée grecque (Malesis 1992), elle-même porteuse de changements pour le corps du Génie. Selon les décrets de mars et d'août 1833, celui-ci est désormais composé de trente-quatre officiers et se voit doté de la force de travail qui lui manquait : deux compagnies de sapeurs sont, en effet, créées pour la construction " de bâtiments militaires, des routes et des ponts ". A ces deux compagnies s'en ajoute une troisième l'année suivante (1834). Fortes d'une centaine de personnes chacune, ces compagnies ont comme sièges Athènes, Missolonghi et Nauplie respectivement[7], et seront directement impliquées dans les premiers travaux de construction des routes dans les années 1830 (Synarelli 1989). Le corps connaît aussi une décentralisation, puisque, toujours

4. En 1830 ont intégré le corps du Génie : A. Callandros, Vritellis, Ph. Mesoglous (Kardamitsi-Adami 1988, p. 70), et, en 1831, Léon Smolenski, grec de la diaspora et à plusieurs reprises ministre de l'armée (Kastanis 1995, pp. 183-184).

5. Voir (Kokkou 1985 ; Kyriazis 1976).

6. Sur Stamatis Bulgaris (1774-1842), et son action en Grèce, voir (Tolias 1999 ; Kyriazis 1976 ; Tsakopoulos 1986).

7. En 1836, le nombre de compagnies va repasser à deux ; en 1838, il n'y a qu'une

en 1833, on crée des directions départementales du Génie, neuf au total, une pour chaque département à l'exception des Cyclades (Malesis 1992, pp. 157-172).

Mais, au delà de ces modifications organisationnelles, l'arrivée d'Othon a aussi comme conséquence un changement important dans la composition " ethnique " du corps. En effet, le futur roi, mineur à l'époque et flanqué d'un Conseil de Régence, amène avec lui une armada de fonctionnaires et d'officiers bavarois qui vont occuper des postes importants dans l'Administration grecque. Parmi ces bavarois qui accompagnent le futur roi, on trouve plusieurs ingénieurs qui vont intégrer le corps du Génie. Ainsi, en 1842, ce dernier est composé de seize officiers bavarois et de quinze grecs[8] (Journal *Aion* 29 avril 1842 et 8 mai 1842).

La révolution de 1843 modifie de nouveau la composition du corps du Génie dans la mesure où elle a comme conséquence le départ de tous les bavarois de l'Administration grecque. Le corps est composé désormais exclusivement d'officiers grecs, sortis de l'École militaire[9]. En 1847, le nombre des officiers du Génie s'élève à trente-neuf (*Stratiotikos Aggelos*, n° 2, 1 février 1847, pp. 93-94).

En 1856, le corps du Génie connaît une nouvelle réorganisation. A sa tête on trouve désormais un colonel, celui-ci étant censé avoir sous ses ordres cinquante et un officiers et vingt-deux sous-officiers (Manitakis 1859, pp. 6-7). Les officiers du Génie sont répartis (dans les années 1860) en plusieurs groupes. Le premier " campe " au *Ministère de l'armée* (État-major), un autre au *Ministère de la Marine* (Service des phares et balises), un troisième au *Ministère de l'économie* (Service topographique et Inspection des mines), un quatrième enfin, de loin le

seule compagnie qui disparaît finalement en 1843 pour refaire surface dans les années 1860 (Malesis 1992, pp. 159-161 ; Megali Stratiotiki kai Naftiki Eggyklopaideia, 1929, t. 4, pp. 536-538).

8. Signalons qu'en 1833, suite à la réorganisation de l'armée par les bavarois, les officiers du Génie sont obligés de passer un examen pour garder leurs postes. On apprend que Ph. Mesoglous avait raté cet examen (Lettre en français de Mesoglous datée de 19 juin/1 juillet 1833 à la Direction du Génie, *Genika Archeia tou Kratous*, F206, Michanikon 1833-35. Voir aussi la lettre de A. Callandros, datée de 14/26 mai 1833, in *ibid.*).

9. Parmi les quarante-neuf officiers sortis de l'École militaire entre 1831 et 1842, on compte vingt-trois officiers du Génie, contre vingt et un officiers d'Artillerie et cinq officiers de l'infanterie (Kastanis 1995, pp. 242-245).

plus important, au *Ministère de l'intérieur* (Service des travaux publics). Et comme dans le passé, le Service des travaux publics du Ministère de l'intérieur est fortement décentralisé puisque l'on trouve pour chacun des départements du pays une direction du Génie dépendant de ce Service[10]. En 1872, on comptabilise quelque quatre-vingt-dix officiers du Génie (dont une dizaine affectés à l'État-major) (Mitroon 1872).

1878 constitue une année importante pour la nature et l'avenir du corps du Génie. Comme nous l'avons déjà vu, le corps était chargé lors de sa création d'une double mission, militaire et civile, cette dernière devenant dominante (et exclusive) très vite. En février 1878, le gouvernement du modernisateur Alexandre Coumoundouros, dans sa volonté de promouvoir un programme important de travaux publics, vote la création d'un corps d'ingénieurs civils (des ponts et chausées, selon la nomenclature française relative aux ingénieurs), dépendant du Service des travaux publics au sein du Ministère de l'intérieur, service jusqu'alors alimenté par des officiers du Génie. D'après cette loi, le Service des travaux publics restructuré est composé désormais d'une direction centrale comportant treize ingénieurs, dont le directeur du service, et de cinquante et un autres disséminés sur l'ensemble du territoire (Oikonomou 1935, pp. 238-239).

1878 marque donc la fin d'une " anomalie ". De sa création en 1829 à cette date, le corps du Génie, " arme savante ", assurait des tâches qui incombaient normalement à l'administration civile. A partir de 1878, il devient enfin un corps au service exclusif de l'armée. Mais si au niveau institutionnel, le corps du Génie se prive du domaine des travaux publics pour se concentrer sur ses tâches purement militaires, plusieurs officiers du Génie vont continuer à œuvrer encore jusqu'à la fin du siècle comme des ingénieurs civils. En effet, la loi de 1878 leur accorde le droit de postuler pour une place au sein du corps d'ingénieurs civils du Ministère de l'intérieur. Parmi les vingt et un ingénieurs qui intègrent le nouveau corps durant l'année de sa création, treize, dont le directeur du service D. Scalistiris, sont des officiers du

10. En 1833, le royaume de Grèce est divisé en dix départements : Attique-Béotie, Eubée, Phthiotide-Phocide, Etolie-et-Acarnanie, Achaïe-Ilide, Arcadie, Laconie, Messénie, Argolide-Corinthe, Cyclades (Papageorgiou 1988, pp. 122-123). Les îles Ioniennes faisant, à partir de 1864, partie de la Grèce, trois nouvelles directions du Génie sont créées, à côté des directions existantes, à Zante, Corfu et Céphalonie (Mitroon 1872).

Génie, qui quittent ainsi leur corps l'origine pour une carrière civile (Oikonomou 1935, pp. 239-240).

Devenus vite minoritaires dans le corps des ingénieurs civils du Ministère de l'intérieur, progressivement peuplé par de jeunes grecs ayant étudié à l'étranger[11] ou sortis de l'École polytechnique d'Athènes (devenue véritable école d'ingénieurs à partir de 1887, voir plus bas), ces ex-officiers du Génie n'en joueront pas moins un rôle non négligeable dans le déroulement des grands travaux qui vont marquer le ministère de Tricoupis durant les années 1882-1895 (chemins de fer, isthme de Corinthe, réseau routier...). Ils vont, en effet, occuper des postes élevés au sein de la nouvelle administration et seront investis des missions importantes. Ainsi, Leonidas Vlassis, sorti de l'École militaire en 1848 (G-1848), ancien élève externe de l'École polytechnique de Paris, sera chargé de recruter à l'étranger pour le compte de l'État plusieurs ingénieurs (au nombre de quinze) ainsi qu'une série de conducteurs et de dessinateurs (huit), qui vont participer, à côté des ingénieurs grecs du corps du Ministère de l'intérieur et des ingénieurs français de la mission des ponts et chaussées présente sur le territoire grec, à la réalisation des travaux publics de la période de Tricoupis (Oikonomou 1935, pp. 241-243 ; Papamichalopoulos 1885). La direction du Service des travaux publics du Ministère de l'intérieur sera assurée, par ailleurs, jusqu'en 1912, par l'un de ces ex-officiers du Génie[12]. Notons enfin que plusieurs de ces derniers se trouvent à l'origine de la création de l'Association polytechnique (*Polytechnikos Syllogos*) en 1898, l'ancêtre de la Chambre Technique de Grèce, très présente dans l'espace public de l'époque (Chatzis 2000).

11. Ainsi dix grecs diplômés de l'École nationale des ponts et chaussées de Paris entre 1881 et 1889 ont intégré, après la fin de leurs études, le nouveau corps (*Registre matricule des elèves externes de l'École des ponts et chaussées*, MS 3275, Archives de l'École nationale des ponts et chaussées).

12. D. Scalistiris (1878-1883) (G-1836) ; Leonidas Vlassis (1885-86) (G-1848) ; Xenophon Vlachopoulos (1886-1899) (G-1861) ; Michel Saourot (1899-1910) (G-1859) ; Panagiotis Zafeiriou 1910-12 (G-1862) (Oikonomou 1935, 241-245).

Partie II : Les actions des officiers du Génie

Les officiers du Génie et les travaux publics

Durant les années 1829-1878, les officiers du Génie sont pratiquement les seuls[13] à œuvrer dans les domaines des travaux publics, de l'urbanisme et de la construction des bâtiments publics. Quel est le bilan de leur action ?

Relevés topographiques, élaboration et mise en application des plans de villes[14], construction des routes et des ponts –jusqu'aux années 1840, ceux-ci semblent être plutôt en bois, ensuite en pierre–, construction d'ouvrages de protection contre les inondations, travaux d'assèchement, construction de bâtiments publics (hôpitaux, écoles, voire églises), alimentation en eau et assainissement des villes, voire travaux miniers à Mylos : sans pouvoir entrer ici dans les détails, les informations que l'on peut glaner ici et là[15] montrent que nos ingénieurs du Génie ne chômaient pas.

Mais un examen des informations et des témoignages de l'époque révèle que, pour la période 1829-1878, les projets en matière de travaux publics seront bien plus nombreux que les réalisations. Peu nombreux pour les besoins d'un pays où tout est à refaire, le plus souvent submergés par les tâches qu'ils doivent assurer[16], nos officiers

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13. Notons qu'en 1830 l'architecte grec St. Kleanthis et son collègue allemand E. Schaubert, diplômés de l'École des Beaux Arts de Berlin, sont nommés architectes du gouvernement grec. On leur doit plusieurs plans de villes dont le premier plan d'Athènes (1833). En 1834, au sein du Ministère de l'intérieur fonctionnent deux Bureaux : celui *d'Architecture* et le *Bureau Topographique*, le premier étant dirigé par E. Schaubert, le second par D.A. Guebhard. (Kokkou 1985, pp. 360-62). Juste avant le départ des bavarois, en 1842, on compte seize géomètres et huit architectes (tous des bavarois) (Journal *Aion* 17 mai 1842).

14. Durant le règne d'Othon (1833-1862), dix villes nouvelles ont été créées et vingt-trois autres reconstruites (Kokkou 1985, p. 363).

15. Voir : journal *Aion* 9 septembre 1857 ; Manitakis 1866 ; Kokkou 1985 ; Istoria tou Ellinikou Ethnous 1977, pp. 515-528 ; Oikonomou 1935, pp. 217-231 ; Dimitracopoulos 1937 ; Despoiniadou 1998 ; Tsakopoulos 1986 ; Karadimou-Gerolymbou, 1985 ; Synarelli 1989 ; Biris 1966 ; Tsokopoulos 1984 ; Xenikos 2000 ; Skouzès *et al.* 1963.

16. Manitakis (1859, pp. 17-18) donne une longue liste des travaux qui incombent aux trois ingénieurs du département de Achaïe-Ilide (Péloponnèse) dans les années 1850.

du Génie vont se heurter, jusqu'aux années 1870, à une politique budgétaire qui accorde aux travaux publics la portion congrue. Toutes les données disponibles concourent à l'élaboration du même constat : une carence grave de la part de l'État grec en matière d'infrastructures, que la contribution directe des municipalités ainsi que le travail gratuit des habitants concernés par certains travaux ne suffisent pas à compenser[17].

Reste tout de même un travail de législation en matière de travaux publics, d'urbanisme, de construction et d'hygiène, préparé en grande partie par ces ingénieurs du Génie, qui s'inspirent le plus souvent de l'exemple français[18]. Incapables de moderniser le pays sur le plan matériel faute d'argent, les officiers du Génie essaient, à l'instar des autres acteurs de l'État grec durant le XIXe siècle (Sakellaropoulos 1991), de le moderniser sur le plan institutionnel. Essais de modernisation institutionnelle, qui, d'après des témoignages de protagonistes, même s'ils ne coûtent rien en argent, ont souvent du mal à passer. Ainsi la loi relative au réseau routier, qui semble avoir été préparée de longue date, sur l'exemple de la loi française de 1836 (Guillerme 1984), n'est votée qu'en 1852, suite aux atermoiements, paraît-il, du roi (Manitakis 1869, p. 11).

Notons enfin que plusieurs des officiers du Génie vont s'illustrer tout au long du XIXe siècle comme architectes de bâtiments publics mais aussi privés (Biris 1966 ; Istoria tou Ellinikou Ethnous 1977, t. 13, pp. 519-528). Il faut attendre les années 1930, pour que les officiers du Génie se voient définitivement interdire le droit d'exercer comme ingénieur civils et architectes.

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17. Dans un bilan exhaustif des travaux réalisés par les officiers du corps du Génie entre 1844 et 1857, les chiffres avancés en matière de coûts de construction ne dépassent pas le million de drachmes (Journal *Aion* 9 septembre 1857). Manitakis (1869, p. 9) avance que durant l'époque d'Othon, l'État a consacré aux travaux publics quelque 7,3 millions de drachmes alors que l'ensemble des dépenses de l'État s'élèvaient pour cette période à 470 millions (pour les routes, les gouvernements successifs ont dépensé, entre 1835 et 1862, 3,7 millions de drachmes (Synarelli 1989, p. 91)). Quel contraste avec les travaux de la période de Tricoupis. Pour les seules années 1879-90 les routes absorbent quelque 65 millions de drachmes. Le canal de Corinthe (1882-1893) coûtera au total 60 millions de drachmes, et les chemins de fer vont absorber, pour la période, 1883-1892, 144 millions (Synarelli 1989 ; Papagiannakis 1982 ; Papagiannopoulou 1989).

18. Pour une liste complète de tous les lois et décrets relatifs au fonctionnement du corps du génie jusqu'aux années 1850, voir (Manitakis 1859).

Les officiers du Génie et la diffusion des connaissances techniques.

Un domaine où les officiers du Génie vont s'illustrer au XIXe siècle sera celui de la transmission en Grèce des connaissances et savoir-faire élaborés en Occident. Envoyés souvent à l'étranger, surtout en France, pour parfaire leurs connaissances en matière de sciences et de techniques[19], les officiers du Génie se trouvent à la tête des établissements dispensant un enseignement technique, assurent une grande partie de l'enseignement et publient plusieurs traités adressés aux ingénieurs mais aussi aux artisans[20].

Durant le XIXe siècle, l'enseignement technique en Grèce est l'apanage de deux établissements : l'École militaire et l'École d'arts et métiers, l'ancêtre de l'actuelle École polytechnique d'Athènes.

Parmi les premiers enseignants de l'École militaire figure un officier du Génie, Dimitris Stavridis (voir note 3), qui va y enseigner pendant plusieurs années les mathématiques pratiques, l'architecture et la géométrie descriptive. D'après les témoignages de l'époque, Stavridis va procéder à " l'hellénisation " (traduction) de nombreux termes d'architecture, de la mécanique et de la géométrie descriptive (*Efimeris tou stratou Apomachos*, n° 21, 30 sept 1860, p. 336). Selon le programme de 1839, deux (sur quatre) des professeurs qui enseignent des cours techniques à l'École militaire sont des officiers du Génie[21].

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19. Parmi les élèves grecs (originaires de l'État grec) de l'École polytechnique de Paris entre 1830 et 1880, on compte douze officiers du Génie, à savoir le tiers de la population grecque de l'École durant cette période. Ces officiers sont : D. Antonopoulos (G-1844), L. Vlassis (G-1848), A. Fountouklis (G-1856), D. Karageorgis (G-?), D. Koromilas (G-1836), I. Marcopoulos (G-1860), N. Metaxas (G-1855), I. Sechos (G-1849), D. Sekeris (G-1854), D. Skalistiris (G-1836), N. Tsamados (G-1858), E. Isaias (G-1839). Sur les élèves grecs à l'École polytechnique, voir (Nicolaidis 2000). D'autres officiers du Génie sont envoyés en Allemagne. C'est le cas par exemple de Panagiotis Vougioukas (1818-1889) (G-1839) et de Michel Soutzos (G-1839) (Vaxevanoglou 1996, pp. 77-80).

20. Parmi les premiers traités techniques (non lithographiés), figure un traité de construction des routes, paru en 1855 et signé par l'officier du Génie N.I. Soutsos (G-1844). En ce qui concerne les publications grecques à caractère technique du XIXe siècle, leur étude est à ses débuts. Grâce à un projet de l'École polytechnique d'Athènes, un recensement de ces ouvrages sera bientôt disponible.

21. Outre Stavridis, V. Nicolaidis (G-1836) enseigne la topographie (Stasinopoulos 1933).

En 1851, ils forment le tiers du corps professoral, et en 1866 presque les deux tiers[22].

L'École militaire sera jusqu'aux années 1880 le seul établissement grec de formation d'ingénieurs[23]. Mais à la fin du siècle, un autre établissement, l'ancêtre de l'actuelle École polytechnique d'Athènes (en grec : *Ethniko Metsovio Polytechneio*), va éclipser l'École militaire comme lieu de formation des ingénieurs (Biris 1957). Son histoire au XIXe siècle n'est pas moins marquée du sceau des officiers du Génie, qui vont assurer à plusieurs reprises sa direction et lui fourniront une grande partie de ses enseignants.

En 1837, un jeune bavarois, l'officier du génie F. R. von Zentner, se voit chargé d'organiser à Athènes une école d'arts et métiers (appelée à l'époque *Polytechniko Scholeio*) destinée à former, grâce à des cours du dimanche, des ouvriers qualifiés et des contremaîtres dans le bâtiment. Un autre officier du Génie, grec cette fois, Théodore Komninos (1807-1883) sera l'un des premiers enseignants de l'établissement. Il y enseigne de 1837 à 1854 les mathématiques et la mécanique, la géométrie et l'Architecture, selon les années (Biris 1957, pp. 486-487). A la tête de l'établissement, de 1844 à 1862, l'architecte L. Kaftantzoglou renforce l'orientation artistique de l'établissement aux dépens de sa vocation technique initiale. Mais pas pour longtemps. A partir des années 1860, la Grèce commence à découvrir l'industrie, Athènes connaît la mise en place d'un plan d'aménagement, d'autres villes commencent à s'équiper en bâtiments publics et en infrastructures. Pour répondre au nouveau contexte, l'établissement change à la fois de statut et d'orientation. Ce sont deux officiers du Génie, D. Scalistiris (directeur de l'établissement en 1864-1873) et A. Theophilas (directeur en 1879-1901), qui transforment cette école orientée vers les beaux arts en établissement d'ingénieur de

22. A. Fountouklis (G-1856) enseigne la construction des machines, I. Kokkidis (G-1854) la mécanique, Th. Ipitis (grec de la diaspora qui intègre le corps en 1850) les fortifications, G. Rikakis (G-1850) la topographie, I. Sechos (G-1849) la construction et les travaux publics, L. Pangalos (G-1844) l'architecture et la géométrie descriptive, E. Kallergis (G-1859) la topographie et l'astronomie, A. Theophilas (G-1853) la physique et la météorologie, M. Mousoudakis (G-1839) la géologie et la chimie (Journal militaire *Onisandros*, t. 3, 15 déc 1866, pp. 253-255 et 1 sept. 1866, p. 182).

23. Notons que des officiers du Génie avaient exprimé l'idée que l'École militaire admette aussi des élèves destinés à une carrière d'ingénieur civil (voir Vlassopoulos 1859, pp. 669-670).

niveau universitaire. Entre 1837 et 1901, quatre directeurs sur six, comptabilisant au total un demi-siècle de direction, sont des officiers du Génie[24], et le corps, avant d'abandonner ses fonctions civiles en 1878, avait fourni presque 40% du corps enseignant (un peu moins du tiers des enseignants jusqu'en 1890)[25].

Les officiers du Génie et la politique

Faisant partie de l'élite de la société grecque durant le XIXe siècle, les officiers du Génie, outre leurs fonctions d'ingénieur civil (des ponts et chaussées) au compte de l'État, vont participer activement, à l'instar de l'ensemble des militaires, aux évolutions politiques du pays (Veremis 2000). Ils sont ainsi présents lors de la révolution de 1843, qui débouche sur l'adoption d'une constitution[26]. On les trouve également souvent assis, comme leurs collègues des autres corps, sur le banc des députés (Varda 1980). Le corps aura par ailleurs le triste privilège de fournir à la Grèce un dictateur célèbre, I. Metaxas (1871-1941), sorti de l'École militaire en 1890.

Partie III : Deux portraits

Après avoir proposé des tableaux de synthèse sur les officiers du Génie au XIXe siècle, nous aimerions terminer cette note par deux gros plans sur deux membres du corps, Emmanuel Manitakis et Nicolaos Solomos[27].

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24. Les directeurs de l'établissement sont : Fr. Zetner (1837-1843), officier du Génie ; Lysandros Kaftantzoglou (1844-1862), architecte ; (1863-64) direction collective : Gerasimos Metaxas-officier du Génie (G-1833), St. Krinos-civil, I.G. Papadakis-civil ; D. Skalistiris (1864-1873), officier du Génie ; D. Antonopoulos (1873-76) officier du Génie; G. Mavrogiannis (1876-78), civil ; Anastasios Theophilas (1879-1901), officier du Génie.

25. Calculs à partir de (Biris 1957), qui comprend des notices biographiques consacrées aux professeurs de l'établissement.

26. Parmi les cinquante-cinq officiers impliqués dans la révolution figurent les officiers du Génie : V. Petmezas (G-1832), N. Mousoudakis (G-1836), V. Nicolaidis (G-1836), A. Politopoulos (G-1836) (Gerozisis 1996, pp. 110-11).

27. Nous contribuons ainsi à la constitution de la galerie de portraits des officiers du Génie au XIXe siècle inaugurée par Christine Varda (2000).

Emmanuel Manitakis (1808 -1883)

Emmanuel Manitakis est né en 1808 en Crète. Dans les années 1820, on le trouve en France, à Paris d'abord, où il étudie au Lycée St-Louis et à la Sorbonne (la physique et la chimie), et à Metz ensuite, où, selon toute vraisemblance, il suit des cours à l'École régimentaire de l'artillerie. En rentrant en Grèce, alors que la révolution pour l'indépendance nationale est en train de s'achever, il parcourt, selon ses dires, en 1829, le pays en qualité d'aspirant-ingénieur sous les ordres des ingénieurs-géographes de l'expédition française Peytier et Boblaye (Manitakis 1866, p. 20).

Quand le corps du Génie voit le jour en 1829, Manitakis l'intègre comme sous-lieutenant. Il devient capitaine en 1834, chef de bataillon en 1847, et lieutenant-colonel en 1854 (Mitroon 1872). En 1848, il est affecté comme chef du Service des travaux publics au Ministère de l'intérieur (*Stratiotikos Aggelos*, n° 6, 15 mars 1848, p. 29), service qu'il dirige pendant une vingtaine d'années. En 1877, Manitakis est nommé président du Conseil d'Administration de l'École polytechnique d'Athènes (Biris 1957, p. 262), et l'année suivante figure parmi les membres de la *Société pour l'encouragement de l'industrie* avant de présider à sa destinée en 1880 (Vaxevanoglou 1996, p. 76).

En 1866, Manitakis publie un *Aperçu sur les progrès matériels de la Grèce* (en français). Rédigée à une époque où le philhellénisme de jadis fait déjà figure de passé, et la Grèce est souvent dépeinte devant l'opinion européenne sous des couleurs sombres (Basch 1995), cette petite brochure est investie, aux yeux de son auteur, d'une mission nationale. Manitakis veut démontrer que, toute proportion gardée, la Grèce a accompli depuis son indépendance des progrès matériels substantiels et que, par conséquent, elle ne mérite pas le dédain dont elle est accablée.

Document riche d'informations sur les travaux publics réalisés en Grèce depuis l'indépendance nationale, la brochure nous renseigne également sur son auteur. Celui-ci proclame, dès la deuxième page, que " progrès et travaux publics sont synonymes " (1866, p. 2), " que les routes sont, par excellence, la pierre de touche des progrès matériels d'un pays " (*ibid.*, p. 11). Cette foi dans les effets bénéfiques des travaux publics prend même la forme d'une philosophie de l'histoire selon laquelle le progrès matériel constitue la condition du progrès intellectuel et éthique d'un peuple (Manitakis 1872, p. 17). Cohérent avec ses positions, Manitakis sera très impliqué dans les grands projets de son temps (tel que l'assèchement du lac du Copaïs, par exemple[28]), et va prôner, à plusieurs reprises, la création d'un Ministère des Travaux publics indépendant (1872, p. 17) –" ministère du progrès " dira l'auteur en se référant à un discours de Lamartine du haut du balcon de l'hôtel de Ville de Paris (Manitakis, 1866, p. 2)–, voeu qui sera exaucé bien plus tard, avec la création du Ministère des transports en 1914. Il propose également la nomination des ingénieurs à tous les arrondissements du royaume (et non plus seulement aux chefs-lieux des Départements) (1872, p. 23), ainsi que la création d'une Caisse spéciale, dotée chaque année d'une somme fixe de 200000 drachmes, pour la réalisation de travaux d'assèchement, d'irrigation et de protection contre les inondations (*ibid.*, pp. 22-24). Et quand, suite à la construction du canal de Suez (1869), la question du chemin de fer transcontinental liant l'Europe aux Indes fait son apparition en Europe au début des années 1870, Manitakis, chiffres à l'appui, exhorte le gouvernement grec à défendre le Pirée contre la Thessalonique ottomane comme la " tête " de la partie européenne du réseau. Par la même occasion, il lance un appel aux grecs riches de la diaspora pour qu'ils s'impliquent activement dans la construction de la partie grecque du futur réseau (Manitakis 1871).

Plaçant une confiance quasi absolue dans les effets bénéfiques des travaux publics, Manitakis sera un déçu de la politique de son temps. Après avoir réglé, avec sa brochure de 1866, ses comptes avec les étrangers, il s'en prend aux hommes politiques grecs de son époque, le roi Othon y compris. Dans des pages pleines d'ironie (Manitakis 1869, 1872), il fustige la classe politique dans son ensemble –seulement quelques hommes comme Mavrocordatos ou Zographos et surtout le " grand " et irremplaçable Capodistrias trouvent grâce à ses yeux– d'avoir tout fait pour empêcher le progrès matériel de la Grèce, en ne consacrant au financement des travaux publics que des miettes tout en dilapidant l'argent public pour le financement de postes inutiles dans l'administration – Manitakis est particulièrement irrité par la prolifération des professeurs de l'université d'Athènes, qu'il juge excessive (Manitakis 1872, p. 8-9).

28. Sur le rôle de Manitakis dans les projets autour du lac " Copaïs ", voir Xenikos 2000.

Comment dès lors expliquer ce rejet sans appel de la classe politique, indifférente aux travaux publics, et la défense de la thèse selon laquelle la Grèce a accompli depuis son indépendance des progrès matériels importants, défense qui fait l'objet de la brochure de 1866. Double langage en fonction de l'audience ? Le patriote qui s'adresse aux étrangers fait taire le citoyen qui critique ses propres gouvernants ? Quoi qu'il en soit, Manitakis semble être conscient de cette contradiction, qu'il tente de résoudre en rendant hommage au *peuple grec*, véritable auteur du progrès matériel du pays contre l'action néfaste des gouvernements successifs : " Il résulte de ce qui précède que les progrès accomplis, (...) appartiennent au peuple Hellène qui, en cela, s'est montré supérieur à ses gouvernants. Cette vérité, si consolante pour l'avenir du pays, prouve qu'à l'encontre de ce qui se pratique généralement, le mouvement de l'avant s'est transmis de bas en haut et que les progrès effectués auraient été bien autrement marqués si l'inverse avait eu lieu " (Manitakis 1869, pp. 11-12). L'inaction des gouvernants depuis 1833 fournit également à Manitakis l'occasion d'affirmer que la Grèce a besoin d'une *action administrative* (*dioikitiki energeia*) à la place de l'action politique (Manitakis, 1872, p. 10). Manitakis serait-il influencé alors par le saint-simonisme ? Sans pouvoir trancher, les thèmes de sa pensée, son vocabulaire même, rendent cette hypothèse vraisemblable. Un élément supplémentaire en sa faveur serait ses relations attestées avec un saint-simonien avéré, Gustave d'Eichthal[29], qui a travaillé pour le compte du gouvernement en Grèce entre 1833 et 1835.

Nicolaos I. Solomos (1840-)

Nicolaos Solomos est né en 1840 à Patras. Il intègre le corps du Génie en 1860. En 1862 Solomos a le grade de sous-lieutenant, il devient lieutenant cinq ans plus tard. En 1872, on le trouve à la direction du Génie au département d'Argolide (Mitroon 1872). Il est capitaine en 1878 quand il intègre, parmi les premiers, le nouveau corps d'ingénieurs civils du Ministère de l'intérieur (Oikonomou 1935, p. 239). Tout en exerçant des fonctions professorales à l'École militaire

29. Voir les multiples références à Manitakis dans (Eichthal 1974). Signalons que Moskof (1972) et Lappas (1985) dans leurs études sur le saint-simonisme en Grèce ne citent pas Manitakis.

ainsi qu'à l'École polytechnique, Solomos va se spécialiser dans la rédaction de manuels adressés non pas tant à ses collègues-ingénieurs mais aux ouvriers et artisans grecs, important ainsi en Grèce une pratique inaugurée par quelques polytechniciens français, tels que Dupin et Poncelet, dans les années 1820 (Chatzis 1998). Parcourons rapidement quatre ouvrages de vulgarisation signés par Solomos (Solomos 1875, 1893a, 1893b et 1893c).

Le premier ouvrage, intitulé *Guide pratique de l'artisan grec,* dédicacé au roi Georges Ier, " protecteur des sciences et des arts ", est un manuel composé de quatre parties : *Arithmétique*, *Algèbre*, *Géométrie pratique* et *Mécanique*, cette dernière occupant à elle seule plus de la moitié de l'ouvrage[30]. L'auteur semble s'être inspiré des traités similaires établis en France, mais aucune référence précise à des auteurs n'est donnée.

Si le livre précité est expurgé de toute trace de subjectivité de son auteur, Solomos dans ses trois autres livres examinés par la suite alterne allègrement réflexions d'ordre général, jugements sur la réalité de son temps et conseils techniques adressés aux artisans grecs. A travers ces livres, on fait la connaissance d'un homme aux " deux cultures ", scientifique et littéraire, au courant à la fois des dernières évolutions de sa discipline (du Génie civil) et avide de connaissances historiques, observateur attentif et juge des pratiques sociales de son époque, qui n'hésite pas à " orner " ses textes techniques de citations d'Homère.

Dans une petite brochure intitulée *Des constructions antisismiques* (1893a), vendue au profit des victimes du séisme qui a frappé Zante en 1893, Solomos écarte le recours à des solutions mettant en jeu des connaissances théoriques sophistiquées et exigeant l'utilisation de matériaux devant être importés de l'étranger. Les solutions doivent, d'après lui, être souples et diversifiées, respectueuses des ressources de chaque localité à protéger. L'auteur, bon connaisseur des techniques constructives utilisées dans des pays fréquemment touchés par les tremblements de terre, comme le Japon, les Philippines et le Pérou,

30. La partie *Mécanique* est divisée en 10 chapitres : *Des connaissances générales élémentaires* ; *De la composition et décomposition des forces* ; *Des machines simples* (A) ; *De la friction et de la dilatation des corps* ; *Des machines simples* (B) ; *Des machines d'élevage des eaux* ; *Des mécanismes* ; *De la résistance des matériaux* ; *Des machines à vapeur* ; *Des machines hydrauliques.*

n'hésite pas à mobiliser, afin d'élargir la palette de mesures envisagées pour se protéger contre les séismes, les leçons de l'histoire. Il prône ainsi des solutions simples qui s'inspirent des techniques mises en œuvre par les grecs anciens et les romains (*Vitruve* est alors une référence constante).

Son expérience d'ingénieur de terrain lui permet, par ailleurs, de déceler à l'origine des dégâts causés l'action de causes sociales et économiques. Et Solomos de proposer des remèdes simples qui éradiquent ces causes. Ainsi, l'auteur constate, qu'en ce qui concerne le Péloponnèse, les séismes touchent beaucoup plus les constructions les plus récentes dans les régions spécialisées, à partir des années 1870, dans la production du raisin sec. Pourquoi une telle polarisation ? L'explication avancée est que les producteurs, voulant stocker les raisins chez eux, construisent des habitations dont le rez-de-chaussée est privé de murs de support en vue d'augmenter le volume potentiel de stockage. En revanche, ils divisent le premier étage de leur maison en plusieurs chambres. Cette asymétrie rend le bâtiment fragile en cas de tremblements de terre. La solution prônée alors consiste à cloisonner de façon identique les différents étages de la maison (1893a, pp. 7-8).

Comme son collègue Manitakis, Solomos croit aux effets bénéfiques de la technologie. Dans un ouvrage traitant des applications du fer dans la construction, il se sent autorisé à écrire que " les grands développements de la civilisation sont dus au perfectionnement de la métallurgie " (1893b, p. 4), avant de déplorer, chose curieuse pour un ancien élève d'une École militaire, le fait que le fer se trouve également à l'origine des moyens de destruction massive de l'homme par l'homme (*ibid.*, pp. 4-5).

A travers ses écrits, Solomos s'avère être un " fonctionnaliste " en matière d'architecture, voulant déduire la forme du bâtiment des fonctions que celui-ci est censé remplir. L'auteur ne peut cacher son hostilité, doublée de dédain, à l'égard des pratiques architecturales de son époque, sévissant, d'après lui, surtout à Athènes. Solomos n'a pas de mots assez durs pour ces pratiques qui mettent au premier plan l'ornement extérieur et font montre d'une indifférence, inexcusable à ses yeux, à l'égard des fonctions qu'une habitation doit assurer, notamment en matière d'hygiène et de confort intérieur (disposition des différentes pièces par rapport au soleil par exemple...). Et l'auteur de crier : " la beauté très souvent gît dans la simplicité " (1893c, p. 12).

Militant en faveur de l'intervention de l'État en matière de règles de construction, Solomos ne s'en insurge pas moins contre les politiques de taxation touchant des matériaux de construction comme le bois importé, étant donné que " l'État (grec) ne produit pas et n'espère pas pouvoir produire dans l'avenir la quantité de bois nécessaire " (1893c, p. 21).

Terminons cette brève rencontre avec l'auteur par une remarque sur son travail sur la " langue ", travail qui accompagne, mieux qui soutient, les efforts de Solomos pour diffuser des connaissances scientifiques auprès des artisans grecs. En effet, pour transmettre la " science " auprès des artisans, Solomos est obligé de faire tenir ensemble trois lexiques distincts. Le premier est composé des termes scientifiques des langues européennes. Le deuxième vocabulaire est celui des termes scientifiques traduits en grec " savant ". Mais il y a un troisième lexique, celui utilisé par les artisans eux-mêmes. Dans ses ouvrages de vulgarisation, l'auteur établit alors constamment des correspondances entre les trois lexiques (pour le plaisir du lecteur grec, je donne ici juste l'exemple du concept de *pression* en mécanique : le terme correspondant en grec " savant " de l'époque est *thlipsis* ou *piesis* ; le terme utilisé par les forgerons et les ouvriers du bâtiment est *zoulgama* (1893b, p. 22).

Conclusion

Dans cette brève conclusion, j'aimerais m'appuyer sur le sujet particulier de mon intervention, à savoir les officiers du Génie dans la Grèce du XIXe siècle, pour effleurer un thème de recherche beaucoup plus large, l'étude de l'Administration grecque (et, plus généralement, de l'État grec) durant le XIXe siècle. Celle-ci est, me semble-t-il, le plus souvent étudiée " en bloc ", comme si elle constituait une structure unifiée, une entité cohérente. Les outils d'enquête utilisés –évolution des dépenses publiques, nombre de fonctionnaires par habitant– ont, par ailleurs, favorisé cette vision " homogène " de l'Administration grecque (et de l'État), envisagée plutôt par l'intermédiaire des fonctions qu'elle était censée assurer qu'à travers ses pratiques effectives (je songe évidemment aux études classiques de Tsoucalas (1981) qui envisage l'État grec comme principal agent de distribution du surplus économique *via* le recrutement dans l'administration). Or, je crois qu'il y a d'autres entrées dans l'étude du champ bureaucratique (et de l'État grec), qui pourraient utilement prolonger, voire rectifier, les résultats obtenus par les approches " macro ", privilégiées jusqu'alors. L'étude de l'action, multiforme et souvent insaisissable par une approche quantitative –comment saisir et évaluer, en effet, le travail ainsi que les retombées pratiques de traduction des termes techniques ?–, de groupes particuliers, tels que les officiers du Génie, qui ont fait fonctionner l'État grec au quotidien, en est une. Mettre l'accent sur les groupes particuliers et sur les pratiques matérielles qui assurent la construction et le fonctionnement quotidien de l'État ne manquera pas, selon toute vraisemblance, de nous faire voir la réalité grecque sous un jour nouveau.

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YIANNIS ANTONIOU, MICHALIS ASSIMAKOPOULOS

NOTES ON THE GENESIS OF THE GREEK ENGINEER IN THE 19th CENTURY: THE SCHOOL OF ARTS AND THE MILITARY ACADEMY*

«"Everybody that will stand out for their sedulousness and intelligence to the school's subjects and their works will be chosen in the annual school's examinations... without these prerequisites any request for scholarships will be rejected."

Ioannis Kolettis, Minister of Interior, 1844. NTUA Archives, file 2.

"That middle epistemology was a way of knowing that invited the active manipulation of human instruments to purposeful ends. It partook neither of the savant's speculative study of nature, nor the artisan's immersion in the particularistic details of his craft. Engineers were therefore cautioned against the sociability associated with these deficient epistemologies. An epistemological pose is also a moral code."

Ken Alder, 1997

About technology

The term 'technology' has a different past in various languages. English distinguishes *technique* and *technology* taking for granted that *technique* refers to something quite different, skills and methods. On the Continent, in French and in German, both terms can be used in a supplementary way. *Technique* covers all activities associated with technical things and *technology* refers to something more specialized and technically advanced. English has not the equivalent of *technique*

* This paper has two parts. The first part aims to give a theoretical framework for engineering studies, having also in mind the Greek reader and the second deals with the formation of the Greek engineer.

in its Continental meaning and uses *technology* to cover both *technique and technologie.*[1]

The term appears early in 1728 in Christian Wolf's *Philosophia rationalis sive Logica* and its main influence was the opening of the university teaching to the technical culture in general, that is "the science of things made by man's labour." Later on in the century, Joseph Beckman used the word "technology" in the title of one of his books, but the term in this case put an emphasis on a fiscal science encompassing political economy finance and management. On the other hand, we find in the *Encyclopédie* a full description of the technical professions and, as Salomon writes,[2] the whole undertaking of the project was directed at the accommodation of technical matters with the culture and practice of the *honnête homme* and was a hymn to progress. Technology triumphed on the basis of the progress ideology, on the very eve of the technical changes, which ultimately threaten this ideology.

In 1832, Babbage in his *Treatise on the Economy of Machines and Manufacture*, while lamenting over the situation of English science, focused on the social economic aspects, paving the way to K. Marx to identify technology as a social process. Bigelow, a botanist and a physician, in his lectures at the Harvard University in 1828, coined the term technology in English[3] where he meant "the principles, process and nomenclature of the most conspicuous arts, particularly those which involve applications of science, which may be considered as useful..." Thomas Carlyle, in the seminal article "The Age

1. These uses are justified in the entries of the *Oxford, Hachette* and *Langenscheidt* dictionaries. See also: Jean-Jacques Salomon, "What is Technology? The Issue of its Origins and Definitions", *History and Technology*, vol. 1, 1984, p. 113.

K. Jacobsen, K. Andersen, T. Halvorsen and S. Myklebustin (M. Hard and A. Jamison eds, *The International Appropriation of Technology, Discourses on Modernity, 1900-1939,* MIT Press, 1998, p. 105) assert that the Anglo-Saxon "applied science" discourse finally had no need of the distinction between *technologie* and *technique* according to the Continental version. In this discursive framework the science of technique was science. The use of the term technology in the title of several panoramic histories, which appeared in the 1950-60's edited by C. Singer, E.J. Holmyard, A.R. Hall, T. K. Derry, T.I. Williams reflect, according to our opinion, the methodological spirit of the historians at that time and it cannot hold as a counter argument to the use we propose.

2. Jean-Jacques Salomon, 1984, p. 125.

3. Leo Marx, "Technology: the Emergence of a Hazardous Concept", *Social Research*, vol. 64, 1997, p. 974.

Machinery," published in Edinburgh in 1829, defined the new era, through the mechanical components of the technological system, but soon it became clear that those were only a small part of the system. Strict definitions and monocausal explanations, though helpful they may seem usually hinder the knowledge of the past, which also holds for the case of mechanization. Referring to these definitions, we must bear in mind, as Landes neatly comments[4], that no economic or social system, at least historically, has ever been pushed to its extreme logical consequences.

Bigelow's definitions and early exclamations for the novelty and the power of scientific research applications were soon followed by critical voices. Thoreau wrote in 1847, "they are but improved means to an unimproved end" and the same anxiety was expressed in the classic novel *Moby Dick*. The railway in the USA created a network and by the end of the 19th century, the growth of electrical and chemical industries, forged the amalgamation of science and industry. The school culture of engineers dominated the traditional shop culture of manufacturing and the useful arts reached the level of "fine arts."

But as Leo Marx comments, these changes were not enough. Technology was not simply filling a semantic void which was simply representing the means through which progress could be achieved, technology virtually came to constitute progress, was reified, and became independent. The classical problem of the relation between society and technology emerges, since it was thought that there is a need of drawing the boundaries between the two. But the "impact" of technology to society today is thought not to be a simple problem and hard demarcations are difficult if not impossible. This being the case, it leads to a web notion of amorphous technology, very helpful to modern historical studies, but difficult to handle. We will not pursue here this issue; we will just say that the image of autonomous technology, which appears in various approaches, leads to a notion of an institution uncontrollable by social life, raising great political and moral issues.[5]

4. David Landes, *The Unbound Prometheus*, Cambridge University Press, 1969, 2nd ed., 1999, p. 547.

5. We refer to these problems in our manuscript, Y. Antoniou, M. Assimakopoulos, D. Xenikos, "From technological determinism to constructivism and actors networks. Technology studies at the end of 20th century," in Greek.

The above reading about the genesis of the notion of technology, leads us to the idea that technology can help to fill the chasm in all the dualisms that follow the generic Platonic scheme. An excursion to book VI of *Nicomachean Ethics*[6] can show the limits of the relevant ancient Greek framework about technology[7] and can also help to clarify its modern character.

Developments relevant to technology differ in various contexts and countries, as the example of France and Britain shows for the 19th century. While the notion of technology was linked to the practical exploitation of abstract categories and the creation of relevant institutions, U. Wengenroth's phrase characterizing technology as "a way to do things, rather than ways to produce things"[8] captures the meaning of 19th century technology.

The notion of technology thus hints to its social essence and

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6. Aristotle came close to a formulation of the term technology when he defined art, 1140a20, "art (τέχνη), then as it has been said, is a state that concerns the making, involving a true course of reasoning (λόγος)". This notion of art is linked to making (ποίησις) which differs from action (πράξις), 1140a15. Making has an end other than itself; something that action has not. The above are constituent parts of his teaching of virtues. Practical wisdom (φρόνησις) the virtues, which is of our concern here, is not defined by the Stagirite, who recommends to grasp it "by considering who are the person we credit with it," 1140a25, while elsewhere, 1103b, he tells us that people become builders by building (οικοδομούντες γίνονται οικοδόμοι).

Practical wisdom is not a science since there is no demonstration of things through first principles, it is "not art because action and making are different kinds of things" (άλλο το γένος), 1140b1, is concerned with human things, 1141b10. The above Aristotelian notion "must be a reasoned and true state of capacity to act with regard to human goods ... is an excellence and not an art," 1140b20-27, (αρετή τις εστίν και ου τέχνη) and "thus is of the same state of the mind as the political wisdom, the politicians acting as manual labourers," 1141b28 (ώσπερ οι χειροτέχναι).

A first conclusion which can be drown is that Aristotle keeps a notion for art which requires, *techne* and *logos*, relates it to the making not the acting, he is differentiating it from practical wisdom, remaining within the Platonic framework. His treatment of practical wisdom, which links it to a social, political, moral teaching provides a framework that is in accordance with the modern treatment of technology. E.T. Layton Jr. in "Technology as knowledge," *Technology and Culture* vol. 15, 1974, pp. 31-41, treats the mater somehow differently. *A New Aristotle Reader,* J. L. Ackrill, Princeton U.P., 1987, is used for the translation of the Aristotelian passages.

7. The Liddell-Scott dictionary justifies that the ancient Greek word 'τεχνολογία' (technologia) meant the grammatical inquire and analysis of the words.

8. U. Wengenroth, "Science, Technology and Industry in the 19th century", web working paper.

therefore, its study and its overall influence require an estimation of the general trends and values of the social environment in question. For the case of Greece these social elements can be traced in the conclusions of two Greek scholars, who produced important works in the fields of industrial history and the history of the railways.

Ch. Agriantoni closes her fundamental work saying that "we have to do probably with a new society [Greece at the end of 19th century] … Alien to the insistence and patient long term commitment and systematic way required for industrial works,"[9] and characterizes the big state development projects of the last quarter of 19th century as an "economic expression of the leading 'Great Idea,' that is the policies of irredentism, which was dominant in the century until 1922."

L. Papayannakis[10] in a recent manuscript commenting on his work about the economic history of the establishment of the Greek railways says "the railway was situated outside the socio-economic framework, where it was born and reached adulthood".

Engineering studies

Engineering studies[11] is a developing discipline within the framework of Science and Technology Studies. Although hard demarcations are not in the first line of research, the relations between applied science and engineering on one hand and technology and engineering on the other, are important topics of study. Engineering can be studied historically, philosophically and sociologically, but as it has been shown in a very convincible way that none of these approaches can grasp the essence of its subject matter.[12] The dominance of the historical practice approach to engineering, despite its great importance, cannot answer problems related to the continuity

9. Christina Agriantoni, *The beginnings of industrialization in 19th century Greece*, Historical Archive Commercial Bank of Greece, Athens 1986, in Greek, p. 350.

10. Lefteris Papayiannakis, *Technology and Public Works in 19th century Greece*, manuscript 14 April 2002, pp. 3, 9.

11. As basic text on the subject we used Gary Lee Downey, Juan C. Lucena, "Engineering Studies" in *The handbook of Science and Technology Studies*, edited by Sh. Jasanoff et al, Sage, 1995, pp. 167-188.

12. G. L. Downey, A. Donovan, T J. Elliott, "The Invisible Engineer: How Engineering Ceased to be a Problem in Science and Technology studies", *Knowledge and Society*, vol. 8, 1989, pp. 189-216.

either of engineer's self-determination or their orientation. The pure study of structures related to engineering, examined by philosophical or sociological approaches, ended mainly in a deadlock.

Sociological studies on engineering were part of industrial sociology, which flourished in the 1950's, and their origin can be traced in the work of the classics of sociology and their notion that liberal professions were linked to an ideal of public welfare.

Talcott Parsons in his seminal paper, "The profession and social structure," legitimised the functionalist study of engineers and led it to its limits, writing "profession occupies a position of importance which is unique in history," "the professional man is not thought of as engaged in the pursuit of his personal profit but in performing services."[13] According to Parsons, at the institutional level of study between business and profession there are differences to appear, which are maintained through a complex balance of social forces.

The structuralist model of sociology of professions had to identify the social features of the profession on the basis of an abstraction of common characteristics and also to verify empirically that the professional action reproduced the initial professional structure. Barber gave an often cited list of characteristics of the professions: high degree of generalized and systematic knowledge, primary orientation to community interests, self control behaviour through codes of ethics, a system of rewards, primary of a symbolic essence.[14]

Engineers in the developed world of the 20th century moved from the individual work to the corporate structure and the sociology of professions had to study these organizations, where relevant contingencies played an important role. After the events of the1960's, the power issue also played a prominent role. The structural model could not study the new framework, especially for the industrial engineers.

In general, social mobility of engineers is stronger than in law and medicine, although universities, especially the elite ones, were reluctant to introduce science and engineering into their educational curriculum, especially in Britain where "in any case the top places in industry were given to the Oxbridge graduate rather than the somewhat socially dubious engineer." On the other side, in the engineers'

13. T. Parsons, "The Professions and Social Structure", *Social Forces*, vol. 1, 1939, pp. 45, 8.

14. Downey, Lucena, 1995, p. 192.

professional associations, there was always present a tension between the inherent anti-managerialism of the union and the role of engineers in big corporations and also a tension between the union and the profession.

All the above schemes, must be noted, leave the content of technical knowledge as a 'black box,' the same way the Mannheimean sociology of knowledge leaves scientific knowledge.

The relation of the engineer with the craftsman is a major problem especially in the last two centuries and aspects of it will be mentioned in the historical retrospection that follows.

P. Whalley[15] on the basis of empirical material, especially from the United Kingdom, writes on this issue and comes to define the notion of the trusted worker.

He avoids identifying 'essentialist' characteristics of engineering, which could distinguish it from craft labour,[16] showing the importance of the organizational boundary that guarantees the demarcation, which is constituted of social arrangements. The category of the trusted worker refers to the one who carries out strategic jobs in the corporation with a fair degree of autonomy. Corporate practices suggest ways to maintain trustworthiness among part of their employees. "You feel part of it … on the shop-floor its more just a matter of loyalty," "a degree is useful for a career, but you don't need it to do the job here…" are demarcation phrases in a language which is not the language of science nor of formal knowledge nor even of authority that is spoken, but rather the language of attitude, responsibility and trustworthiness" more even of authority. This social selection is strengthened through recruitment across the traditional barriers, by promoting loyal self-taught technicians, clerical workers and skilled labourers, while it has been pointed out "the official definitions of professional in the United States are not epistemologically but socially authoritative, and are the result of political lobbying."[17]

The centre of the research has moved now to the sociology of the

15. P. Whalley, "Negotiating Boundaries of Engineering: Professionals Managers and Manual Work", *Research in the Sociology of Organizations*, vol. 8, 1999, pp. 191-215.

16. In this sense, he avoids K. Marx's and M. Weber's attempts to distinguish engineering from craft labour as can be seen for example in *Theories of Surplus Value*, vol.1 of the former, or in *Science as Vocation* of the latter.

17. Whalley, 1999, pp. 205-207.

professions for the big corporation rather than of liberal professions. In the Greek case, where the model of the self-employed engineer prevails, the above schemas must be treated with caution.

The philosophical study of engineering in the framework of positivism and postpositvism was focusing on the epistemological status of engineering knowledge and was linked to the problem of demarcation engineering from applied science.

Popper, challenging Kuhn's notion of normal science, expressed a common view of the humanitarians for the engineers, arguing that the characteristics of normal science exist for the engineers and not the scientists.[18] Among others, E. Layton, W. Vincenti and R. Laudan, examine technology as knowledge. Layton[19] proposes a view of technology as a spectrum with ideas at one end and techniques and things at the other, with design being in the middle, while in his major work[20] considers the American community of engineers as a mirror image of the scientific community. Vincenti[21] considers theoretical knowledge as a component of engineers' knowledge and he adds a cluster of devices related to the theoretical ones in addition to the mathematical tools in use. R. Laudan[22] treats technological change as a problem solving driven process, refers to the same technology, which is applied in different social environments and proposes an inversion of the common argument of the necessity as mother of invention.

The discussions in the 1960's between Bunge and Agassi who studied the demarcation problem between science and technology and Skolimowski who tried to overcome it did not come to a solution. In philosophical tradition, where scientific knowledge is considered a copy of a reality out there, it is generally not possible to treat engineering action and its irreducible social component.

Kline, in a study[23] about technology as an applied science in the

18. See for example K. Popper in I. Lakatos ed., *Criticism and the Growth of Knowledge*, Cambridge UP, 1970, p. 198.

19. Layton, 1971, op. cit., p. 37.

20. E. Layton, *The Revolt of Engineers*, J. Hopkins University Press, 1986.

21. See Downey, Lucena,1999, p. 170. E. Ferguson can be related to this group of scholars with his *Engineering and the Mind's Eye*, MIT Press, 1994, where he studies forms of visual and analytical thinking in engineering, see for example, p. 41.

22. R. Laudan, "Cognitive Change in Technology and Science" in R. Laudan ed., *The Nature of Technological Knowledge. Are Models of Scientific Change Relevant?*, Reidel, 1984.

23. R. Kline, "Construing 'Technology' as 'Applied Science' ", *ISIS*, vol. 86, 1995

United States in the period from 1880 to 1945 came to the conclusion that "scientists and engineers have rhetorically drawn flexible and historically changing boundaries while presidents of engineering societies drew sharp boundaries and argued for autonomy from scientist and craftsmen, industrial and engineering researchers underlined these boundaries for similar reasons." According to Kline, the spectrum between science and technology under the umbrella label of applied science was continually modified by introducing new keywords without upsetting a hierarchy of pure and applied science, which seemed beneficial both to scientists and engineers.

Since the 1980's, the engineering approach immersed in the philosophy of technology[24] which influenced the study of engineering practice rather than the one of theory, making the purely philosophical analysis of engineering impotent. In the post-Kuhnian times, where STS is developing, there are no hard demarcations between the social and the cognitive approaches to science and thus to engineering as well.

The social structure approach for engineering studies either in its functionalist or later implicit in the organization oriented studies, cannot appreciate the factor of knowledge in engineering, a factor that hints to the importance of the cognitive approach. The latter cannot treat the irreducible component of engineering action, showing its own limits. The historical approach with its inherent contingency cannot talk about the continuity of engineers' orientations and self-determination.

Historical studies of engineering are not in general of an internalist orientation but focus on the influence of engineering in the social development and vice versa and thus can provide a genealogy for the study of the engineer.

In the case of the United States, where there is a rich bibliography of

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p.194-221. Jacobsen et al. pursue further these ideas and include also the British case. In the United Kingdom, the engineers had to compete with the "rule of thumb" tradition of the British industry and the social hegemony of the Oxbridge liberals. The notion of "applied science", related to the engineers' education comes as an attempt to promote British engineers in the social ladder (themes to be developed later). K. Jacobsen, K. Andersen, T. Halvorsen and S. Myklebustin (M. Hard and A. Jamison eds., *The International Appropriation of Technology. Discourses on Modernity, 1900-1939*, MIT Press, 1998, pp. 105-106.

24. See for example, C. Mitcham, *Thinking Through Technology*, Chicago University Press, 1994.

this kind, we find topics such as: the engineers, usually civil ones, who transformed the 19th century rural America and led to its corporate structure and industrial development; the conflict between school culture of university formed engineers and shop floor culture of the elite craftsmen; the functional professionals engineers that influenced big corporation from subordinate positions; attempts by engineers to re-establish themselves in the interwar period of the 20th century, as social leaders, arbiters between the firm and the workers; the engineers as bearers of technological change within the framework of big industrial corporate structure, having highly qualified engineers in their top hierarchy; engineers as dominated by corporate capitalism.

We can name problems as the ones mentioned above, as an attempt to make a rough description of the American engineer. We propose a list of arguments and relevant open issues to form a description of the Greek engineer, since the 19th century. We must bear in mind that the Greek bibliography consists essentially of a fundamental book written by Biris in 1957, the 1934-35 year book of the Technical Chamber of Greece (TEE) and some recent sociological studies. We do not know studies of cognitive orientation; the latter could throw light on Greek advances on engineering and also could deal with the issue of the adoption, assimilation or appropriation of international engineering.

The issues of the study could be, engineers in the public and the private sector, engineers and construction of infrastructure, their employment in industry or in commercial activities, foreign educational influences of mainly French, German and American, engineers and the military, engineers as agents of modernity, their relation to traditional pre-industrial forms of production, groups of builders (bouloukia), traditional shipbuilding, professionalism of engineers and professional organizations, engineers and politics, engineers and working class movement, issues of social mobility of engineers, the problem of shop versus school culture, gender problems, engineers and their role in the technology transfer, foreign engineers in Greece, engineers in big organizations, corporations and multinational companies.

There are some studies made on the problems mentioned and there is also a collective experience, but most of the subjects remain open.

The three authors[25] came to a convincing conclusion that "disciplinary approaches that viewed engineering action as reproducing

25. Downey, Donovan, Elliot, 1989, pp. 209-10.

either purely social or purely cognitive structures ultimately handcuffed themselves by including the other as non-analysable practice, while approaches that viewed engineering action as contingent practice failed to account how it reproduces structures." Later on, it is proposed the idea that structures could be treated as a diachronic phenomenon rather than a universal one, while practices could be studied also from the aspect of the reproduction of some pre-established structures, even in the cases of the most radical changes. The later structures hint to a notion of engineers' identity and its continuity. The above conclusion leads naturally to a study of engineering as work, how engineers do their work, understand and reflect on it far from essentialist definitions and professional autonomies.

Engineers' work can be examined from a professional or a class perspective or even from a trans-national one, but new fields of study is also closely related to the content of engineering knowledge. That is the problem of maintenance of engineering disciplines and the experiences of the engineers related to the shift of intellectual hegemony from civil, to mechanical, to chemical, to electrical engineering, the evaluation in industry and university of the distinction between engineering science and engineering design, the study of the status differences between designing and manufacturing engineering and its relation to their knowledge content, the conception of job satisfaction in engineering and its implications and the role of engineers in knowledge based societies .

Meiskins and Smith,[26]in their influential book on engineering labour, classify the organization of technical work into four models. The craft model, based on apprenticeship close to manual labour, the managerial based on formal education close to management, the estate model based on the hierarchy of credentials linked to the status hierarchy and the company-centered one, based on formal education and in contact with both labour and management. The models mentioned above are naturally related to the engineering practices at the leading countries, although not in a one to one way. And although in a country we can see more than one model to apply, the craft model is linked to Britain, the estate to France, the company to Japan, the managerial to the United States.

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26. P. Meiskins, Ch. Smith eds, *Engineering Labour. Technical Workers in Comparative Perspective,* New York, Verso, 1996, pp. 236-249.

From the history of engineering

We now present a highly selective excursus on the history of engineering in a number of key countries in order to be able to study influences and models in our project on Greek engineering.

In Britain, the industrial revolution provides a rich framework to study engineering, its role into the production and its relation to the rest of the educational system. The term 'industrial revolution' is under critique from various sides,[27] but in any case it refers to events of great importance[28] it has very strong local attributes, it is elusive in character, it is influenced from below and not from a general state plan,[29] and in no case it is a social phenomenon of a total character.

Dobb,[30] agreeing with A. Toynbee, refers to four great inventions between 1769 and 1792, the 'water frame' patented by Arkwright, the 'spinning-jenny' by Hargreaves, Crompton's 'mule,' all three are totally independent of science,[31] and Kelly's 'self acting mule' as well. All the above art crafts made use Watt's steam engine. Toynbee[32] also refers to the economics of the period by having a ten-year increase of 10% at the end of the 18th century and of 14% in the first decade of the 19th century, while in the 1750's there was only 3%. The patents per decade for the period 1781-1829 were 910 and for the period 1702-1760 only 28. [33]

In the 1980's, a new orthodoxy was created rejecting the discontinuous character of the British industrialization; was written "it was possible that there was virtually no advance during 1780-1860."[34] M. Berg, A. Paulinyi, among others, show that discontinuity[35] did

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27. M. Berg, *The Age of Manufactures 1700-1820*, London, Routledge, 1994, 2nd edition, ch. 1, pp. 13-50.

28. Landes, 1969, p. 5.

29. I. Inkster, *Science and Technology in History. An Approach to Industrial Development*, Rutgers, 1991, p. 61.

30. M. Dobb, *Studies in the Development of Capitalism*, Routledge, 1963 p. 261.

31. D.S.L. Cardwell, *Technology and Science in History*, Heinemann, 1972, p. 100. Inkster, op. cit., p. 71, refers to a catalogue of 498 British applied scientist and engineers in the period 1700-1859, where only 33% of them had university education, the ratio being constant throughout the period.

32. Dobb, 1963, p. 257.

33. Inkster, 1991, p.41, elaboration of table data.

34. Craft, cited in Berg, 1994, p.17.

35. Akos Paulinyi, "Revolution and technology', in *Revolutions in History*, R.

occur, but the whole phenomenon of industrialization was complex, rooted in the particularities of Britain, initiated from below. Technological and organizational changes played an important role but the importance of the 'handcraft' occupation cannot be neglected, "innovation was discontinuous and clustered, but it was also embedded in a context of adaptive technical skill."[36] Samuel argues that "the one innovatory (steam power), the other traditional (hand technology), were the two sides of the same coin, and it is fitting that the Great Exhibition of 1851 –the authentic voice of British capitalism in the hour of its greatest triumph– should have given symbolic representation to them both... Skill was important as toil ... and in mid-Victorian times it was plentifully available ...19th century capitalism created many more skills that it destroyed."[37]

Berg also came to the conclusion that innovation does not mean mechanization, but also the development of hand and the intermediate techniques as well as the wider use of cheap labour.[38] The quantification of these effects is very difficult, as J.S. Mill commented at his time "a thing not yet so well understood, is the economical value of the general diffusion of intelligence among the people."[39]

The new production could be characterized as a system when included new transport and new sources of energy power.[40] The story of industrialization shows its complex character, the necessity of interdisciplinary studies and the difficulties of its bold exportation.[41]

Furthermore, we will focus on the story of the British engineer; Samuel concludes, "The mid-Victorian engineer was a tool-bearer rather than a machine minder; the boiler was an artisan rather than a

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Porter, M. Teich ed., Cambridge 1986, p. 281, "the perfection of the apparatus for hand spinning resulted ... not in a spinning Jenny."

36. Berg, *1994,* p. 30.

37. Raphael Samuel, "Workshop of the world: Steam power and hand technology in mid-Victorian Britain," *History Workshop*, vol. 3, 1977, p. 57-9.

38. op. cit., p. 281.

39. *I*nkster, p. 78.

40. Marx's comment in the Capital vol. 1, p. 506, Penguin edition, on the basis of his observations of the Great Exhibition that machines produced by machines is a prerequisite for the new production, is commented by contemporary historians that this was happening since the first decades of the 19th c.

41. Wengenroth web paper, p. 5, "California experienced successful industrialization without the use of coal and steam."

factory hand."[42] There is also a highly controversial literature about Britain's industrial decline due to the low educational standard of its engineers, to its unwillingness or inability to modernize the educational institutions.[43] Inkster provides a dichotomy scheme, where he classifies France and Britain in the late 19th century as an organizational backward, and Germany and USA as innovative,[44] where the former are characterized by amateur education, fragmented industrial structures, protective social preferences and the second professional education, growing industries and competitiveness.

Engineers in Britain had a low social esteem, are related to the craft system and until the 1910's "no clear procedure was fixed for evaluating the standard of theoretical preparation of the candidates for associate membership"[45] to the Institution of Mechanical Engineers. The system of entering in the engineering profession had a strong dual character, either through apprenticeship or through the university education. In Britain during the 19th century, since the 1820's were established chairs of engineering in most universities, but engineers' university education becomes full time only by 1880's. Oxbridge was reluctant to support engineering, Oxford established a chair by 1908 and only in 1964 the department of Mechanical Sciences in Cambridge renamed to Mechanical Engineering. The entrance to the professional association since the mid 19th century, in all cases required a heavy fee and was hardly less exclusive than the bar[46]. A Corps Royal of Engineers was formed at 1812 and is considered to be a professional body in contrast with the general army where commissions were available by a purchase system.[47] The British manufactures, the people

42. Samuel, 1977, p. 60.

43. See for example, R. Fox, A. Guagnini, *Laboratories, Workshops and Sites*, Office for History of Science and Technology, University of California at Berkeley, 1999, *p. 276*. D. Edgerton's, *Science, Technology and the British Industrial "Decline" 1870-1970*, Cambridge UP, 1996, presents a different view.

44. Inkster, *1991*, p. 91.

45. A. Guagnini, "Worlds Apart: Academic Institution and Professional Qualifications in the Training of Mechanical Engineers in England 1850-1914", in R. Fox, A. Guagnini eds., *Education, Technology and Industrial Performance in Europe, 1850-1939*, Cambridge University Press, 1993, p. 37.

46. *Ibid*, p. 24.

47. P. Lundgreen, "Engineering Education in Europe and the USA, 1750-1930: The Rise to Dominance of School Culture and the Engineering Profession", *Annals of Science* vol. 4, 1990, p. 47.

who launched the industrial revolution, were hesitant to support engineering academically and only in 1855 such a support is referred[48].

Germany wanted to catch up economically with Britain[49], faced the problem of national unity and the dominance of archaic aristocratic structures. Education and especially the technical education were conceived as a means to overcome the backwardness. In Prussia, a corps of army engineers was established in 1729 and in general the system of engineering education in the German states in the 18th century was a copy of the French. In 1799, the Prussian *Bauakademie* was established, whose civilian graduates were called not *Ingenieure,* but *Baubeamte*, construction officials, modelled in the system of law dominated German civil service.[50] During the first decades of the 19th century, when the Humboldtian humanistic ideal was flourishing in the Universities, the *Sturm und Drang* movement was in its highs, a series of *Polytechische Schulen* were formed and later developed as *Technische Hochschulen.* During the same period, *Gymnasia* were built, where in these schools, "for the state and the educated classes,"[51] the teaching of the classic languages of Greek and Latin was predominant. In 1859 the *Realschule* (realistic school), where only Latin and not Greek was taught, were given somehow equal status to the *Gymnasium.* Within this framework, an opposition between the professor and the producer was developed, reinforcing the overvaluation of theoretical knowledge and growing the divide line between status and class. Yet, the way to the functional elites was passing through the *Gymnasium.*

The *Verein Deutscher Ingenieure*, the Union of German Engineers, formed in 1856; there was absence of restrictive admission policies and it was formed on the following basis: "it will be our duty to participate in the common patriotic work ... by the advancement of technology, which ranks with science and art and stands between them as a cultural-historical achievement of the human spirit in general and

48. Guagnini, 1993, p. 27.

49. Inkster, 1991, p. 137, provides P. Bairoch's useful data. Volume of production in Britain is indexed as follows 1750: 2.4; 1830: 17.5; 1860: 54; 1900: 100. For Germany, the data are 1750: 3.7; 1830: 6.5; 1860: 11.1; 1900: 71.2.

50. Lundgreen, 1990, p. 41.

51. K. Gispen, *New Profession, Old Order. Engineers and German Society, 1815-1914*, Cambridge University Press, 1989, p. 24.

the German nation in particular".[52] The *Verein Deutscher Ingenieure* had faith in nationalist industrialization, to a selfless technology and therefore, it was difficult to provide a basis for a professional identity.[53] German engineers through their technical expertise and loyalty to a higher cause or an impersonal master shared the values of the pre-industrial Germany, although they never became a part of the old regime elites. The market economy was developing until the 1870's against the pre-industrial, bureaucratic tradition of the old regime; in any case, chemists and engineers were the only academically trained people employed in the private sector in mid 19th century Germany.

The *Kultur-Zivilization* issue is of some help here. This difference is conceived as an expression of the national problem of the Germans,[54] the contraposition of national differences, the self-consciousness of the need of a constant recreation of the national boundaries on one side and the universal values of people who had established a national identity for centuries on the other. The engineers were linked to the *Kultur*[55] since the material outcome of a truly creative existence belonged to the latter, while they were an important means for national unification and progress.

The engineers' education was linked with two important dualisms. A two tier system within the field, that is *Technische Mittelschulen* and the *Technische Hochschulen*; the former demanding less educational preparation was training for the industrial private sector, the latter for the civil service. At the highest level there was an antagonism between Universities and the *Hochschulen*, the latter given University status, in 1899. The selection process through the *Gymnasium* and *Abitur* was very restrictive, only 2% of the age cohort was successful in fulfilling the demands of the conservative modernization, as Lundgreen[56] calls this process of engineers' formation.

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52. Gispen, 1989, p. 51.

53. Gispen, 1989, p. 52-60.

54. N. Elias, *The Civilizing Process*, Blackwell, 1994, p. 5. Elias links Kultur to Statism and Zivilisation to historical relativism.

55. See M. Hard, German regulation: "The integration of modern technology into national culture", in M. Hard, A. Jamison, *The intellectual Appropriation of Technology. Discourses of modernity,* 1900-1939, MIT Press, 1998, p. 42. Landes, 1969/1999, p. 543.

56. P. Lundgreen, "Education for Science–Based Industrial State? The Case for 19th

Late 19th century, new chemical, optical and electrical and refrigeration industries were developed with close link to science; they were the science-based industries, and the whole process is often called the "second industrial revolution." Germany was believed, by the turn of the 20th century, to hold a top position not only in science but also in its application.[57]

This seemed to be a game with two players: Germany and the United States. Relatively to the science based industries, there arises the question, if it is nearer to historical evidence to talk of industry based sciences, since it seems in a heavily documented study for the electrical industry by Koenig[58] that the graduates were not ready to work after graduation nor the professors were aware of the industry problems. The industrial laboratory, the emblem of the new industries, is a German affair for chemistry and a German-American one for the electrical industry.

The German engineer in a status-ridden society[59] where everything of importance was academised[60] was a strong figure at least until 1933.[61] His characterization varies from one side as "a precise national weapon," from the other as a "disguised mathematician," and Koenig in his review article[62] came only to a modest conclusion, that the German system of technical education was not a constraint on the development of industry.

In France, engineering is a state affair since late 17th century, the first corps of military engineers established in 1691. From the 18th century

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century Germany," *History of Education*, vol. 13, 1984, p. 67.

57. Lundgreen, 1990, p. 57. Sombart talks at 1913 in *Der Bourgeois,* p. 152, Greek edition, for Germany's victorious way due to its devotion to scientific foundation and application of productive methods.

58. W. Koenig, "Science-Based Industry or Industry–Based Science? Electrical Engineering in Germany Before World War I", *Technology and Culture*, vol. 37, 1996, p. 100. In this article we find data of the educational level of career beginners in industry. Before 1880 self-educated were 40% and after 1895 only 2%, p. 79. In the laboratories of the ten leading German electrical industries by the end of the 19th century, there worked 100 engineers, mainly for testing practices than for innovation, cited in Fox, Guagnini, 1999, p. 261.

59. Wengenroth, web paper.

60. Inkster, 1991, citing Shadwell of 1906, p. 101.

61. J. Herf, *Reactionary Modernism: Technology, Culture and Politics in Weimar and the Third Reich*, Cambridge University Press, 1984.

62. Koenig, 1996, p. 81.

onwards, engineers enjoyed a legally sanctioned exalted status that lasted at least till late in the 20th century. Nothing similar can be seen in any other advanced country.

The first elite corps of non-military state engineers were established later on (in 1716), the corps des Ponts et Chaussées and, in 1747, the homonymous first real engineering school in the world was founded. École Polytechnique was established in 1794, where algebra and descriptive geometry were predominant but in general the theory was seen as a means for the solution of practical problems. French engineering is characterized by lack of specialization and the dual character of engineering education and employment is reflected in the shop floor culture, which developed in parallel to the elite schools, for the engineers of the small business, which they usually owned.

French engineering is totally rational, positivistic in its comprehension, totally utilitarian in its application, in the service of the state and secondary in the industry. Under the influence of Saint-Simon, Fourier, J.B. Say and Comte the positivistic tradition saw engineering as the embodiment of the principles of Enlightenment not simply as a means but also as a final end putting also the basis of scientific management, which it tried to export.[63] French modernity can be examined as a union of science, technology, capital and republican politics. Alder studies French engineers as a planned meritocracy who eventually replaced the old regime elites. "Mathematics –an impersonal measure of merit– seemed to open upward mobility to democratic competition" and in the realm of the Revolution "the engineers promised an utopian scheme to remake the world."[64] According to Alder, the failure of French engineering, with respect to the mass production can be seen in the interchangeable parts of guns industry showing their political limits, in comparison to the developments in the United States that took place early in the 19th century.

A. Picon studies French engineers taking into account the simultaneous representations of nature and society, subscribing to the French contributions to the contemporary sociology of knowledge by M. Callon and B. Latour, arguing that "major transformations of

63. The role of Saint-simonians in the mid 19th c. Greece has drawn the attention of historians.

64. K. Alder, *Engineering the Revolution, Arms and Enlightenment in France, 1763-1815*, Princeton University Press, 1997, pp. 310, 346.

technological thought correspond to changes in these representations."[65] During the late 18th and until the middle of the 19th century, there was a change from a Vitruvian to an analytical rationality, from geometrical static principles to a dynamic one, designed to change art craft, from a closed society to the mobility of *laissez-faire, laissez-passer*. The Ponts et Chaussées engineers were building up roads and bridges, the embodiment of these ideals, using analytical not simply geometrical tools.

French industrial development was related at start to a successful technology transfer from Britain by the end of the 18th century and these initiatives spread in the country. Landes[66] comments that France had developed a high self-esteem based on its past glory and after 1815 could not compete with Britain, the country of coal and iron. A more humane economy was developed in France based on family units, a balance between agriculture and industry, with a state intervention, where substantial contributions to technology were made, at the absence in all cases of a notion of industrial revolution. The rate of development was moderate but constant during the 19thcentury.[67] After the disaster of 1870-71, industries developed in the economically safe sectors where there were some breakthroughs, but in general lost ground in comparison to Germany.[68]

The engineering education, which was elitist in character, has raised discussions about its effectiveness respectively to industrial development. Among the graduates of the prestigious *École Polytechnique*, only 10% avoided the safety of the state corps[69] and only 5% of them were related to scientific or technical research.[70]

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65. A. Picon, "Towards a History of Technological Thought", in R. Fox ed., *Technological Change*, Harwood, 1996. Also by the same author, *French Architects Engineers in the Age of the Enlightenment*, Cambridge University Press, 1992.

66. Landes, 1969/99, *p. 551.* M. Levin, "What the French Have to Say About the History of Technology" in *Technology and Culture*, vol. 37, 1996, pp. 158-168, comes to similar conclusions.

67. Inkster, 1991, p. 137, on the basis Britain's volume of industrial production in 1900 indexed 100, France had in 1750, 5% (higher than the United Kingdom); in 1830, 9,5% (the United Kingdom had 17,5%); in 1860, 17,9 %; in 1900, 36,8% when the United Kingdom had 100%.

68. R. Fox, "Contingency or Mentality" in R. Fox, *Science, Industry and the Social Order in Post-Revolutionary France*, Variorum, 1995, p. 66.

69. Lundgreen, 1990, p. 39.

70. T. Shinn, "Pillars of French Engineering", *Social studies of science,* v. 29, 1999,

Kranakis, in a series of publications,[71] produced a comparative picture of American and French engineering. On the basis of a detailed study on the design, research and the construction of the modern suspension bridge in the rural Pennsylvania and in Paris in early 19th century, she came to the conclusion of French engineering being theoretical, methodologically deductive and monumental, linked to state carriers, while engineering in the United States being empirical, utilitarian and economically efficient. The French engineering community is characterized by Kranakis with figures such as Navier, Dupin, M. Levy, J. Resal, L. de Bussy, all of them with important theoretical work, while the American engineers are the autodidactic T. Edison, E. Sperry, E. Thomas, J. Westinghouse, H. Ford, W. and O. Wright. In the United States, we can also add in side the names of people of various origins with important contributions to manufacturing in the antebellum period, such as Eli Whitney, John Hall, Samuel Colt, Cyrus McCormick and Isaac Singer.

In the United States, in the early 19th century, there were neither pre-industrial elites nor a tradition of a guild system: the very few hundreds of men who built the communication systems in a rural country represented mainly engineering. After the Civil War, industrialization begins and the big systems are created.[72] A quarter-century later, by the 1900's, four former classmates at the MIT were chief executives of General Motors, General Electric, Du Pont and Goodyear.[73]

The appropriation and development of technology in North America, the "new garden of the world," the place of the machine in a bucolic world is a theme highly reflected in the American cultural history and literature. It can be limited by the Jeffersonian ideal of the 1780's of the autonomous citizen, of the acceptance of the machine as a token of the liberation of the human spirit and at the same time the rejection of

p.143.

71. Eda Kranakis, "The French connection: Gifford's injector and the nature of heat", *Technology and Culture*, vol. 23, 1982, pp. 3-38, "The Social Determinants of Engineering Practice: A Comparative View of France and America in the 19th century, *Social Studies of Science*, vol. 19, 1989, pp. 5-70, *Constructing a Bridge*, MIT Press, 1997.

72. See the classical, A. D. Chandler, *The Visible Hand. The Managerial Revolution in American Business,* Harvard University Press, 1977.

73. D. Noble, *America by Design. Science, Technology and the Rise of Corporate Capitalism*, Oxford University Press, 1977, p. 51.

the factory system as a feudal oppression. On the other side, Whitman's verses, written in the 1880's, "Burn high your fires, foundry chimneys! Cast red and yellow light over the top of the houses," echoed loudly.[74] L. Marx's study of the transformation of the pastoral ideal, we think is an exemplar study, which deserves some more lines.

In the early 18th century, colonial writers in North America, inspired by landscape, expressed a utopian vision grounded in a firm doctrine of geographical determinism. The new society was made in symmetry with nature.[75] The paradise is regained, but the garden metaphors appear from the beginning to be two, a wild, pre-lapsarian Eden of the Indians and a cultivated garden of the immigrants. Later, some authors built a bridge between the old pastoral ideal of reconciliation man and nature towards a more congenial to a scientific commercial age, a mixture of "garden and forest," where beauty and leisure class were separated from utility and work[76]. Jefferson admires the steam, but his Enlightenment ideal obscures him to see the new machines as a threat to his rural ideal. Others, during the same period expressed the nascent manufacturing interests "factories which can be carried on by water-mills... are not burdened with heavy expense... of paying workmen... we can make pig and bar iron..."[77] The machine becomes a cultural symbol and is literally expressed as an embodiment of the same ultimate laws of nature. When Carlyle, in 1829, criticized mechanization, it is defended in the United States in the name of democracy. Mechanization will be hardly seen as a menace to those upon whom society confers little dignity of soul (or status) in the first place[78]. By the mid 19th century, progress takes the form of explosion in the New World, the railway, as a symbol of industrialization is to be related to the native landscape, machine technology belongs or can be made to belong to the landscape, but in any case the old pastoral ideal now has little influence outside the South. The American landscape is

74. W. Whitman, "Crossing Brooklyn Ferry", cited in L. Marx, *The Machine in the Garden. Technology and the Pastoral Ideal in America*, Oxford University Press, 1964, p. 222.

75. Walt. Whitman, *Leaves of Grass*, Greek translation by N. Prostopoulos, Estia, n.d., p. 314, "The song of sequoia".

76. L. Marx 1964, pp. 77-87, 93.

77. *Ibid.*, p. 153.

78. *Ibid.*, p. 189.

the industrial pastoralized landscape. The inability to create a substitute for the ideal of the middle landscape, the entrance of the machine into the garden presents finally a political and not an artistic problem.[79]

The new period is one of technological enthusiasm,[80] with the emblem of mass production, the establishment of the American system of manufacture, which was followed by Ford's moving assembly line and dominated the scene till World War II. The key aspect of mechanization that characterizes the American case is the aspect of uniformity[81] that was promoted through the techniques of using interchangeable parts in the artifact production. Eli Whitney, who is considered to be the father of this system, is related to these initial attempts; historiographical controversies around him seem to come to a conclusion supporting that he was a publicist of mechanized, interchangeable parts manufacture and not a creator.[82]

The technique of interchangeable parts was attempted in arms production since 1801, under government contacts, exploiting French ideas. It lasted long, in the various fields to achieve complete use of the new technique in a mechanized form, but the idea was there since the beginning of the century. The successful Singer sewing machines, which eventually dominated the market at the commercially crucial years 1856-1870, were made by hand manufacturing as cheaper to the machinery, only at the 1880's production was mainly automatic.[83]

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79. *Ibid.*, p. 365.

T. P. Hughes begins his book *American Genesis: A Century of Invention and Technological Enthusiasm,* Penguin, 1989, with the phrase, "this book is about an era of technological enthusiasm in the United States, an era now passing into history".

80. T. P. Hughes starts his book *American Genesis: A Century of Invention and Technological Enthusiasm,* Penguin, 1989, with the phrase, "this book is about an era of technological enthusiasm in the United States, an era now passing into history", p. 1.

81. M. R. Smith, *Harpers Ferry Armory and the New Technology*, Cornell University Press, 1977. Cited from *Technology in America,* C. Purcell ed., MIT Press, 1981, p. 54.

82. D. A. Hounsell, *From the American System to Mass Production*, J. Hopkins, 1985, p. 31.

83. *Ibid.*, p. 9. R.B. Gordon stressed this point, writing about individual artificers, who until the first decades of the 20th century dealt *with the* manufacturing precision none mechanically. According to Gordon these artificers turned the mechanical ideal into mechanical reality. Robert B. Gordon, "Who Turned the Mechanical Ideal to Mechanical Reality", *Technology and Culture*, vol. 29, 1988, pp. 744-778.

The production of bicycles in the 1890's, which were constructed from various parts made from pressed steel, influenced the automobile industry and Ford's assembly line, an idea taken outside the metalworking probably from the disassembly lines of meatpackers.[84] The stage of a relatively easy change of the model of production, within the mass production system came through the consumer's change of tastes.[85] The issue of advisement as an element for the domination of the market became important for the new products since the middle of the 19th century, according to the Singer machine story.[86]

The independent inventors like Edison and the genesis of the laboratory are two crucial elements. There is a rise in the number of patents from 4,800 before the civil war to 26,000 in 1890 and the invention of the empirically oriented laboratory where the inventors "treasured their model builders, their chemists, their scientists, their laboratories, because they facilitated experimentation the life blood of invention."[87]

Engineers in the United States were educated in the Military Academy at West Point, which was established in 1802 and was modelled on the École Polytechnique but with some major differences. The French idea of high entrance standards was rejected; student fees were easily spared[88] as the idea of armoury and the barracks keepers, the two schools being altogether different in their curriculum, as well as their socializing role.[89]

The Rensselaer School, later renamed Polytechnic Institute, was the first civilian institution of higher technical learning in the United States whose curriculum in the 1830's was modelled after the École Centrale. The RPI dominated the scene until 1861. It is interesting that 19th century leading US scientists, such as J.W. Gibbs, H. Rowland, and J. Henry were RPI[90] graduates. MIT, which opened in 1865 and established by Boston civic leaders after the reluctance of Harvard

84. Hounsell, 1985, pp, 10-11.

85. Hounsell, 1985, pp. 13. T. Misa in his *A Nation of Steel,* J. Hopkins, 1995, argues that relationships between producers and consumers are the single most important determinant of the dynamics of technology and social change.

86. Hounsell, 1985, p. 6.

87. Hughes, 1989, pp. 14-51.

88. B. Hacker, personal communication, 20 August 2001.

89. Kranakis, 1989, p. 55.

90. Noble, 1977, p. 22.

University to promote engineering, became the leading technical institution.

The Americans had to choose among the competing European educational systems and adapt them to their needs. Finally, the result was distinctively American, based ideologically on Scottish common sense, which is a synthesis of idealistic and empirical theories of knowledge. In a politically democratic, but at that time socially hierarchical, formal education was primary a sign of personal virtue than a certificate to a useful expertise, the later accomplished almost entirely through apprenticeship.[91] The American engineers did not see themselves as an extension of skilled labour as the British nor accepted their social position to be determined by the state[92] being much more linked to the capital than other liberal professions and remained an elite body until the 20th century[93]. French positivism, as a vehicle of enlightenment, was never strong in the United States and the new nation had to link science and technology with the practical applications of the needs of the people and its national unity. Later in the 19th century, the German university was dreamed to be an ideal of education and research, but to the uninterested pursuit of knowledge, the Americans added liberal education, as a means for social education and practical investigation in areas of public concern.

By the end of 19th century, the university model had reached a consensus and since then, it was completed with a specific system of administration where the Rectors "captain of erudition" were modelled on the basis of the captains of industry of the period.[94] We close this part with some data concerning the engineers in the European periphery of the time.[95]

The French model influenced engineering education in Italy until the fall of Napoleon, who had a very strong mathematical background. Later, the German model was dominant, although the Italian engineers had University status since 1859, forty years before their new prototype. Engineers, too numerous, had generally a low level of studies. The civil engineers dominated the scene, after the political

91. A. Donavan, "Education, Industry and the American University» in Fox, Guagnini, eds., 1993, p. 260.

92. Meiskins, Smith, 1996, pp. 62-64.

93. Noble, 1977, p. 39.

94. Donavan, 1993, p. 268.

unification of the country, industrialization started and the inadequacies of the technical education became evident.

In Sweden, engineering is a successful story for the industrial engineering of the private sector and especially for science based industry. The dominant institution was the Royal Technical University of Stockholm, KTH, which was formed as a Technical Institute at 1826.

In Spain, France influenced higher technical education until the middle of the 19th century and civil engineers dominated. Later, mainly during the so-called "second industrial revolution," the educational system was influenced by Germany. The country had regional differences that influenced also the engineering tradition. There was an elite school of engineering in Barcelona in 1868, where the prerequisite for admission was three years of studies in science. Modernization came late in the country, during the 19th and 20th century. The Spanish engineering seems as a story of an attempt to "fit" in the state, the economy, the landlords, the bourgeoisie, the specialists and the foreign technology.

The stories presented until now show that local frameworks concentrated either on the field of production, in the ruling ideologies, in deep running social tensions or in attempts for integration in the international market, played crucial role in the specific formation of the engineers at the various countries.

The paragraphs that follow are an attempt to describe the Greek engineer of the 19th century. They are based on research in the archives of the National Technical University of Athens and in the relevant secondary literature. This work continues and we hope to present as soon as possible more results.[96]

From the Military Academy to the Corps of Civil Engineers

The professional identity of the engineer in Greece until the 1880's was almost exclusively bestowed to the graduates of the Military

95. The data for Italy, Sweden and Spain are taken from the relevant articles in the Fox, Guagnini, eds, 1993.

96. See also: Yiannis Antoniou, Michalis Assimakopoulos, "The State and Professional Identities: The Emergence of the Socio-Professional Class of the Greek Engineers at the Beginning of the 20th century," 20th International Congress of History of Science, Mexico City, 2001.

Academy and in particular, to those who were members of the Corps of Engineers. The Corps was under the command of the Internal Affairs Secretariat and it was in charge for the public works in Greece, until 1878.

The institutional ratification of this exclusiveness was enshrined in the decrees of Capodistria, the Regency, King Otto's reign and the first period of King George's reign, until 1878. The first of these decrees were published in July 1829 and provided the establishment of the "Corps of Fortification Officers and Architects". In April 1833, the decree "about the formation and the authorization of the Internal Affairs Secretariat" was published and a few months later, in October of the same year, the decree "on the formation of the Corps of Engineers" which was under the jurisdiction of the Secretariat of Internal Affairs.[97]

The structure of this organization did not change until 1878. During this period, 14 new decrees expressed the intention of the administration to accomplish the institutional framework about the public works. For example, a major accomplishment was the decree of 1 December 1836, "on the surveillance of public roads," in which the term *nomomichanikos* (county-engineer) was used for the first time. This office was attributed to the members of the Corps who were in charge for the public works in a county.[98]

The Military Academy (*Scholi Evelpidon*) held one of the most privileged ranks in this structure. The adoption of the École Polytechnique model is obvious. The school, apart from being a military institution, it was the supreme educational institution, which

97. The first commander of the corps was the Bavarian Major Anton Chech and the members of the administration were: the Captain Fr. Braker, the Lieutenants L. Smolenski and M. Spich, and the second Lieutenants Ad.Treser, Ed. Luft, J. Lamey and Fr. Muller. L. Smolenskis was the only one of Greek origin. Agelos Oikonomou, "Sintomos Historia ton Technicon Ergon eis tin Ellada" (Brief History of the Public Works in Greece), *Techniki Epetiris tis Ellados (Technical Year-book of Greece)*, Athens, ed. Technical Chamber of Greece, vol. A, 1935, pp. 232-237. M. Kardamitsi, Adami, "Oi Proti Ellines Mechanikoi" ("The First Greek Engineers"), *Technica Chronica (Technical Journal)*, Athens, October-December 1988, Scientific Area A, vol. 8, no. 4, pp. 63-89. A. Kastanis, *I Scholi ton Evelpidon kata ta prota xronia tis leitourgias tis (The Military Academy during the first years of its function 1828-1834)*, Ioannina, PhD thesis, 1995.

98. The term is the equivalent of the French *ingenieur en chef.* Agelos Oikonomou, 1935, pp. 220, 238.

was officially authorized to produce the qualified officers, i.e., the personnel that were going to be the sovereign elite of the state administration. At the same time, the graduates of the Polytechnic School, founded in 1837, were destined to be foremen and craftsmen.[99] The legislation of this ranking produced also the first official hierarchy in the technical professions in Greece, itself based on an educational hierarchy. The major criterion that consolidated and legitimised this hierarchy was the early adoption of a scientific orientation in the curricula of the Military Academy and especially, the instruction of calculus.

The Academy was founded in 1828, by Capodistrias as a secondary school with three-year duration of studies (*Stratiotikon Scholeion*). The courses taught within the curriculum included, apart from military instruction, elementary mathematics and technical subjects like road construction, building construction, building and machine designing etc. The Regency administration reorganized the school in 1834, and assigned it in the highest level of the educational pyramid. The studies lasted for eight years and the new curriculum provided Differential and Integral Calculus, Spherical Trigonometry, Descriptive Geometry, Surveying, Geodesy, Measurement of buildings and machines, Static and Mechanics of solids and liquids, Road Construction, Bridge-building, Hydraulics, Architecture etc.[100]

The Constitution of 1843 and the expulsion of the Bavarians from the state administration consolidated the staffing of the technical services exclusively for the Greek military engineers, members of the Corps. Some of them had been sent for further studies abroad by the government. To this group belonged also four of the directors of the School of Arts, in the late 19th century, Gerasimos Metaxas, Dimitrios Skalistiris, Dimitrios Antonopoulos and Anastasios Theofilas.[101]

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99. Apart from the Royal Decrees of 1836 and 1843, which determined the educational and professional status of the graduates of the Polytechnic School, the Royal Decree of 29 April 1851 defined their professional perspectives and their ranking to the hierarchy of the technical professions. *Ephimeris tis Kiverniseos* (*Official Gazette*), no.13, 24 May 1851, Athens.

100. Epaminondas Stasinopoulos, *I Historia tis Scholis ton Evelpidon (The History of the Military Academy),* special edition for the 125 years of the Academy, (1828-1953), Athens, 1953, pp. 49 and 103. A. Kastanis, 1995.

101. E. Manitakis belonged to this group. He studied physics and chemistry in Paris and then to the Military Academy of Metz. When he returned to Greece he was trained

These officials were destined to play a most important role in the forming of state bureaucracy. They could combine at the same time three conditions of social power, the military, the administrative and a third one, totally new in this particular period, the authority of the engineer, i.e., the one who was the authorized executive on modern technology. Their long-term service in the high ranks of the administration not only differentiated them from the rest of the officers, but also provided them with the capability to express a model of Greek *homme d'État*.[102]

These state executives were going to be the policy makers in crucial specialized fields, without necessarily to participate straightaway to what was called current politics. Even the reorganization of the public service during 1870's would largely depend on them and they will

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to the French Mission of Maison, in 1828-29 and he was one of the first graduates of the Military Academy. He was appointed director of the Public Works Service of the Ministry of Interior in 1845 and kept this chair for 22 years. In 1878, he became member of the "Committee for the Encouragement of Industry" and its president in 1880. In the same group belonged also his successor to the Ministry in 1867, the captain of the Corps, G. Soutsos who was also a Professor in the School of Arts. To this group also belonged: G. Vougioukas, graduate of the Military Academy in 1839, he studied in the 1840's Physics, Mathematics and Mineralogy in Germany. Vougioukas during his long professional career was appointed to the high ranks of the state administration and mainly directed the mining works. Sp. Mostras, graduated from the Military Academy in 1851, studied to the École Polytechnique and other French technical institutions. Leonidas Vlassis studied in France and became Professor in the Polytechnic School and executive of the Public Works Service. Dimosthenis Gonatas, graduate of the Military Academy and École des Ponts et Chaussees, Professor in the Polytechnic School etc. Costas Biris, *I Istoria tou Ethnikou Metsoviou Polytechniou* (*History of the National Technical University of* Athens), Athens, ed. National Technical University of Athens (NTUA), 1957, p. 500, 504, 511, 512, 517, 521. Constantinos and Spiridon Vovolinis, *Mega Viographicon Lexicon,* (*Biographical Dictionary*), Athens, ed. "Viomichaniki Epitheorisi", 1958, volume A', p. 306-313 and volume E', pp. 242- M. Synarellis, 1989, p. 90, 100, 101. M. Kardamitsi-Adami, 1988, p. 74. F. Asimakopoulou, K. Chatzis, «Education et politique au XIX^{e} siècle: les élèves grecs dans les Grandes Écoles d'ingénieurs en France au XIX^{e} siècle", in Ihsanoglu et al., eds, *Multicaltural science in the Ottoman Empire,* Brepols, 2003,. Vaxevanoglou, *I Koinoniki Ypodochi tis Kainotomias. To Paradigma tou Exilektrismou tis Mesopolemikis Elladas (The Social Reception of the Innovation, The case of Electrification in Inter-war Greece),* Athens, Ethniko Idrima Erevnon, 1996, pp. 77-79.

102. Stephen Crawford, "The Making of the French Engineer," ed. P. Meiskins and C. Smith *Engineering Labour. Technical Workers in Comparative Perspective,* London, Verso, 1996, pp. 99-102. A. Vaxevanoglou, 1996, pp. 81.

continue to prevail in the new institutional framework. Their hegemony in the administration of public works, as well as to the administration of the Polytechnic School lasted until the beginning of 20th century; when their replacement by the first civil engineers who had graduated from the Polytechnic School and from other European polytechnic schools began.

The enormous projects of Trikoupis' period, mainly the construction of roads and railways, were the starting point for the changes in the structure of the Ministry of the Interior. Since the beginning of the decade, certain decisions were assumed towards this direction. In August of 1873, a new section, the "Department of Public Works," was established in the Ministry, and D. Skalistiris was appointed as its head. However, the crucial move for the reorganization was the law "XPH" of 6 February 1878, "On the Establishment of the Corps of Civil Engineers."[103]

The law adopted the French model of administration providing the configuration of an autonomous department called "Public Works Direction." This new mechanism replaced the pre-existing rudimentary and centralized structure, and covered to the entire country, having the jurisdiction over public works.

The hard core of reorganization was the establishment of the Corps of the Civil Engineers. The law provided that the members of the Corps should have the credentials and the capability to run not only a single construction, but also an entire project of works in regional or national range. The executives to be employed in this service had to be qualified engineers with a ten-year practice in the profession. From that moment, the institutionally ratified relationship between the academic and the professional title would determine the professional identity of the engineers in Greece.

The law provided for 64 engineers members of the Corps: the Director of the Corps, two Inspectors (E*pitheorites)*, five Department Heads (*Isigites)* and five Assistants (V*oithi)* in the central service, thirteen County-Engineers (*Nomomichanikoi*) and 38 Provincial Engineers (E*parhiaki Michanikoi*). In 1878, the first 21 engineers and 18 foremen were employed. Among the military engineers that were still the majority of the Corps, were also employed seven citizens, graduates of European polytechnic schools. Two of them were from

103. Agelos Oikonomou, 1935, pp. 238-240.

Polytechnic School of Munich, N. Padaziris and G. Katsaros, two from Zurich, I. Gravaris and A. Triandafyllidis, one from the École Centrale des Arts et Manufactures, A. Zinopoulos, one from Berlin, I. Isigonis and one from Naples, P. Sambo.

In 1882, the law "ΑΙΣΤ", "on technical assistants," provided the increase of the inferior staff to 81. The law also provided that the graduates of the School of Arts had the exclusive privilege to be appointed as foremen to the public works. After his death in 1883, D. Skalistiris was succeeded in the direction of the Service by Anastasios Soulis, graduate of the École des Ponts et Chaussées and Professor in the School of Arts.[104]

Another provision of the law was the hiring of foreign engineers. The introduction of know-how based on the exploitation of knowledge and expertise of foreign technicians was already in use since Capodistria's period.[105] This continued under the Regency and King Otto.[106] The construction of the Athens-Piraeus railway, in 1857-69,[107] and the first attempts of draining Kopais Lake, in 1867,[108] were also conducted by foreign engineers and foreign technical enterprises.

The Trikoupis administration, after negotiations with the French government, in 1882, called in Greece a group of French engineers (the *Mission Française des Ponts et Chausées*), who were members of the Corps des Ponts et Chaussées.[109] The *Mission* comprised six

104. Agelos Oikonomou, 1935, p. 240-241.

105. The French corps of Colonel Maison, the French engineers Garnot and Peytier, etc., M. Kardamistsi-Adami, 1988, pp. 64-68, and M. Sinarelli, 1989, pp.100-101.

106. In 1857, the Voulgaris government called P. E. Daniel engineer of the Corps des Ponts et Chaussées along with his assistant to organize the publics' works administration of the Ministry of Interior and to be in charge of roads construction in Athens. This decision did not come to an end because of the inefficiency of the technical means and the trained staff. After King Otto's expulsion in 1862, the contract was not renewed. Biris, 1957, p. 312 and M. Sinarelli, 1989, p. 103.

107. Lefteris Papagiannakis, *Oi Ellinikoi Sidirodromoi* (*The Greek Railways), 1882-1910,* Athens, Cultural Institution of the National Bank (M.I.E.T.), 1985, p. 51.

108. D. Arliotis, "Ta Ydraylika Erga stin Ellada" (The Hydraulic Works in Greece), *Techniki Epetiris tis Ellados (Technical Year-book of Greece),* Athens, ed. Technical Chamber Greece, 1935, vol. A', pp. 278-279. Dimitris Xenikos, "I Apoxiransi tis Kopaidas" (The Drainage of Kopais Lake), unpublished post-graduate paper, Athens, National Technical University, 2000.

109. Agelos Oikonomou, 1935, p. 241. E. Papagiannopoulou, *I Dioriga tis Korinthou. Technikos Athlos kai Oikonomiko Tolmima (The Corinth Canal. Technolo-*

engineers, six foremen and six assistants. The chief engineer was Alfred Rondel and A. Gotteland and Ed. Quellenec were his assistants. Later, fifteen more engineers, seven draftsmen and foremen were recruited. [110]

The *Mission's* assignment was the design and the construction of the public works, and the reorganization of the technical services. According to the decree of 10 January 1886, "on the tasks of the French Mission," the duties of the foreign engineers were the designing and mapping of roads, the budgets of the projects, the supervision and the taking over of the works, as well as the managerial commitment in the central department of the Public Works Direction.

During the ten-year stay of the *Mission*, apart from its crucial participation in the design and the construction of the works of this period, it contributed to the readjustment of the institutional framework about the public works and the introduction of the French law.[111] The *Mission* also contributed to the training of Greek engineers and craftsmen. By introducing the Western technology of the constructions, via France, the Greek state turned to the appropriation and implementation of the Western technological phenomenon in the country. The contribution of the *Mission* to this turn was highly important. Equally important was the role of the Greek engineers who studied in France, [112] especially in the École Nationale des Ponts et

gical Feat and Economical Venture), Athens, Morfotiko kai Technologiko Idrima ETBA (Cultural and Technological Foundation), 1989, pp. 49-53.

110. L. Blassis, military engineer and executive of the Ministry of Interior, recruited these additional personnel on behalf of the Greek government. Among them was also the Greek engineer N. Sideridis, graduate also of the École des Ponts et Chaussées; he was born in Evritania, grew up in Constantinople and studied in Paris. Sideridis will keep working as an executive of the Public Works Service even after the departure of the Commission in 1892. Agelos Oikonomou, 1935, pp. 241-242.

111. A. Oikonomou asserted that the decree of 1884 "...on the Public Works' contracts" was a copy of the French, "Cahiers des Charges". The law "ΑΥΛΘ'", which provided a series of amendments to the 1878 law, regarding the organization of the Public Works' Administration, enacted under the same influence, *ibid*, pp. 243-244.

112. Since the 1860's the graduates of the School of Arts (Polytechnic School) could be sent for further studies abroad. Decree of August 26th 1863, "On new organization and direction of the School of Arts", *Ephimeris tis Kiverniseos (Official Gazette)*, n. 33, Athens, September 14th 1863. 180 Greek students appear to the records of French Grandes Écoles during the 19th century. F. Assimakopoulou, C. Chatzis, 2003. Konstantinos Tsoukalas mentions also that in 1885, among the 18 graduates of the

Chaussées and in other European polytechnic schools.

In the previous period, the introduction of the new technology meant the partial reorganization of the new techniques within the traditional framework. The result was a more or less passive reception of them. The state intervention, the new institutional framework and the foreign engineers changed many things. The reception of the technological innovation was not passive anymore. Technological innovation was still imported, but at the same time it was incorporated in the structures of the administration and converted to an active one. This transformation caused a radical revision of the convictions and the relative practices about the technological innovation. The dominant element of these new convictions was the realization of the crucial role of the engineer's profession and of the educational institutions that were authorized to reproduce it.

The modifications of the institutional framework to the public works, during the last part of the 19th century and the first decade of the 20th, followed basically the direction inaugurated in 1878. The important innovation came in June 1914, when the Transportation Ministry was established.

From the Sunday School to the School of the Industrial Arts

"A school is going to be established in Athens in which those who want to become craftsmen in architecture will be taught during Sundays and Holidays."[113]

This is the first article of the Royal Decree No. 32 according to which the School of Arts[114] was established. In its starting point, the

École des Ponts et Chaussées, four of them were Greeks. Konstantinos Tsoukalas, *Exartisi kai Anaparagogi, O koinonikos rolos ton ekpaideutikon michanismon stin Ellada, 1830-1922 (Dependence and Reproduction. The Social Role of the Educational Mechanisms in Greece, 1830-1922)*, Athens, Themelio, 1982, p. 434. In the period, 1855-1900, 23 Greek engineers graduated from the Federal National Polytechnic School of Zurich. Alexandros Tsatsos, *Epetiris ton Foitisanton Ellinon eis to Omospondiakon Polytechnion tis Zyrichis (Year-book of the Greek Students in the Federal National Technical University of Zurich)*, 1855-1978, Athens, 1978, p. 84.

113. *Ephimeris tis Kiverniseos (Official Gazette)*, No. 82. Decree on the Education in Architecture, 31 December 1836.

114. The School during this first period had a variety of names like: "Polytechnic

School was not linked to a specific kind of educational conception and it was not part of the official educational pyramid.[115] Actually, it worked independently and in parallel with the rest educational institutions. The training of engineers appointed to the Military Academy of Greece (*Scholi Evelpidon*) and the plans for the establishment of an Architecture School in the University of Athens were never materialized.

The establishment of the School[116] was mainly a response to the pressing dearth of trained craftsmen who were necessary for the building of the new capital. The problems of the construction, the new techniques and the organizational exigencies of the worksites were issues completely out of the ethos and the technical capabilities of the traditional artisans.[117]

Friedrich von Zedner, a Bavarian aristocrat, captain of the corps of engineers, was named the first director of the School. Zedner's aspirations were by a long shot grater than the decree's provisions. He envisaged the organization of the School of Arts according to the model of the Technical School La Martinière in Lyon and the Bavarian technical schools,[118] he suggested the instruction of calculus, mechanics and the machinist's craftsmanship. For the training of the students equipped the School with the *Michanothiki*, a kind of

School", "School of the Constructing Arts and Professions", "School of Craftsmen", "Royal Engineering School", "Royal Polytechnic School". The official name, consolidated in 1840, was "Royal School of Arts", but the prevailing one in use was "Polytechneio" ("Polytechnic School"). Biris, 1957, p. 28.

115. In the Bavarian's educational legislation (1834-1837) three levels were provided: the Basic, corresponded to the Elementary school, the Secondary which corresponded to the Hellenic and the Gymnasium schools and the Higher, which corresponded to the University.

116. The School accommodated in the Vlahoutsi's mansion to Piraeus Street. This mansion was the first residence of the Regency.

117. *Official Gazette*, n. 35, November 6th 1837, "Announcement on the creation of National Technological School", 15 October 1837. El. Kalafati, "To Ethniko Metsovio Polytechnio sto gyrisma tou aiona. Epagelmatikes prooptikes ton apofoiton kai thesmiko plaisio" (The National Metsovion Polytechnion in the turn of the century. Professional Perspectives and its Institutional Framework) *Panepistimio, Ideologies kai Ekpedeusi, Istoriki Diastasi kai Prooptikes (University, Ideologies and Education, Historical Dimension and Perspectives),* Athens, ed. Istorico Archio Neas Genias, Geniki Grammatia Neas Genias, (Historical Archive of the Greek Youth, General Secretariat of Youth), 1989, p. 167-183.

118. Technical schools of secondary level, C. Biris, 1957, p. 25.

collection of plaster casts, models of machines and tools for manufactures, constructions and agriculture.

In 1841, the School divided unofficially in two departments, the "Every Day School" and the "Sunday School". These changes will be official in 1843. A new decree provided three departments, the "Sunday School", the "Every Day School", and the "Higher School", which was dedicated to the instruction of the beaux-arts.[119]

After the expulsion of the Bavarians, in 1843, and the cancellation of Fr. Zedner's plans, the artistic inclination of the School came to be, if not the exclusive one, but the undeniably sovereign until the beginning of the 1860's.[120] Zedner's *Michanothiki* had the same end as the Royal Manufacture, a kind of a state industry, a model for the development of the industrial production in the newly established state.[121] The traditional techniques in farming and manufacturing were proved to be stronger than the productive, educational and professional modernizing vision of the Bavarians.

The School under the direction of Lyssandros Kaftatzoglou, probably one of the most important Greek architects of 19th century,[122] was not much dedicated to the spreading of the new techniques or the development of the new professions. The main focus of instruction was the spreading of neoclassic aesthetic ideals and their assimilation to the traditional techniques and the traditional professions. This inclination expressed the ruling ideology of the time. The prevailing anticipation was the return of the ancient Muses to their birthplace and the regain of the ancient glory. This could be managed through the

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119. *Ephimeris tis Kiverniseos* (*Official Gazette*), No. 38. 9 November 1843, Decree on the organization of the School of Arts.

120. Gr. Papadopoulos by criticizing the policy of Zedner's direction, said: "...the wrong purpose of considering it (the School of Arts) as an institution of specialized industrial application contributed to a great extent to its failure" and added by claiming that normally, the educational contribution of the institution should be considered equal to the one that the University offers and that it would be more proper to name it "Kallitechnion" (School of Beaux-arts). Gr. Papadopoulos, *Logos peri tou Ellinikou Polytechniou (Speech about the Greek Polytechnic School)*, Athens, 22 July 1845, p. 7.

121. About the "Royal Manufacture", Ch. Agriantoni, *I Aparhes tis Hellinikis Viomichanias ton 19o aiona (The Beginning of Industrialization in the 19th century)*, Athens, Istoriko Archio tis Emporicis Trapezis (Historical Archive of the Commercial Bank), 1986, pp. 15-17.

122. Dimitiris Philipidis, *I Neoelliniki Architectoniki (Modern Greek Architecture)*, Athens, Melissa, 1984, pp. 65-72, 77-93.

familiarization of the modern Greeks with the morphologic and aesthetic ideals that came out from a particular reconstruction of the antiquity's image. The above ideology projected as the par excellence effective one for the final escape of the modern Greece from the "barbarian" past of the Ottoman conquest and its return to the civilization, from where it had been expelled by "history's adventures". Within this context the effective contribution of the School to an ideal of technology and economy of the Western industrial type was de facto subordinated.[123]

The educational courses taught within the curriculum included the instruction of arts. The basic subjects were drawing, oil painting, calligraphy and, later, the plastics. Among those, the drawing was considered the most important and was attended by the majority of students. Gr. Papadopoulos,[124] in his speech in the graduation ceremony, in 1845, before King Otto, said about the importance of the lesson, "...for its general need in all arts and because it is the crown of any significant upbringing."[125]

In this first period, the faculty was composed by Bavarians and later by Greek officers, Professors of University, teachers of in secondary education, architects, artists, etc.[126] The students could be enlisted in the

123. Ioannis Kolettis, Prime Minister of Greece in 1844, was present at the inauguration ceremony of the school year 1844-1845 and saluted the teachers of the School by mentioning especially the contribution of Rafail Tsekolis, a teacher of drawing. "We are glad because we are in this ancient Metropolis of Fine Arts which leads our students to the arts and I want to praise M. Tsekolis for his philhellenism, a man who teaches for free and cares about our destitute students and wants to contribute as much as possible to the introduction of the ancient arts in their ancient homeland". And five years later in July 30th 1849, the newspaper Aion added, "Greece needs the fine arts! How promising is the Polytechnic School for this purpose" Biris, 1957, pp. 78-79. Also, Dimitiris Philipidis, 1984, pp. 65-72, 77-93.

124. Gr. Papadopoulos was an important public figure by the King Otto's time, philologist and historian, competed with C. Paparrigopoulos for the chair of history teacher in Athens Gymnasium. He instructed the history of arts in the School of Arts.

125. From a total of 635 students in 1844-45, 310 of them attended the drawing, whereas 30 attended geometry and 24 physics. Gr. Papadopoulos, 1845, pp. 8-9. Biris, 1957, p. 80-82. Until the 1870's, the total of the annual prize giving to the best students of the school was related with their performance in the artistic subjects. Even by the end of this decade, 21 students out of 27 were given a prize for their performances in the artistic subjects. Archive of National Technological University of Athens, f. 39, 1879.

126. Among the 37 teachers who taught in the School of Arts during this very first

several departments regardless of educational credentials and limit of age.[127] The school did not provide diplomas but credentials that certified the successful attendance of several lessons. By the end of this period, in 1862, 412 students were enlisted in the register of the School.[128]

Kostas Biris, the historian who composed in 1957 the only and last, until now, exhaustive history about the Polytechnic School and the Greek engineers, is uneasy when he tries to rank the School in a certain educational grade during this first period. In the beginning, Biris suggests that from a typical point of view, it could be ranked at the elementary grade. Later, he underlines in many cases the peculiarity of the institution that rendered no meaning in any formal classification. Finally, he classified the School in the grade of informal technical academy. A. Fenerlis asserts that the School, from the very moment of its constitution, expressed a kind of a national inspiration.[129] Some lessons, especially these of the artistic department, the high status

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period, five were officers, five were architects, seven were University were Professors, three of them teachers of in secondary education, 15 were artists, painters, sculptures, calligraphers, musicians etc, one physician and one agronomist. Biris, 1957, pp. 485-500.

127. During the period 1837-1840, about 400 students were enlisted annually. The teachers were C. Hansen, drawing, Th. Komninos, practical mathematics and geometry, K. Loran, K. Heller, plastics, F. Zedner, constructions. The prevailing way of instruction was the mutual teaching method. In 1843, 312 students were enlisted and the teachers were 10. In 1844-45, the students were 635, 11 of them were between the age of 25 to 40 years old (1,5%), 44 between 20 to 25 (6,9%), 256 between 15 to 20 (40,3%), 270 between 10 to 15 (42,5%) and 54 from 7 to 10 (8,5%). The teachers were still 10. Gr. Papadopoulos, 1845, p. 9. Biris, pp. 33-35, 62-64, 80, 110-111.

In 1859, the enlisted students were 612. Among them, 230 were painters, sculptors, architects, bookbinders, merchants, tailors, ironsmiths, carpenters, shoe-makers, coach-makers, builders, typographers, etc. 23 of them were non-commissioned officers of the artillery. The rest 382 were students of the University, of the Gymnasium, and the Hellenic School and some of them students of the elementary schools. The members of the faculty were 13. The title of the professor was only mentioned to those who had a chair to the Gymnasium or to the University. Archives of the National Technical University of Athens, Register no. 10, 1859-1871.

128. Register no. 10, Archives of National Technical University of Athens.

129. A. Fenerli, "Spoudes kai Spoudastes sto Polytechneio, 1860-1870" (Studies and Students in the Polytechnic School, 1860-1870), *Panepistimio, Ideologies kai Ekpaideusi, Istoriki Diastasi kai Prooptikes (University, Ideologies and Education, Historical Dimension and Perspectives),* Athens, ed. Istorico Archio Neas Genias, Geniki Grammatia Neas Genias (Historical Archive of the Greek Youth, General Secretariat of Youth), 1989, p. 151.

some of the faculty,[130] the relations of the School with the state administration and society, especially with technical professions, the important donations of the benefactors from Metsovo for the construction of the magnificent buildings to the Patision Street could confirm the above assertions.[131]

After King Otto's expulsion, the School was reorganized according to the decree of 1863. The aims transformed to "...the theoretical and practical education of the craftsmen and the owners of the manufactures to the most necessary arts, that is the building construction, the smothery, the joinery, the sculpture, the painting, the ceramics, the tanning, the soap-making etc."[132]

The new institutional framework provided that the artistic orientation would be delimitated to the "Beaux-arts" department and the technical instruction became the mainstream for the "Every Day School."

The organization of the School provided again three departments and the courses lasted one year for the "Sunday School", three years for the "Every Day School" and five years for the "Artistic School.". The preconditions for those students wishing to enlist to the "Sunday School" were being literate and, concerning the "Every Day School" to have the certificate of secondary level education, the "Hellenic School." For the "Every Day School" the decree provided examinations at the end of the year and diplomas after the graduation. The curriculum provided the instruction of geometry, trigonometry, principles of static, architecture and principles of building, theoretical and practical mechanics, physics and chemistry. The decree also

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130. Xavier Landerer, Professor of chemistry in the University, the Hansen brothers, famous architects, Georgios Vouris, Professor of Astronomy in the University, the Bavarian sculptor Christian Siegel, D. Skalistiris, graduate of the Military Academy and of the École Nationale des Ponts et Chaussées were members of the faculty during this period.

131. The models of the weights and measures were kept in the School. The expertise about the strength of materials was officially appointed to the School. The first daguerreotype camera in Greece was also exhibited there. In 1856, Kuhlmann, the German Professor of Physics, instructed for first time in Greece the magnetic and static electricity in the School of Arts. The first Greek telegraphers were also trained there. Archive of National Technical University of Athens, f. 82. Biris, pp. 22-24, 67, 77, 86, 89, 126-127, 180-195, 201, 278.

132. *Ephimeris tis Kiverniseos* (*Official Gazette)*, no. 33. "Decree on the new organization and the direction of the School of Arts," 26 August 1863.

provided the operation of laboratories for the training of the students. According to the new organization, the School was officially classified as part of the secondary level of education.

A supplementary decree, published in 31 October 1863, provided the designation of a "School Committee" charged with the surveillance of the school. Members of this Committee were appointed the president and two members of the "Committee for the Encouragement of National Industry," university professors and officers of the Corps.[133]

After 1864, and under the direction of D. Skalistiris, the technical direction of instruction was farther straightened. The French middle technical schools, the Écoles d' Arts et Métiers, became the outspoken model of the School.[134] In 1867, the "Every Day School" was renamed to "Manufacture School" ("Viotechniko Scholeio") and was divided in three departments, the "Architectural",[135] the "Surveying" and the "Mechanical", the courses in the first two of them lasted four years and in the third five years. The instruction provided calculus, geometry, designing, land surveying, architecture, physics, chemistry, mechanics, bridge building, road construction, hydraulics and strength of materials.[136] All these changes manifested the intention of Skalistiris as well as the next directors and the faculty[137] of the School towards

133. Some of the most eminent figures of public life of the 19th century, officers like G. Metaxas and E. Manitakis, state executives, like A. Mansolas, engineers like A. Kordelas, professors of the University like A. Ragavis, I. Papadakis, Th. Orfanidis and of course K. Paparrigopoulos, were appointed to the committee of the School periodically. Official Journal, art. 38, 31 October, "Decree about the staffing of the Committee of the School of Arts", 3-9-1863. Archive National Technological School of Athens (N.T.U.A), f. 19, 1872.

134. D. Skalistiris in one of his letters addressed to the Ministry of the Interior, in 12 October 1864, in regards to the reorganization of the School of Arts mentioned the Écoles d' Arts et Métiers, characterizing them as an advisable model to follow, signalling in this way the need of return to Zedner's ideas. Biris, p. 180-181.

135. Actually it was a civil engineering department.

136. Archives NTU, "Tables of marker" (Vathmologia) 1864-1865, 1880-1881, 1881-1890.

137. Among the 70 teachers who taught to the School during 1863-1887, 19 were military officers, 3 architects, 9 University professors, 5 gymnasium teachers, 17 artists, 1 physician, 9 machinists, 1 accountant, 1 stenographer, 3 civil engineers, 1 surveying engineer and 1 miner analogist. 47 of them had studied abroad and 16 were graduates of the School of Arts. Among the 19 military officers 7 had studied abroad, the 6 of them had studied to the École des Ponts et Chaussées, Biris, 1957, pp. 498-526.

the establishment of an arsenal for the education of civil engineers out of the Military Academy.

The upgraded demands of the new organization diminished drastically the number of the students and gradually changed the profile of the School. For example, in October 1867, only 20 students of the "Manufacture School" participated to the examinations whereas the register shows a total of 246 enlisted students.[138] The number of participants increased gradually during the 1870's. In 1880, 146 students participated in the examinations of the "Manufacture School" and in 1887, 328.

Significant changes were also recorded concerning the age structure, the educational level and the professions of the students during the period 1860-1887. The percentage of the age group 15-20 years old increased, as well the students who had a certificate from the secondary grade education. Another element shown at the register is the impressive decrease of students who declared being artists or artisans. These elements reinforce the case that, for the majority of the students, enlisting at the school was not any more a simple chance to improve an already acquired professional capability, but principally the systematic education for the acquisition of the necessary knowledge and skills of the architect, the land surveyor and the machinist.[139]

During the period 1867-1890, 380 Architects,[140] 140 Surveying engineers and 40 Machinists graduated from the "Manufacture School." The majority of them worked to the public works, to the private buildings in Athens, in Ermoupolis and Patras, while the most of 40 machinists joined the navy.[141]

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138. The decrease of students, according to Biris, is attributed to the educational criteria for the enrollment of the students, to the enforcement of the technical inclination and to the difficulty of examinations. Biris, 1957, p. 180-195, 201, 278. A. Fenerli mentions that the decrease was mainly related to the political turbulence of this period, A. Fenerli, 1989, p. 154.

139. Archives of National Technical University of Athens, Register no. 10, 1859-1871.

140. Actually civil engineers.

141. A. Ginis, *Ta tou Scholiou ton Viomichanikon Technon (About the School of Industrial Arts, 1912),* Athens, 1912. p. 5. I. Hatsopoulos, "To Ethnikon Metsovion Polytechnion" (The National Metsovion Polytechnion), *Techniki Epetiris tis Ellados (Technical Year-book of Greece),* Athens, ed. Technical Chamber of Greece, vol. A,

In 1887, a new decree changed again the status of the School. The new organization was named "School of Industrial Arts" and included two schools, The School of Civil Engineers and the School of Mechanical engineers, both classified as part of to higher education. The aim of this transformation, according to the decree, was not anymore the training of craftsmen but the scientific education of engineers who would be capable to face the new needs of the steam age and the demands of the ambitious technical projects of the Trikoupis period.[142] Actually, the new reform was going to produce the necessary technical personnel for the staffing of the Public Works Administration and the Corps of Civil Engineers, which both were established in 1878. During the period 1889-1914, a total of 272 civil engineers and 49 mechanical engineers have graduated.

The industry and the Greek engineers

The shaping of the state, the relevant institutions, the public works and of course the evolution of the Polytechnic School provide the potential of a relatively cohesive narration, at the end of which the Greek engineers already represented a distinctive socio-professional group. On the other hand, the situation in the industry, regarding to the engineers and not only them, is far beyond the relevant cohesion of the above image. The profession seems quasi-absent from the few steam-working factories in the biggest part of the 19th century. Its restricted, but relatively discernible, presence will be apparent by the turn of the century. The so called "second wave"[143] of the Greek industrialization, the Greek engineers, graduates of German Polytechnic Schools and the developments to the educational and professional institutions, are some of the reasons of this change.

The assignment to the "Internal Affairs Secretariat," in 1837,[144] to promote the training of the necessary manpower for the buildings and

1935, p. 62. *Odigos Spoudon toy Ethnikou Metsoviou Politechniou 1950 (Guide of Studies of the National Technical University 1950)*, Athens, ed. NTU, 1950, p. 174. A. Fenerli, 1989, pp. 151-166.

142. *Ephfimeris tis Kiverniseos (Official Gazette)*, Decree ΑΦΜΑ, 27 May 1887.

143. Ch. Agriantoni, "Viomichania" (Industry), *Istoria tis Elladas ton 20o aiona (History of Greece in the 20th century)*, Athens, Vivliorama, vol. I, 1999, p. 174.

144. The decree of 19 April 1837, among the duties of the "Internal Affaires Secretariat", defined: "The enhancement and the encouragement of the arts, the

the manufactures, Zedner's "Michanothiki," the idea of the "Royal Manufacture" and finally the law about the "encouragement of national industry" as well as the institution of the homonymous committee,[145] corresponded to the political intention of the newly established state to organize the field of the industrial production following the conditions of the Western industrial model. However, the distance that separated these intentions from the economic and social reality of the country was proved to be enormous. The first material traces of these intentions will be noticeable after 40 years.[146]

The emergence of the first steam-working factories in Syros, Piraeus, and Patras as well as the gradual expansion of the steam navigation accentuated the need for trained craftsmen.[147] The realization of this need was expressed in several ways. One of these was the enactment of scholarships, initiated in 1856. The enactment provided the training in smitheries with the apprenticeship method and under the jurisdiction of the "School of Arts" of young people from the provinces. Moreover, the steam engine of the public machine shop of Chalkida was transferred to the "School of Arts" in 1868. The engine was going to be the basis for the establishment of a machine-shop laboratory in the school.[148]

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manufactures, and the establishment of technical schools ...", Agelos Oikonomou, 1935, p. 233.

145. G. Anastassopoulos, *Istoria tis Ellinikis Viomichanias, 1840-1940 (History of the Greek Industry, 1840-1940)*, ed. Greek Publishing Company, 1947, vol. I, pp. 47-53. Leon. Kallivretakis, *I Dynamiki tou Agrotikou Eksychronismou stin Ellada ton 19o aiona (About the Modernization of Agriculture in 19th century Greece)*, Athens, Educational Institute of Agricultural Bank, 1990, pp. 56-74.

146. Vasilis Panagiotopoulos, "I Viomichaniki Epanastasi stin Ellada 1832-1871" (The Industrial Revolution in Greece, 1832-1871), *Eksychronismos kai Viomichaniki Epanastasi sta Valkania ton 19o aiona (The Modernization and the Industrial Revolution in the Balkans in the 19th century)*, Athens, Themelio, 1999, pp. 216-235.

147. In an article of the newspaper *Athina*, of January 19th 1855, it was mentioned: "Even if the ironsmiths learned skills from the Bavarians and other European craftsmen who came to our country, we are still far behind to the smithery and it would be so worthy to send young ironsmiths to learn the many works of smithery and most of all the basic works, in order to have craftsmen with a capability of mending the parts of machinery which deteriorate by usage and mostly steam-working machines. For this reason, the government must reintroduce the crafts and thus to benefit our country, and to release the working people from the exploitation of the leisure class", C. Biris, 1957, p. 128.

148. *Idem*, pp. 189-191.

The reorganization of "School of Arts" in 1867, the establishment of the "School of Industrial Arts" in 1887, may be recorded to this tendency; especially if they are seen within the framework of what Ch. Agriantonis called the "take-off" of the Greek industry in the end the 1860's and the period that followed with the unfolding of Trikoupis' effort.[149]

Yet, it is difficult to say that these institutional developments materialized to industry. The reform of 1887 concerned mostly the new demands of the state's technical services and not so much industry. The major tendency of the students of the "The School of Industrial Arts" to study at the School of Civil Engineers reinforces this case.

Only ten mechanical engineers[150] graduated from the Polytechnic School between the years 1890-1900, against 123 civil engineers of the same period. Biris, by commenting this excessively small number attributes it to the restricted professional chances of the qualified mechanical engineers in the labour market contrary to the assured professional course of the civil engineers in the public service and the public works. He also considers that in this context the establishment of the School of Mechanical Engineers was premature, criticizes its overgrown theoretical orientation, and the subsequent degradation of the practical training to this very sector. He finally comes to the conclusion that the qualified mechanical engineers were practically, "not at all or slightly useful."[151]

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149. According to the Statistics Year-book of Greece of 1931, in 1867 there were 168 factories, 22 of them were steam working. Their total established power was 296 HP. In 1875, mentioned 95 steam working factories, 1967 HP. In 1889 there is no total number of steam working factories, however 145 of them are recorded with 5,568 HP. "The Greek industry during the last years", *WORKS,* Athens, vol. 152, 39/9/1931, pp. 220-224. See also Ch. Agriantoni, 1986, pp. 400-419.

150. There are five available biographies about them. Three of them became executives to the administration of the railways, one became Professor in the Polytechnic School and two started their carrier in the Vassiliadis' factory in Piraeus and later on they became the owners of the Hermes machine shop in Piraeus. *Techniki Epetiris tis Ellados (Technical Year-book of Greece),* Athens, ed. Technical Chamber of Greece, vol. II, 1934, pp. 84, 88, 115, 263, 299, 365.

151. Biris, pp. 311-313 and 328. Em. Giannopoulos, mineralogist and professor of metallurgy, in his article, "The School of Industrial Arts and the future of the mechanical engineers" published to the newspaper Acropolis in 28 August 1887, wrote: "The civil engineers, who graduate from the Industrial School of Arts, are hired to the Public Work Administration. On the contrary there is not any kind of

This inclination may be better understood if it is examined within the general framework of the ideology and the consequent attitude of Greek society towards industry. The industrial venture seemed not to be legitimised either as an alternative perspective for the economical development of the country neither as a permanent entrepreneurial nor as a professional one. For some entrepreneurs, the framework of the favourable economic conjuncture in the beginning of the 1870's appeared as an investing chance. Most of them will abandon this so called chance after the turbulence that came up in the mid of the decade and they will turn their interests to more lucrative and safer entrepreneurial fields.

X. Zolotas, in his study *Greece in the Stage of Industrialization*, written in 1926, asserted that the labour class and especially the people from the countryside, who abandoned their farming occupation in search of a better luck in town, dealt with the factory's work as a temporary solution. On the contrary, their future expectations, if they were not inspired by the prospect of return to the native land or the transatlantic immigration, were guided by a socio-professional ideal firmly fixed by the intention of self-employment.[152]

Therefore, if industry was not the first and permanent solution for the unskilled manpower, it is reasonable this tendency to be much more enforced among the students and the qualified engineers of the "School of Industrial Arts," leading the overwhelming majority to the School of Civil Engineers and to the subsequent anticipations for a career in the public service, the public works and the liberal professions. It is obvious that the reasons of this preference apart from being professional and economic they were also strongly social.

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professional consolidation for the mechanical engineers to the public service, not because of malice but because of the lack of positions in this sector. The state leaves the young scientists defenceless..." cit. in G. Anastassopoulos, *History of Greek industry, 1840-1940*, Athens, ed. Greek Publishing Company, 1947, vol. I, p. 1887.

152. X. Zolotas, *I Hellas eis to Stadion tis Ekviomichaniseos (Greece in the stage of industrialization),* Athens, Eleftheroudakis, 1926, p. 65. This assertion is also at large adopted in some major posterior studies about the Greek industry, like Ch. Agriantoni, 1986, p. 347-350, G. Dertilis, *I Elliniki Oikonomia kai i Viomichaniki Epanastasi, 1830-1910 (The Greek Economy and the Industrial Revolution, 1830-1910),* Athens, ed. Sakkoula, 1984, pp. 39-44, 49-54, 60-66 and Ch.. Hatziiosif, *I Girea Selini. I Viomichania stin Elliniki Oikonomia, 1830-1940 (The Old Moon. Industry in Greek Economy, 1830-1940),* Athens, Themelio, 1993, pp. 333-335, 407.

Until the last decade of the 19th century, the foreign engineers and craftsman almost exclusively faced the need for trained personnel in industry. These people occupied the leading posts to the hierarchy of the factory, trained the Greek workers and artisans and practically became the living factors of introduction and spreading of the industrial technology in the country.

Engineers like Mayers, who was the chief engineer of the state machine-shop in Chalkida, or the French Formas, engineer to the Vassiliadis machine-shop in Piraeus and director of the machine- shop to the School of Arts in 1865, or the Scottish MacDowall, owner of the machine-shop *Hephaestus* in Piraeus or the brothers Étienne and Bartholomée Perrin, owners of a machine-shop in Piraeus are some indicative cases. Even more indicative however, are the French communities in Piraeus and in Lavrio that numbered 500 members, among them 250 engineers, foremen and craftsmen of all types.[153]

The last decade of the 19th century many young workers were trained in the apprenticeship courses that some industrialists established within their factories in Piraeus. Some others were trained to the technical schools of "Prometheus" and of "Piraeus Association", which were established in Piraeus the same period.[154] A. Ginis, director of the Polytechnic School, also asserted that some of the 40 machinists, who graduated from the Industrial School during the period 1867-1890, were employed in the industry.[155] Finally, a number of graduates of the Industrial, the Mechanical and the Mining department of the "Commercial and Industrial Academy," a private technical school, seem to be employed in several factories in the beginning of the 20th century.[156]

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153. Ch. Agriantoni, 1986, pp. 104, 126, 194, 198-199, 249-250, 294. El. Kalafati, 1989, p. 178. Vas. Tsokopoulos, *Pireas, 1835-1870. Eisagogi stin Istoria tou Ellinikou Manchester (Piraeus, 1835-1870. (Introduction in the history of the Greek Manchester),* Athens, Kastaniotis, 1984, p. 232. I. Tzamtzis, "Neohelliniki Naypigiki" (Modern Greek Shipbuilding) *Historia tis Ellinikis Technologias (History of Greek Technology),* Athens, ETBA, 1988, pp. 23-24.

154. Lydia Sapounakis-Drakakis, "I Ekpaideysi tis Ergatikis Taxis ston Pirea" (The education of the working class in Piraeus in the 19th century), *Historica,* Athens, vol. 6, December 1986, pp. 387-415.

155. A. Ginis, *About the School of the Industrial Arts*, Athens, 1912, p. 5.

156. *Deltion tis Emporikis kai Viomichanikis Akadimias (Journal of the Commercial and Industrial Academy),* Athens, volume E΄, issue 4-5, September 1914, p. 60-63. In

The emergence of the so-called "science based" industries will partially change the picture, during the first decade of 20th century. The chemical, cement, electrical, telecommunication, and the construction industries created a fresh entrepreneurial field and a radical type of entrepreneur, notably different from the accepted standards of the Greek version of capitalism.[157] In many cases, this new class of Greek entrepreneurs established affiliations with Greek engineers, principally with those who graduated from German-speaking polytechnic schools and especially with a six-person group, the "Circle of Zurich," who graduated from the Federal Polytechnic School of Zurich in the turn of the 20th century.[158] These people virtually established the emergent industries, decisively contributed to the social and institutional formation of the Greek industrialist class, and eventually became the luminaries of Greek industrialization during the interwar period.

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this issue there is a detailed report about the employment of the Academy's graduates in factories like, "ΧΡΩΠΕΙ" (5), the "ΑΕΧΠΛ" (3), the "TITAN" (4), the French Company of Lavrio (2), wine factories and chemical laboratories (32), etc. Relative reports of the same journal are in the issues to follow: number 6, p. 52, no. 9, issue 1, p. 1, no. 8, issue 1, 1903-1904, p. 2 no. 10, issue 11, March 1906, pp. 161-162. The overwhelming majority of those mentioned apart from accountants were chemists. There is also a relevant report on the subject in the *Panhellenic Album of National Centenary.* Maria Tsokana, *I Emporiki kai Viomichaniki Academia (The Commercial and Industrial Academy)* unpublished postgraduate paper, National Technical University (N.T.U.A)-National Kapodistriakon University of Athens.

157. Chr. Agriantoni, 1999, p. 184.

158. The members of the "Circle" were Alexandros Zachariou, Nikolaos Kanellopoulos, Kleonimos Stilianidis, Leontios Economidis, Leonidas Arapidis and Andreas Hatzikyriakos. 23 Greek engineers graduated from the Federal Polytechnic School of Zurich the last thirty years of 19th century. Alexandros Tsatsos, *Epetiris ton Foitisanton Ellinon eis to Omospondiakon Polytechnion tis Zyrichis, 1855-1978 (Year Book of Greek Students in Federal Polytechnic School of Zurich, 1855-1978)*, Athens, 1978, p. 84 *Technici Epetiris tis Ellados* (*Technical Year Book of Greece*), Athens, Technical Chamber of Greece, 1934. vol. II Constantinos kai Spiridon Vovolinis, *Mega Viographicon Lexikon,* (*Biographical Dictionary*), Athens, "Viomichaniki Epitheorisi", 1958, vol. I, pp. 46-57, 73-83, 85-102, 105-111, vol. II, pp. 311-328. Eleni Calafatis, "Alexandros Zahariou, o kat' exochin michanikos tis ellinikis viomichanias" ("Alexandros Zahariou: the Engineer of the Greek Industry"), *to "Vivliothiki kalliston anagkaiounton vivlion kai omologoumenos kalliston ephimeridon", I palies silloges tis vivliothkis tou E.M.P (The Old Collection of the Polytechnic School Library...)*, Athens, ed. National Technical University, 1995, pp. 119-144.

Conclusion

The Greek state, representing itself an institutional innovation in regard of the pre-existing Ottoman administration, was, during the 19th century, the *par excellence* leading power of innovations within all the fields of the public domain and the inspirator of any kind of project that exceeded the limits of traditional techniques. The conception, the design, the institutions, the surveillance and in many cases the public works' construction were initiative of the state and its authority. The roads and ports, the urban planning, the building constructions, the railways, the Corinth Canal, the drainage, and the land reclamation works in the countryside were the material expression of a major political intention, the shaping of the country in a modern way. Modern Greece was constituted so as to be part of the West.[159]

Who were the Greek engineers that undertook this modernization project in the newly born state during the 19th century? Following the above narration we can find several types in the genealogy under examination. Some indicative examples are:

- The first Greek engineers, who studied in France, in Austria, in Russia, in Italy and served the Corps of the Capodistrian administration.[160]
- The Bavarian Junger, Captain Fr. von Zedner, the first director of the School of Arts.
- The architects L. Kaftantzoglou, E. Ziller and P. Kalkos, who left their mark to the urban landscape of Athens and Ermoupolis, bringing the neoclassical ideal to the place of its origin.
- The saint-simonian E. Manitakis, who tried hard to introduce technological rationalism to the country.
- The less known *nomomichanikoi* (county-engineers), described in the Manitakis pamphlets, who built the roads of the new state.
- T. Komninos, the talented officer, who wrote the first differential and integral calculus textbook in the mid 19th century.

159. M. Synarelli, *Dromoi kai limania (Roads and Ports),* Athens, Cultural Technological Institution E.T.B.A, 1989.

160. For example, T. Vallianos, who studied in Russia, D. Stauridis, who studied in Austria, E. Manitakis and I. Kallergis, who studied in France and S. Isaia, who studied in Italy. M. Kardamitsi, Adami, 1988, p. 71.

- The anonymous School of Arts' graduates, who built the private and public buildings in Ermoupolis.[161]
- G. Metaxas and D. Skalistiris, the officers who changed the School of Arts' orientations toward the so-called "crude arts" and served the state administration as leading engineers.
- The military engineer A. Theofilas, the *homme d'État*, who led the Polytechnic School the last decades of 19th century and also built important buildings in Athens.
- The French Formas, who worked in Vassiliadis' machine shop, where important mechanical engineering works were done, and the Scottish MacDowall, the owner of the machine shop *Prometheus* in Piraeus.
- P. Kyriakos, the talented graduate of the School of Arts who studied in Marseilles and tried to introduce the modern mechanical engineering as Professor of the Polytechnic School.
- A. Mansolas, the state executive, who measured the productive activities.
- A. Kordelas, the chief engineer in Lavrio, the high ranked state executive who composed the legislation about mines in Greece.
- N. Sorokiadis, the industrial engineer who wrote with a Protestant faith in the industry's benefits and the necessity to be developed in Greece.
- I. Angelopoulos, graduate of the École Nationale des Ponts et Chaussées, Professor in the Polytechnic School, the engineer who introduced the reinforced concrete in Greece.
- The first graduates of the "School of the industrial Arts," who entered to the public service the late 19th century. Among them the first mechanical engineers, V. Dimitriou, C. Douvanas and L. Papayiannakis, who preferred the administration of the railways instead of the job in the factory.
- The graduates of the Polytechnic School of Zurich, the famous "Circle of Zurich," the engineers who introduced the idea of "science based industries" and organized the class of Greek industrialists in early 20th century.
- The Professors of Polytechnic School, A. Ginis, P. and D. Protopapadakis, N. Kitsikis, engineers of 20th century, closely and personally linked with the problems of this era.

161. The municipal architects of Ermoupolis, J. Vlisidis, J. Koumelis, D. Eleftheriadis, the A. Fenerli's subject of study. A. Fenerli, 1989, pp. 162-163.

We hope that the above genealogy has escaped from the dichotomies between individual and society.[162] The above-mentioned persons form a heterogeneous set; institutions, architectural forms, regulatory decisions and laws, administrative measures, scientific statements, moral positions, foreign influences, all together act vigorously and the story of the state formation is unfolding. They are formed by the state and, at the same time, they form it. They are the products of a modernizing vision, while they reproduce it in their own terms.

Topics for further study can be easily drawn from the engineering studies material presented. For example, the relation between traditional techniques and modern technology, at the level of practices and personnel; public constructions in relation to private industry; social mobility through the engineering study; the issue of the "twin" communities, scientists and engineers, etc.

162. See for example P. Carrol, "Science, and Power Bodies: The Mobilization of Nature as State Formation", *Journal of Historical Sociology*, vol. 9, 1996, pp. 139-167.

DIMITRIS VOGIATZIS

Military Technology in Greece in the 19th Century

The 19th century witnessed the introduction of many significant innovations in the realm of military hardware. The most celebrated is the invention in the U.S. of the process that eventually led to the production of standardized industrial products, that is the manufacture of infantry weapons with fully interchangeable parts. This process, known as the American system of manufacture, spread rapidly throughout all branches of world industry. It was an innovation of the first order: the humble infantry rifle was remodeled as a miniature weapon system, where every component was mass produced to exact specifications with known material propensities. The examples made from 1834 to 1844 were improved percussion models of the French flintlock model of 1777 Charleville 0,69˝, a rifle that incidentally was widely used during the Greek Revolution. Although this outmoded rifle was not developed further, it was now in theory possible for every single 'nut' and 'bolt' that mattered, to be developed separately, each part subsequently traveling on its own development path. In rifles the important parts were the barrel, the firing mechanism and during the later stages the ammunition feed. All these components could be further split into many minuscule parts (depending on the system of operation used) which could also be redesigned. Between smooth-bore flintlocks and rifled repeating rifles, there were a great many variations on the theme and also dead-ends. The appearance of rifled one-shot and repeating rifles transformed the battlefield: for the first time infantry was able to outperform the artillery since the lethal range of the rifled infantry weapons was longer than the range of early grapeshot firing artillery pieces. New types of ammunition (Migné and later Full Metal Jacket Bullets), propellants (smokeless powder, nitro cellulose mixes) and automatic weapons (of the end of the century) further enhanced the firepower of infantry. These changes necessitated reforms in tactics and organization, speeded up the pace in artillery development and ultimately led to the stalemate of W.W. I. The abundance of firepower that was available to both sides on the Western Front, thus preventing either side from achieving a breakthrough, can be traced back to developments in the 19th century.

The impact of these changes in Greek military and semi-military formations during the latter half of the 19th century is difficult to assess. From 1829 until 1900 the statute, the Order of Battle and the tables of organization of the tiny Greek Army were revised more than twenty times. The haphazard skirmishes and the confused battles of the same period do not lend themselves easily to analyses. Scholarly treatises on military technology and industry in Greece do not exist, and serious research on socio-military relations has only recently began, therefore access to military or industrial archives in Greece is better treated as a topic for deliberation rather than a straightforward method of enriching one's sources.

If the Great Idea was the common denominator of Greek society in the 19th century then its chief medium of implementation was no other than the rifle. I have therefore limited the scope of this paper to observations on a weapon that in the low-technology 19th century Greek Army played a dominant role.

An important question is how to treat the dichotomy between regular and irregular troops and their respective accommodation to weapon's technology. As it will be shown later, Greek irregulars of the 19th century had a special affection for their weapons, unknown to western soldiers. It is assumed that with the introduction of Western drill, tactics, clothes and weapons, beginning at the latest with the reign of King Otto (1833-1862), Greek regulars severed the tradition of the irregulars. In my opinion, this was not accomplished until the 1912-1913 Wars and goes a long way to explain the spotty performance of regular troops from 1829 to1900. During the same period, many semi-military formations ('chorofilaki', national guards, mobile troops, etc.) coexisted with the regular army. Greek governments extensively used irregulars as tools of foreign policy in the Ottoman-occupied lands. As far as I know, the last irregular formations ('proskopoi') fought alongside the Greek Army during the 1912-1913 Wars.

The Greek War of Independence (1821-1829) was fought largely by irregular troops organized by local chieftains, the 'kapetanioi'. This type of organization harks back to the long reign of Turkish rule, when the 'kleftes' and the 'armatoloi' often changed roles in the self regulating system of Ottoman policing. Leaving aside the more traditional edged weapons, their main weapon was the 'kariofili', a muzzle loading flintlock rifle with a barrel that varied in length from 1,20 to 1,70 m. The 'sisane' and the 'daliani' were rifled versions of the same weapon used by sharpshooters and cavalry respectively. The earliest examples date from 1750 but we should note that in the Balkans weapons were used for centuries and every usable part was recycled. Flintlocks survived well into the 19th century. Before the treaty of Campoformio (1797) that put restrictions in the manufacture of Italian weapons, the highest quality firearms came from the master gunsmiths of Brescia. The Brescian craftsmen were famous throughout the East for their exceptionally fine, lightweight and durable gun barrels. From the beginning of the 19th century, weapons and parts were imported from Belgium, France or England. It is interesting to note that many weapons were produced exclusively for the Orient, sometimes incorporating features of archaic appearance for marketing reasons. From the other side, certain western- produced weapons were preferred over indigenous designs and there were many local copies with fake western constructor's markings.

Balkan weapons manufacture was definitely a craft since no single weapon looked like another. The artisans used locally manufactured or imported parts or even parts discarded from other weapons. Larger workshops existed in Konstantinopolis, Smyrna and Southern Albania, which was the main source of finished weapons for Greek warriors. Smaller workshops existed in Naousa, Grevena and Kalarytes. The most interesting thing about these firearms is their expensive decoration. Velvet, ivory, copper, brass, bronze and especially silver were the preferred materials. As a result, the wood and metal surfaces of Greek firearms were completely covered in granulated repousse work. Brass was the material of choice for kariofili decoration. In a recorded case, the silver content of two similar weapons was exactly the same since the weapons were to be given to two brothers as part of a legacy. The gleaming silver decoration denoted the status of the bearer, who sought the most beautiful hand-crafted example, not the most lethal or effective. In another case the gilded decoration with its protuberances impaired the weapons effectiveness as it was difficult to handle in combat. The glamour bestowed on his owner was preferred over the weapon's functionality.

It is obvious that Greek weapons of the revolutionary period served as well as status symbols, objects d'art and high value investments, that were passed on from generation to generation. In my opinion, the economic function of these firearms is today largely overlooked and is clearly a matter open to dispute. Training was a father to son affair and in Mani the rifles were given ceremoniously to youths upon reaching 15 years of age. These weapons embody as artifacts the ideals of a preindustrial society and the fighting spirit of the irregulars. Their presence in the museums today explains to a degree the reluctance of 19th century Greeks to fight, train and clothe according to Western manner. Who would like to trade this beautiful kariofili for a lacklustre Brown Bess or a mle 1777? The last vestiges of this tradition are visible in surviving monochromes of early 20th century makedonomachoi chieftains, brandishing before the camera their latest Mausers or Mannlichers.

Curiously naval crews didn't display the preference for ornamented oriental weapons like their mainland compatriots. They used almost exclusively imported western made weapons. This cultural difference is best explained by the fact that ships make bad aiming platforms. Oriental weapons had a adequate range due to their long barrel, but they were notoriously difficult to aim for two reasons: the weight of barrel and stock was unbalanced and the stock design was influenced by artistic rather than ergonomic criteria. Accuracy was crucial in the long range fire duels between ships preceding boarding. Additionally there was no Balkan equivalent for the trombone, the preferred naval close range weapon that fired pellets instead of balls.

Western weapons coexisted with kariofilia long before the Revolution, thanks to earlier French and Russian efforts to alter the local status quo. As rule standardized, Western weaponry was supplied to the various units established as regulars during the War. The lack of a regular Army was highlighted during the painful contacts with Ibrahim Pasha's Egyptian troops. Greek irregulars proved no match against these western-led and equipped warriors, who introduced bayonet-led shock tactics in the Balkans. The Philhellenes did their best to raise similar formations in Greece, but in the long run their main contribution to the Greek cause was material. They sent shiploads of flintlocks, but more importantly provided almost all the ammunition of war in the form of lead ingots and black powder. Today these materials are rarely mentioned in accounts of the Greek

Revolution, but as far as I am aware, no adequate local substitute existed. As far as it is known the only Greek powder mill in Dimitsana worked well below requirements. If one discounts Europe as the main source of ammunition, then one must radically revise the standard view on the frequency of fire-fights during the Greek War of Independence.

The first instance of a successful military technology transfer occurred in 1829. During that year some nondescript machines were sent by the Paris Philhellenic committee to establish an Arsenal in Nafplion. The supervising personnel were French officers. There is a lack of data about the true capabilities of this institution that in 1866 employed 29 officers, 54 NCOs and 120 technicians. From 1857-1859 the chief superintendant was a German named Ludwig Steinhauer. His reminiscences, if they survive, would shed light on this subject, as he started his career in the Arsenal in1833. Repair and conversion of existing weapons (that included kariofilia in the early years) was the main occupation of the Arsenal. It is believed that the majority of conversions of Greek flintlock weapons to percussion firing were undertaken there (1855-1858). Manufacture of ammunition, including balls for muskets and possibly even metallic cartridges (from 1876) is also known to have taken place.

In 1849 a French army officer, Captain Mingé patented an elongated bullet, whose hollowed base expanded to fit the grooves of a rifle bore when the charge was fired. The combination of the Migné bullet, percussion firing and the rifled bore, produced a longer-ranging,accurate rifle that required no ramming and was relatively easy to load . This was the final improvement in muzzle-loading arms. The invention of Migné bullet accelerated the pace of development in rifle design. Breechloading and needle guns were next to appear. A bewildering array of competing systems were offered to the various military authorities between 1860 and 1871.During this period five hundred patents on breechloading mechanisms were taken out in the United States alone. The gradual advances in firepower brought by the needle gun, the Migné rifle and breechloaders created an uneasy shifting tactical balance between firepower and the bayonet charge between infantry, cavalry and artillery and between offense and defense. As a rule in Europe, the newer weapons were given to the skirmishers, special units that marched ahead in extended order, paring the way with their superior firepower for the assault of line infantry columns and the engagement of 'cold steel'.

It is typical that, although the Greek Army had skirmisher units, it is not known if this tactic was ever successfully employed (they were certainly trained in these tactics by their predominately French tutors). As a matter of fact, Migné rifles were supplied in Greece both to the infantry of line and to the skirmishers (1858). The Arsenal was tasked to convert 5000 older percussion rifles to the Migné bullet. From 1860 onwards skirmisher units disappear from the Greek Order of Battle. It is possible that their role was given to the Evzoni light infantry units.

From 1856 until 1888, five different rifle designs were introduced in the Greek Army inventory. Three of them were major purchases: the Migné muzzle loader (1856), the Chassepot breech -loading needle gun (1868) and the Gras bolt action single firing rifle(1877), the first weapon in Greek service firing a metallic cartridge. Two other models, the Mylona rifle (1876) and the Martini-Henry (exact date unknown), were procured in small quantities. The most interesting was the Mylona, that was a major Greek inspired redesign of the Belgian Complain dropping block rifle. This weapon was manufactured in Belgium and is today known as the first weapon of Greek design. Limited numbers of the French repeating Kopatchek rifle were also procured during the end of the century on behalf of the Navy.

All these designs were the latest state of the art in rifle technology of the time and they were eagerly adopted as they appeared on the market. In most European armies, the changes from muzzleloaders to breechloaders and from paper to metallic cartridges were held back by the belief that the soldier could not properly handle the new weapon and would use too much ammunition. Normally, government and military officials treat technological innovations with extreme caution. As Dennis Showalter points out, innovations are costly and time consuming, new weapons must demonstrate that they represent more than marginal improvements over their predecessors. In Greece, a different attitude prevailed. There was no doubt that the illiterate Greek peasant-soldier could handle the latest French or Belgian rifle. The irregulars' tradition that lived on in the Regular Army may have retarded its development to a disciplined western style mass Army. Simultaneously the ideals that encouraged individual valour and the proud carrying of arms embraced western weaponry when it was obvious to the descendants of the 'palikaria' that kariofilia were decidedly 'passé'. Of course, other contributing factors to this frenzy of rifle procurement, in spite of the bad finances, were the need to supply irregulars who were fighting outside the Greek border and the chronic tensions along the boundary of the Ottoman Empire.

The demand for rifle ammunition for the above rifles gave birth to two small companies: Maltsinioti Brothers and Elliniki Kalikopoia, that were founded during the last decades of the 19th century. They competed for Army orders until amalgamated in the 20th century forming the first modern defense industry in Greece, the EEPK.

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8. War Museum, *Όπλα των Βαλκανικών Πολέμων 1912, 1913*. Athens, 1972.

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ANDREAS KASTANIS

DESCRIPTIVE GEOMETRY IN 19th CENTURY GREECE

It is generally acknowledged that France can be qualified as the center and the vanguard of mathematics, at least in the first decades of the 19th century. The science of mathematics in France, especially in the 18th century, was not connected to the University, but to the Church or the army[1]. Descriptive geometry was a revolutionary course given the circumstances of that time and it was taught for the first time in a military school. But what influence was exerted upon the mathematical education in Greece in the first years of the 19th century? What were the basic parameters that lead to the incorporation of the course of descriptive geometry in Greece? In which Greek educational institutions it was taught and what educational reference books were used? The answers to these questions will allow us to understand the scope of the influence Greece was subjected to by the teaching of descriptive geometry.

Introduction

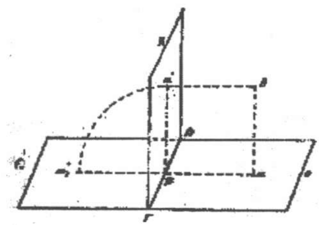
The term *géométrie descriptive*[2] appeared for the first time in a military school in Mézières, France, by Gaspard Monge[3]. The term

1. Boyer Carl, *A History of Mathematics*, John Wiley & Son eds., New York, Chichester, Brisbane, Toronto, 1968, p. 511.

2. The term *Géometrie descriptive* appears for the first time in September 1793 in an outline for secondary education planning by Monge.

3. Gaspard Monge was born in France, in 1746 and died in 1818. Since his was young, he had an inclination for mathematics. He was offered a position of fortification draftsman student in the Mézières Military School, which he accepted. From there he was drawn to the birth of Descriptive Geometry. He applied the principles of the new Geometry in the processing (carving) of stone, in carpentry and in fortification building. He was not allowed to publish his work, as this was

'descriptive geometry' (translated into Greek as *Perigraphiki Geometria* initially, and later as *Parastatiki Geometria*) means the study of three-dimensional figures based on their projection properties in two planes. Monge's method is based on the projection of spatial figures in two levels, perpendicular to each other (the horizontal level is called front and the vertical one plan), in which the vertical level pivots until it coincides with the horizontal. This 90° turn is called inclination[4]. The following figure shows the projection of point A in two levels[5].



The ongoing demands in architecture (civil as well as military) and the development of engines (especially of steam engines) provided strong incentives for the discovery of a scientific tool that would allow communication between technical scientists and technicians. The most appropriate tool should be found in Geometry, which in turn, should adapt accordingly to the needs of technical fields. The realization of

considered military secret. He took part in the French Revolution and in 1792 served as Minister of the Navy. He taught first in the Ecole Normale (higher institution forming teachers and professors) and later in the Ecole Polytechnique.

4. Hatzidakis N., "Geometry, History-Euclidean, Projective, Descriptive, Analytical, Linear, Infinitesimal and Non-Euclidean Geometry, Philosophy of Its Principles," reprint from the *Great Hellenic Encyclopedia*, Pyrsos, Athens, 1929, p. 4 [in Greek].

5. The figure comes from the notes of Evelpis Saripolos from a lecture of Descriptive Geometry by Th. Lybritis in the Greek Military Academy, in the early 1880's.

this reduction demanded a perfect knowledge of not only Geometry, but also of graphic arts and space.

The origin of descriptive geometry can be found in the early ages, when the use of planes was already known, and also in Antiquity, which developed the use of altimeters. It is not clear when the above-mentioned concepts combined to form a technique. During Renaissance, architects knew this technique but in the second half of the 15th century, the correlation of levels with altimeter was related to the Perspective[6] according to which, the geometrical relations and conditions of the three-dimensional space are plotted in a two-dimensional level[7]. The disadvantage of this method is that the three-dimensional figures and the distances in the two-dimensional level are not rendered with accuracy. Another root of descriptive geometry lies in Analytical Geometry, invented by René Descartes (1596-1650). Descartes restricted his geometrical work in the filed of the level, yet he was aware for the possibilities of its expansion in the three-dimensional space. In his second book entitled *Geometrical Matters*, he states:

> "In all this discussion I have considered only curves that can be described upon a plane surface, but my remarks can easily be made to apply to all those curves which can be conceived of as generated by the regular movement of the points of a body in three-dimensional space. This can done by dropping perpendiculars from each point of the curve under consideration upon two plans intersecting at right angles, for the ends of these perpendiculars will describe two other curves, one in each of the two planes, all points of which may be determined in the way already explained, and all of which may be related to those of a straight line common to the two planes; and by means of these the points of the three-dimensional curve will be entirely determined."

Descartes considered that the above explanations covered this subject. Gaspard Monge used the above-mentioned idea in developing

6. Kristi Andersen and I. Grattan-Guinness, "Descriptive Geometry," *Companion Encyclopedia of the History and Philosophy of the Mathematical Sciences*, vol. 2, Routledge, London and New York, 1994, p. 887.

7. Kastanis N., "The Fate of Linear Perspective in Modern Greek Education," *Aspects of Modern Greek Mathematical Education*, Vafiadis, Thessaloniki, p. 57 [in Greek].

descriptive geometry[8], which appeared in the late 1760's in the Mézières Military School. It should be noted that the new mathematical method was considered a military secret[9].

The publishing of thirteen lectures by Monge in the Ecole Normale, in the school's *Journal des Séances*[10], is considered to be the first publication of descriptive geometry. In 1799, was published for the first time a manual of descriptive geometry (*Géométrie descriptive*) with the subtitle "Lectures Taught in the Ecoles Normales in the Third Year of the Republic" (*Leçons données aux Ecoles normales de l'an III de la République*); it was edited by Hachette[11], Monge's assistant. The book was considered as the second edition and included the first nine lecture of Monge to the letter. It comprised first the analytical contents and then was divided in five parts. The meter replaced the foot, as a consequence of the institution of the metric system in the meantime. The last part of the book comprises 25 tables with 50 figures. There are also three short addenda by Hachette on the cylindrical basis, the generation of regular surfaces and the contiguous/tangent planes, based on Monge's teaching. This work has been widely used in the Ecole Polytechnique. It was considered a reference for following re-editions. The third edition came into light in 1811, and was named "new edition"[12]. It comprised a supplementary chapter on curves in space in

8. Booker Peter, *A History of Engineering Drawing*, Northgate, London, 1979, p. 83; *Enzyklopädie der Mathematischen Wissenschaften*, vol. 3 Geometrie, Teubner, Leipzig, 1907-10, p. 559.

9. Kristi Andersen, *op. cit.*, p. 889.

10. Paul Mathias, *Gaspard Monge "Géométrie descriptive" und die Ecole Polytechnique. Eine Fallstudie über den Zusammenhang von Wissenschaft und Bildungsprozess*, Institut für Didaktik der Mathematik, Bielefeld, 1980, p. 173.

11. Jean Nicolas Pierre Hachette was born in Mézières, in 1769. He studied at the Royal Corps of Engineers in Mézières and at the University of Reims. He served as Monge's assistant at the Ecole Normale, in the course of Descriptive Geometry. From 1795 to 1816, he remained professor at the École Polytechnique. He was an active editor of *Correspondance sur l'École Polytechnique* (1804-23) and *Journal de l'École Polytechnique*, and edited Monge's *Géométrie descriptive.* In 1808, he published *La Théorie des machines*. In 1816, he was dismissed from the École Polytechnique, in 1823, his application to the Académie des Sciences was rejected, but he was eventually elected in 1831.

12. Belhoste B. and Taton R., "L'invention d'une langue des figures" in *L'Ecole Normale de l'an III. Leçons de mathématiques*, Dhombres Jean ed., Dunod, 1992, p. 299.

planes[13] by Hachette, who was the editor of this edition without any interference by Monge. The manual's basic text, which was not very different from that of 1799, comprised, apart from the supplementary chapter, another chapter on the applications of descriptive geometry to perspective, sketching, stone carving and machines[14]. The only difference concerned the construction of two perpendicular lines. The three short addenda of the second edition were removed, and thus the editor had to replace the last two tables with one. The 1811 edition was the last published during Monge's lifetime.

Monge's book comprised five chapters, a foreword and an appendix. Specifically, the table of contents was as follows:

CHAPTER 1. Object and principles of descriptive geometry. Inclined plane and lines. Surface construction. Representation.

CHAPTER 2. Tangent of inclined and regular plane. Particular properties of surfaces.

CHAPTER 3. Surface intersection. Tangent on curve intersection. Roberval method[15].

CHAPTER 4. Problem application to surface intersection.

CHAPTER 5. Space and surface curves. Evoluted and evolutionary (region of envolutes of curve).

The appendix comprises the applications of descriptive geometry to the theory of the fall of shadows and in perspective[16].

In 1820, Bernabé Brisson (1777-1828)[17] presented the fourth edition of *Géometrie* to which he added three lessons under the title "Theory of Shadows and of Perspective." It was to be followed by a fifth edition in 1827, a sixth in 1838 and a seventh in 1847, identical

13. Monge treated these subjects in his lectures.

14. Paul Mathias, *op. cit.*, p. 173.

15. Gilles Roberval was born in Senlis, France, on 10 August 1602. He started studying mathematics at an early age and later taught mathematics in various universities. Roberval developed dynamic methods in the first integration studies. He wrote the *Traité des indivisibles* and calculated the defined integral of sine X. He studied the cycloids and calculated the length of a spiral's arc. Roberval was famous for his discoveries on convex planes and for his method for designing a tangent on a curve. This method of designing tangents gave impetus to Geometry of motion. He died in Paris, on 27 October 1675.

16. Kastanis Andreas, *History of the Military Academy During Its First Years, 1828-1834.* PhD dissertation, Ellinika Grammata, Athens, 2000, p. 87. [in Greek].

17. Alumnus of the Ecole Polytechnique, civil engineer and Monge's nephew.

to the 1820 edition. The newest edition was published in 1922, in two short volumes in the collection *Maîtres de la pensée scientifique*, which was a reprint of the 1820 edition. Other works of Perspective Geometry by French scholars completed the collection.

The First Steps in Teaching Perspective Geometry in Greece

The first attestation of descriptive geometry in Greece was probably found in the magazine *Logios Ermis*, which was recommending to its readers various French books. Amongst them was Hachette's *Supplem. à la Géométrie descript. de M. Monge*[18].

The Ionian Academy was among the first educational institutions that taught descriptive geometry, by the mathematics professor Ioannis Karadinos[19] who had studied at the Ecole Polytechnique. Upon his return to the Ionian Islands, he translated a series of French mathematical manuals, most of which he published himself. One of the books he translated without ever been published is probably the *Géométrie descriptive*. According to a *Notification*, about his endeavour to sell his published books, Karadinos states: "... *I became a co-operator of the Teachers of mathematics, so that they may prepare the youth by means of this system and to continue unconstrained in our Academies the application of analysis to every sections of Geometry, Descriptive Geometry, Differential and Integrated Calculus and the Science of Mechanics, i.e., the fields of transcendental mathematics, which I have translated from books written in foreign languages, which I intend to publish in due time, after I have taught them to young Teachers...*[20] "

18. *Logios Ermis* "Catalogue of French Books, Old and New Editions, from Various French Catalogues Compiled for the Amateurs of French Literature Subscribers," 1817, p. 21.

19. Ioannis Karadinos was born in Cephalonia in 1784 and showed an aptitude for mathematics. In 1804, he enlisted in the army of the Ionian Islands. In 1808, he studied at the Academy of Corfu, where his professor in the exact sciences was Charles Dupin, captain of the French army. In 1820, he studied at the Ecole Polytechnique. In 1824, he was appointed as professor of mathematics in the Ionian Academy. He translated and published a full collection of mathematical works. Karadinos played a major role in the development of mathematics in Greece, through his books and students. He died insane in 1834.

20. Greek State Archives, General Secretariat, 22 May 1827, f. 196.

Apart from the above statement, according to a source, Karadinos published the *Géométrie descriptive* by Myot (?)[21]. More clues are provided in the hand-written memorandum found in John Leslie's book *On Analytical Geometry*, translated by Karadinos, where it is stated that he lectured form Monge's text "*Géométrie descriptive* and above-mentioned introduction[22]." The fact that this course was taught is proved by the graduation examinations of 1830, where descriptive geometry was one of the examined subjects[23]. The above information is not confirmed in Typaldos's *History of the Ionian Academy*[24].

The Teaching of Descriptive Geometry in the Greek Military Academy

Even before his arrival in Greece, Capodistria had asked from the French government three or four officers to organise the Greek army. Among them was Captain Pauzié, graduate from the École Polytechnique, to whom he assigned the task to set up an artillery school. One of the courses offered in its curriculum was descriptive geometry, as in Monge's manual[25].

In December 1828, the French undertake the organization of the Greek Military Academy (Central War School or Central Military School), with the Ecole Polytechnique as a model. The curriculum was spread in three grades, but later a preparatory class was added, probably due to the student's low educational background. In the first two grades, mathematics was taught form French educational manuals

21. P. Chiotis, *Historical Memoirs of the Ionian Islands*, vol. 7, Karavias, Athens, 1981, p. 36.

22. Phili C. "La reconstruction des mathématiques en Grèce : l'apport de Ioannis Karadinos (1784-1834)" in L'Europe mathématique, Paris, 1996, pp.304-319. Searching the Gennadios Library, the hand-written programme below was found among the pages of Ioannis Karadinos book *Some Theorems on Polygonometry*, Corfu, 1826 [in Greek].

23. Henderson G., *The Ionian Academy*, Centre of Research and International Communication "Ionian Academy," Corfu, 1980, p. 83-84 [in Greek].

24. Georgios Typaldos-Iakovatos, *History of the Ionian Academy*, Ermis, Athens, 1982, p. 63 [in Greek].

25. Kastanis Andreas, *History of the Military Academy During Its First Years, 1828-1834*. PhD dissertation, Ellinika Grammata, Athens, 2000, p. 49-50. [in Greek].

translated into Greek[26]. More specifically, the curriculum comprised the following courses: arithmetic and algebra, according to Bourdon, geometry and trigonometry, according to Legendre. Their level corresponded to the prescribed knowledge of the candidates for the Ecole Polytechnique. The French influence on the organization of the School's curriculum was obvious. Given the impact of descriptive geometry on French education, it was only natural that the former would be part of the curriculum of Central War School. The original text of the charter was in French and stipulated that Monge's *Géometrie descriptive* should be taught in the second grade. The exact content of the curriculum is not known[27]. Some of the material provided to the students were[28]: a case of mathematics tools, drawing board, portfolio, colour dispenser, pens, colour dissolvers, rulers, rectangles, bowls, paintbrushes, two dozens of Conte's drawing paintbrushes, Indian ink, Indian colour slate (yellow and red), fish-glue, Indian rubber, inkpot[29]. For the needs of the same course, the Ecole Polytechnique provided: Indian ink, French paper sheets, ruler, rectangle, rubber, and penholders. The similarity of the drawing material between the two schools shows that the French organizers of the Central War School gave great importance to the course's meticulous organization[30].

In the second year of studies, descriptive geometry, along with other technical courses (building, mathematical engineering, etc.) were conducive to the accession of the Central War School to the status of a higher education institution.

After the School's charter changed in 1834[31], the teaching of descriptive geometry continued as part of the 6th grade's curriculum. According to the charter, courses[32] were divided into eight grades, of

26. Translated by Karadinos.

27. Kastanis Andreas, *op.cit.*, pp.86-88.

28. Due to the difficulty of rendering technical terms into Greek in that period, some translations are not entirely satisfactory.

29. Greek State Archive, Vlachogiannis, Secretariat of Military-Naval Affairs, doc. 54, January 1829, f. 102, Central War School's Charter.

30. Belhoste B. and Taton R., "L'invention d'une langue des figures" in *L'École Normale de l'an III. Leçons de mathématiques*, Dhombres Jean ed., Dunod, 1992, pp. 291-294.

31. *Official Gazette of the Kingdom of Greece*, Decree on the Organization of Central War School, 17/29 August 1834, f.29.

32. The need of the preparatory classes was due to the lack of educational

which the first four were preparatory. It should be noted that the course is mentioned as *Perigraphiki Geometria* (descriptive geometry) and is a translation of the German 'Geometrie Descriptive.'[33] Probably, in Germany of that period, the term *darstellende Geometrie* (descriptive geometry) was not yet accepted. In 1837, for the first time, the term *Parastatiki Geometria* is used in Greece, in a document of the Greek Military Academy to the Ministry of War[34].

In July 1840, a proposal by the head of the School, Spyridon Spyromilios, leads to the institution of written examinations, as he considered that oral examinations were unfair, the professor trying to help the students asking them convenient questions[35].

Descriptive geometry's next evidence in Greece is found in 1842, in the proceedings of the Education Council of the Military Academy. The main issue of the proceedings was the repartition of the curriculum among the seven[36] years of studies. Descriptive geometry is among the courses taught in the 4th year, 16 hour per week. The subject was: *Intercepts and applications of projectivity to the theory of shadows and perspective*[37].

No manuals were given to the cadets. The professor of descriptive geometry taught from Monge's *Géometrie descriptive*. From the same manual, he taught theory of shadows and perspective. Students were taking notes during class[38]. This information allows us to assume that for the teaching of this course, an edition ulterior to the 4th edition was used, since it is after the 4th edition that a special chapter written by

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background. Therefore, the preparatory class of the Capodistrian period had to expand into four classes.

33. The text cites 'Descriptive' and not 'Deskriptive.'

34. Greek State Archives, King Othon's Archives, Examinations of the Greek Military Academy, 18 January 1838, doc. 4, f. 418 'About Courses Taught in the 5th, 6th, 7th Grades.'

35. Stasinopoulos E., *History of the Military Academy*, Athens, 1954, pp. 79-81. [in Greek].

36. In 1836, a decision by King Othon reduces the years of studies in the Greek Military School to seven, the first preparatory class being abolished. According to the relevant decree, the reason is the upgrading of education in Greece. Vyzantios Christos, *Collection of Laws and Decrees. From 1821 to 1853*, Part I, vol. 1, Athens, 1853, pp. 178 and 179. [in Greek]

37. Greek State Archive, Secretariat of Military Affairs, Central War School's Charter, 27 March 1842, f.372. Proceedings of the Central War School's Students Council.

38. Greek State Archive, Central War School's Library, 27 June 1848, MB, f.423.

Brisson on theory of shadows and perspective was added. The course's theory was taught for two hours per week and drawing for one[39]. Examinations in descriptive geometry were both oral and written[40]. The course's coefficient in the first years of studies was 8, the maximum being 10 for mathematics, topography and Greek language[41]. Comparing course coefficients, it appears that descriptive geometry was a quite important course. Yet, on a broader level, military courses had a lower coefficient, a fact that allows us to draw conclusions about the School's character, which was closer to that of a polytechnic school than to a military academy.

For many years, descriptive geometry was taught by the officer of the corps of engineers Stavridis[42]. Artillery officer Sofianos[43]

39. Greek State Archive, Central War School's Charter, 17 March 1853, f.375. Suggestion about the professors and teachers wages.

40. Greek State Archive, Examinations of the Central War School, June 1857. Central War School Examination Programme.

41. Greek State Archive, Examinations of the Central War School, June 1847, f. 374. Detailed Examination Results for the Year 1847.

42. Stavridis was born in Anchialos, in 1803. He studied in a Greek school of his hometown. His uncle, discerning his inclination for studies, sent him to the Medical School in Vienna. He soon abandoned medicine and registered to the Vienna Polytechnic School, not only because of his inclination for mathematics, but also because he thought that this way he would be able to offer more to Greece. He lived in Vienna for nine years (1818-1827) and graduated as *Docteur ingénieur architecte*. He was taught in mathematics, physics, chemistry, geodesy, topography, astronomy, architectural drawing and elements of building. In 1828, he came to Greece and enlisted in the Dragamestos camp. In April, he was appointed aide of colonel Vallianos, whose main task was the erection of the Orphanage building. The decree of 28 July 1828 provided for the constitution of an "officer corps responsible for fortification-building and architecture," to which Stavridis was appointed as lieutenant. Lieutenant colonel Pauzié, head of the Central War School, requested from Capodistrias that Stavridis teach drawing to the School. Capodistrias approved the request and in November 1829, he appointed Stavridis as inspector. In March 1832, Axelos, the deputy director of the Central War School, appointed him as professor of applicative courses. Since Stavridis was appointed when the preparatory class was instituted for the first time, and because of his studies, it is quite possible that the course of practical mathematics included mathematical engineering and descriptive geometry. It is also possible that he taught technical drawing and civil building. In a latter published list (1839) of the School's professors, Stavridis teaches the courses of architecture, descriptive geometry and building survey. In 1834, he taught as well at the newly founded Gymnasium of Nauplion. Stavridis taught at the Central War School for 23 consecutive years. In 1843, he became its deputy director and in 1855, its director. From 1856 until his death, he served as chief of corps of engineers. He

succeeded him, having previously taught mathematics for a long period in the Central War School[44].

In the archives of the Military Academy were found descriptive geometry examinations. The questions pertain mainly to the courses applications. Some students' answers are also quoted.

Find the intersection of the cannon arms with the mid of the canon[45].

Find the figure of the shadow and the perspective of a cross[46].

Determine the figure of the shadow and the perspective of a rectangular pyramid[47].

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died on 28 July 1866. Kastanis Andreas, *op. cit.*, pp. 149-151.

43. Michail Sofianos was born in Constantinople in July 1811, from where he had to flee to escape the persecutions of the Turks during the Greek War of Independence. He went initially to Naxos and later to Zante, where he attended a local school. He enlisted in the "Cadet Company" on 18 August 1828. He showed an early inclination for mathematics. As second lieutenant he remained in the Central War School and served initially as adjutant, while he taught elementary mathematics. Because of his outstanding record, Colonel Axelos, the School's acting director, recommended him for teaching practical and theoretical mathematics; but the new director, Colonel Rheineck, judged Sofianos as unnecessary. Sofianos taught mathematics for the biggest part of his life, mainly in the Central War School, but also to the Naval School. Later, in 1878, he was proposed to teach descriptive geometry on the Polytechnic School of Athens. In the Central War School he taught descriptive geometry, fortification-building and gun emplacement construction. He published the works *Temporary and Permanent Fortification-building* and *Gun Emplacement Construction* [in Greek]. He also published a complete collection of mathematics comprising: *Courses of Analytical Geometry*, Athens, 1857; *Courses on Differential and Integral Calculus*, Athens, 1858; *Courses on Algebra*, Athens, 1859; *Courses on Arithmetic*, Athens, 1864; *Courses on Linear and Spherical Trigonometry*, Athens, 1871. The above-mentioned books, as stated in their foreword, were used as manuals at the Central War School. The *Courses on Differential and Integral Calculus*, in particular, was the first self-existent manual about its subject in Greece. Sofianos wrote as well the *Treatise on Calendar*, Athens, 1857. He had to make up for the lack of mathematical culture in Greece by himself. As lieutenant colonel, he headed the Naval Officers School from June 1866 till July 1867. He retired as major general a few before he died in Athens, on 24 July 1887. Kastanis Andreas, *op. cit.*, pp. 213-215.

44. Stasinopoulos E., *op. cit.*, p.103.

45. Greek State Archives, Central War School Examinations, 1848, f. 424. A cadet's written examination.

46. Greek State Archives, Central War School Examinations, 1848, f. 424. A cadet's written examination.

47. Greek State Archives, Central War School Examinations, 1848, f. 409. A cadet's written examination.

After the departure of Othon and the arrival of George I, in 1864, a new charter for the School is published. According to it, the number of years of studies was curtailed to six for those destined to the technical weapons[48] and to four for those destined to non-technical weapons[49]. The first three classes were named preparatory and were mandatory to all cadets. Upon completing the fourth, the cadets graduated with the rank of warrant officer. For the first time, there were entering examinations[50]. Courses offered rose to thirteen and descriptive geometry, its applications and building were among them. To provide for the new needs, a place for a lecturer was created.

Descriptive geometry was taught in the last two preparatory years. More specifically, it was taught in the second year (problems pertaining to a point, a line and a plane, along with teaching descriptive geometry drawing in the course of drawing) and in the third year (convex surfaces, surface intercepts, enumerated planes). Descriptive geometry drawings were taught in the course of drawing along with topographical replications. In the fourth (educational) year, in the technical weapon direction (artillery and corps of engineers), were taught the applications of descriptive geometry, i.e., figure of the shadow perspective gnomonics, quarrying and woodcutting[51]. The course's new material shows that Monge is abandoned and is replaced by the manuals of Leroy (C.F.A. Leroy, *Traité de géométrie descriptive*, Paris, 1842) or Olivier (Théodore Olivier, *Cours de géométrie descriptive*, Paris, 1844). This is confirmed by the new material, which includes subjects such as gnomonics or enumerated planes that were not found in Monge's book, but are contained in the above-mentioned manuals. After 1880, when the first lithography manuals appeared, there were translations of Leroy or Olivier, or a combination of them.

The above charter remained into force for only two years and on 31 October 1866 a new charter was issued. According to it, the curriculum was spread into five years of study, three years being preparatory and

48. Artillery and corps of engineers.

49. Infantry.

50. Entering examinations were in religious education, catechism, Greek language, arithmetic, algebra and geometry.

51. *Onisandros*, Official Supplement to the Journal, issue 11, 30 December 1864 (contains the *Charter of Military Academy*, National Press, Athens, 1865, pp. 8-22), p. 185.

two educational. During the preparatory years, general courses were taught, whereas the educational years concerned military courses. In descriptive geometry, the subjects of point, line and plane were taught in the first year; the subject of surfaces was taught in the second year; and in the third year, the applications of descriptive geometry to gnomonics perspective and theory of shadow, stone carving and wood cutting were taught. The coefficient was the highest possible, 10. The chair of descriptive geometry remained, but all lecturer positions were abolished[52].

The 1866 charter remained into force for just one year. In July 1867, the Military Academy closed, and the cadets had to stay home, until a new charter was published. Under pressure, the Voulgaris government re-opened the Military School in January 1868 and put the 1864 charter into effect; it remained so until 1870, when a new charter was published[53].

On 23 October 1870, the new charter is published, providing for seven years of studies. Exact sciences and mathematics were taught in the first five years, after which there were graduation examinations so as to confer on the graduates a diploma allowing them to become professors or civil geometers. Those continuing to further two years of studies, were taught military courses, such as architecture, architectural structures, applied engineering, bridge-building, artillery, military science, fortification-building, road construction, etc.

In the new charter, the chair of descriptive geometry is maintained. The teaching of descriptive geometry started in the third year with the principles of the course, continued in the fourth year with the last part of descriptive geometry and its applications to gnomonics and wooden frameworks; it ended in the fifth year of study with the teaching of descriptive geometry's applications (stone carving, theory of shadow, perspective and enumerated planes). The course's coefficient was still the highest possible, 10. Descriptive geometry was one of the graduation examinations of the fifth year[54].

The charter changes once more, on 5 July 1882, the same year the first descriptive geometry lithograph manuals appear.

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52. Vougioukas Agathon, *Military Charter*, vol. 2, Athens, 1866, pp. 177-225.
53. Stasinopoulos, *op. cit.*, p. 111.
54. Vougioukas Agathon, *Military Charter*, vol. 6, Athens, 1867-71, pp. 117-156.

The Teaching of Descriptive Geometry in the University of Athens

In 1837, in the newly founded University of Athens, the professor of mathematics C. Negris[55] is teaching at the Faculty of Philosophy, where mathematics is taught, "Achette's[56] diagram geometry."[57] The term diagram was used first in Francœur's book on linear drawing[58] translated into Greek by Kokkinakis in 1831, under the title *Courses on Diagram or Linear Drawing by J. Francœur*. The term used was seemingly thought of as unproved by the University and thus, it was replaced in the curriculum of the next semesters with that of descriptive geometry. The study material of descriptive geometry at the University of Athens[59] comprised:

Year	Semester	Duration in Weeks	Subject Description	Remarks
1837-38	Winter	Three	Diagram	The three periods include the teaching of algebra
1838	Summer	Three	Principles of Descriptive Geometry	Teaching of descriptive geometry was due after the teaching of geometry
1838-39	Winter	-	-	-
1839	Summer	-	-	-
1840	Summer	Three	From the surface intersections	The three periods include the teaching of algebra, geometry and differential calculus

55. Constantinos Negris was born in Constantinople, in 1804. A student of Neophytos Vamvas in Chios, he took part in the Greek War of Independence. He was sent to France to study at the Ecole Polytechnique and the Sorbonne. He was one of the first professors of mathematics at the newly founded University of Athens. He was dismissed for political reasons in 1843, he was engaged anew and was finally dismissed in 1845. He died in 1880.

56. It refers to Hachette, the editor of Monge's *Géographie descriptive* second edition.

57. Dimaras C., *Athens, 3 May 1837*, University of Athens Press, 1987, p. 15 [in Greek].

58. Francoeur, J., *Enseignement du dessin linéaire*, Paris, 1819.

59. Historical Archive of the University of Athens. The following semesters are missing from the program: winter semester 1839-40, winter semester 1841-42, summer semester 1842, summer semester 1843, winter semester 1843-44, summer semester 1844, summer semester 1846.

Year	Semester	Duration in Weeks	Subject Description	Remarks
1840-41	Winter	One	Continuation of second degree surface intersections	The periods include the teaching of differential calculus, integral calculus and analytical geometry
1841	Summer	-	-	-
1842-43	Winter	-	-	-
1844-45	Winter	-	-	-

In 1845, Prof. Negris is dismissed for political reasons. From the winter semester of 1845 until the summer semester of 1847, no mathematics courses are taught. In that semester, Prof. Georgios Vouris[60], who used to teach physics, starts to teach algebra. In the winter semester of 1850-51, the University hires Ioannis Papadakis[61], a former student at the Ecole Polytechnique. Papadakis taught at the University of Athens from 1850 to 1867[62]. He returned in 1873 and taught until his death, in 1876.

The Teaching of Descriptive Geometry in the Polytechnic School

Unfortunately, the available information is scant and most of it comes from the *History of the National Technical University of Athens*. For the first time, the course of descriptive geometry was programmed in 1845, but it was not taught. It is possible that the teaching of descriptive geometry started at the end of the 1850's, after the appointment of Prof. Papadakis. The course's material is unknown to us, but it should at an elementary level, given the fact the course was taught every Sunday. Papadakis was replaced by Pilotos[62] in 1857, who taught descriptive geometry until 1862, when Papadakis resumed

60. G. Vouris was born in 1790, in Macedonia. He studied mathematics at the University of Vienna. When the University of Athens was founded, he was appointed as professor of mathematics, physics and astronomy. He founded the Athens Observatory and was its first director. We wrote articles for the German journal *Astronomische Nachtrichten* as well as for the newspaper *Athena*. He also published a collection of mathematical works (5 vols.). He died in Vienna, in 1860.

60. I. Papadakis was born in Crete, in 1825. He was extraordinary professor of mathematics and astronomy in 1850, professor emeritus in 1852 and professor in 1854. He also taught at the School of Arts (precursor of the Polytechnic School).

61. In 1867, he went to Crete to join the Cretan insurrection.

62. His biography remains unknown. According to the Officers Register of 1852,

teaching until his death, in 1876. He was succeeded by Dimitrios Tournakis[63], who taught until 1878. Nikolaos Solomos[64] taught for only one semester, in 1878. This year, Andreas Zinopoulos[65] was appointed and taught descriptive geometry until 1882[66].

Conclusion

Descriptive geometry came into being as a basic scientific tool of communication between technical sciences and technicians. Its impact as a new course in French education was considerable. Education in Greece, and especially military education, was set up on the French model. Therefore, it was natural that descriptive geometry carried a special weight. As in France, at least initially, the course of descriptive geometry was an essential part of higher technical education (Ecole Polytechnique, etc.), its inclusion in the curricula of Greek institutions entitled the latter to status of higher education establishments.

Contrary to other countries, the evolution of the course of descriptive geometry in Greece was upward. Originally, its coefficient was 8, out of a highest 10; later this coefficient was upgraded to 10 and descriptive geometry was among the most important courses. In the charters published after 1864, there was provision for a chair of descriptive geometry, while the teaching hours and material increased. Monge's manual is abandoned and is replaced by modern authors like Leroy and Olivier.

A final remark: 1882 is an important year for the teaching of descriptive geometry, as for the first time appear lithography manuals.

1870, etc, as well as to the *Military Encyclopaedia* of 1926, there was no officer under this name.

63. Dimitrios Tournakis was born in Corinth, in 1820. He was an artillery officer (*Military Encyclopaedia*, vol. 6, p. 481). He was elected deputy of Corinth; he retired in 1890 and died in 1902.

64. Nikolaos Solomos was born in Patra, in 1840. An officer of the corps of engineers, he was appointed professor of trigonometry and analysis at the School of Arts.

65. Andreas Zinopoulos studied at the Ecole Centrale des Arts et Métiers in Paris. He came to Greece in 1878 and was appointed civil engineer at the Public Works direction. He died in 1890.

66. Biris Constantinos, *History of the National Technical University of Athens*, Athens, 1957 [in Greek].

GEORGE N. VLAHAKIS

Military Science for the Public Benefit: The Case of the Hellenic Navy Officers During the 19th Century

We have already formed a rather clear picture concerning science in the Greek-speaking intellectual area during the 18th and early 19th century, but this is not the case for the rest of the 19th century, after the establishment of an independent Greek state. Nevertheless, the Syros seminar has offered a good opportunity, in the last three years, for discussing the topics related to the interaction of science and society in the new Greek state during the second half of the 19th century.

This is reflected on the publication of a thematic volume, which includes the presentations of the previous seminars, and gradually forms a firm background for further research in this field.

When comparing the situation of science during the Neohellenic Revival and that of science in the newly independent state, the general impression is that in the latter case, science was more associated with social factors.

A factor that undoubtedly has always played a very significant role in peripheral countries is the Army. The increasing needs of the Army for developing advanced technology and for its manning with officers of the highest standards, have been proved, according to international sources, a critical factor for the evolution of scientific thought.

We could suggest that in the limited territory of the 19th century Greece, where everything took its place through continuous reforms, radical changes and significant reciprocals, one of the few reliable institutions was the military.

One of the most powerful components of this authority, taking into account the geomorphology of Greece and its political situation, was the Hellenic Royal Navy. The officers of the Navy were traditionally considered nobler and better educated than their colleagues of the Army. It is interesting therefore, to see whether this belief was actually true and if the Navy officers were interested in the scientific achievements of their time.

In this endeavour, the main figures will be a handful of officers, such as Gerasimos Zochios, Andreas Miaoulis (1830-1911), D. Sachtouris and Leonidas Palaskas, who played a very important role in the development of naval education until the first decades of the 20th century.

The first three, Zochios, Miaoulis and Sachtouris were co-authors of a pamphlet titled "Memorandum on the Royal Navy," published in Athens, in 1844.

Its introduction outlines their frame of thought concerning the potential of science in a highly competitive world:

> *"Everywhere and every time, the most powerful has conquered the less strong, those born braves have defeated the cowards and the weak, and those who have acquired power through technology and science [have defeated] the peoples who ignored science and technology. Consequently, truly free and autonomous nations are only those which are naturally strong or those which became strong through science."*

The authors of this manifest attested the poor situation of the Hellenic Navy and proposed a number of indispensable actions for its improvement. Among others, they claimed that before the foundation of a Naval Academy, at least six officers should be sent to England or France. Once there, each should study a particular subject of the naval science, which after his return to Greece, he would teach it, as professor, in the Naval Academy.

Fortunately, these thoughts did not remain in the realm of good intentions. Indeed, we find the above-mentioned three musketeers becoming active in a constantly expanding circle of activities, such as book writing, teaching in secondary education, conducting scientific research and participating in politics.

An interesting question is why these officers cherished so much scientific knowledge. In our opinion, a significant reason was their stay in Europe for advanced studies. For example, Sachtouris had travelled in 1838 to England and Zochios studied mathematics in Paris.

Besides this group, it would be unfair not to mention Leonidas Palaskas (1819-1880), a real legend of the early days of the Hellenic Navy. Palaskas was born in Ioannina. In 1827, he attended basic education in Paris and in 1833, he became a cadet in the Naval

Academy of Brest. Before returning to Greece, he had a brilliant career in the French Navy, where he served until 1844 reaching the rank of lieutenant commander. As young sublieutenant, he traveled around the world with a French sailing vessel. When he arrived in Tenerife, he climbed on the top of the famous volcano Pico de Teyde and there he was inspired a mathematical solution for the determination of the curve formed by the optical rays of the observer on the surface of Earth. This work was published by the French Navy and was received favorably by the French scientific community. Returning to Greece in December 1847, after the invitation of his patron, prime minister Kolletis, he wrote an extensive "Memorandum on the Naval Academy" trying to persuade the relevant authorities to organize an advanced naval school following French standards. Among other things, he wrote: "The constitution of a strong Navy is not improvised ... A strong Navy consists neither of big and numerous vessels, nor of the number and the bravery of its sailors ... but of appropriate education for its officers and proper exercises for its crew".

The ideas expressed by Palaskas were considered too progressive by the leaders of the Navy and remained unapplied. As commander Michail Goudas wrote, the editor of Palaskas's *French-Greek Dictionary of Naval Terms* published in 1898, in his "Introduction":

> *"Leonidas Palaskas coming back to Greece from France brought with him high hopes for the development of our Navy ... in his great heart, which contained only the noblest feelings, there was the hope for the establishment of a respectable Navy in the Mediterranean, aiming at carrying on the feats of the National Revolution, asserting our national rights and realizing the unfulfilled national dreams and desires".*

The Naval Academy was finally established in 1884. Yet, the passage of almost a generation between the original idea and its realization, has proved that in Greece, there is always a lag, which can be quite long sometimes, between the expression of a useful original idea and its realization, due to several social and political reasons.

Palaskas's persistence in his beliefs had driven him to self-exile in Bavaria from 1862 to 1866, where he remained near the deposed King Otto. Returning in Greece in 1866, Palaskas was appointed General Secretary of the Ministry of Naval Affairs and in 1877, for a short time, Minister of Naval Affairs. His long-lasting activity was not without any disappointments and bitterness. With words still touching our hearts, he wrote in 1875:

> *"When I came for the first time in Greece, how many hopes did I have! What a promising future! The Nation was still young, people were more patriotic and less educated ... [Now] I think that our Nation is already as old as myself".*

This disappointment prompted him to burn his manuscripts just before his death, and thus many valuable manuscripts were lost forever.

Among his scientific writings, we would like to mention in particular a significant essay on the history of science, written by Palaskas in French and published in 1856. In this book, he proved that the famous monument by Andronikos of Kyrrhos in Athens, was not a temple, as many believed at that time, but a clock.

In 1866, he participated in a scientific mission to Santorini in order to study the eruption of the island's volcano. Julius Schmidt, the first and most prominent director of the Athens National Observatory, evaluated Palaskas's contribution as following:

> *"Most observations, and the best ones, related to topography, height, depth and angles, are owed to Palaskas's tireless activity."*

As an acknowledgement of his scientific contributions, he was elected Vice-President of the Organizing Committee of the Vienna International Fair in 1873. Two years later, in 1875, Palaskas presented in the Geographical Congress of Paris a contribution titled "Recherches sur les chronomètres et les instruments nautiques. Sur les hauteurs méridiennes observées à la mer, par L. Palasca, Capitaine de vaisseau de la Marine royale hellénique".

Among the officers we have already mentioned, Gerasimos Zochios can be considered an exceptional case, as he was not only a high rank officer in the Navy, but also a well known teacher of mathematics in high schools.

In a pamphlet published in 1855, titled *An address on Time and a description of the activities of the Hellenic School* he wrote:

> *"Following the infallible history, which is the teacher of savant peoples, in which nothing else is found except for rise and fall of nations and*

peoples, we see that the nations that have multiplied the aptitude of time have reached to highest point of power, knowledge and glory, their fame travelled through subsequent generations and centuries. The others, the lazy ones, were buried alive".

Zochios taught in the Rizarios and the Hellenic Schools. In the latter, the headmaster was the French Charles Pottine, who had organized it upon the French school model. Zochios taught mathematical and physical geography, algebra, geometry and stereometry, as well as experimental physics according to Poulliès's book.

In the course of algebra, Zochios used a textbook written by himself and published in 1854 under the title "Elements of Algebra," where some problems proposed by Soutsos and Ragavis, two eminent Greek scholars, were added.

As for geometry, Zochios's course was based on a book written by the famous mathematician Legendre, which Zochios translated and published in 1862, pointing quite brilliantly at the scientific value of the original:

"Why have we translated Legendre's Elements of Geometry, and not any other book? To those asking such a question the answer is futile, because ignorance is the worst of things".

Ignorance was certainly an unknown word for Miaoulis, who may be considered to be the founder of modern oceanography in Greece. One of his first works was the *Textbook on Naval Knowledge*, published in 1874. An interesting point in this book is the extensive list of the subscribers, which, following an 18th century tradition, is included at the end of the book.

There, one may find not only the names of almost all the Navy officers of the time but also, and this is impressive, a list of 35 learned ladies, something that proves that Miaoulis's activities were, at least to a degree, carried in the higher social strata.

His masterpiece on oceanography was a book titled *On the tides of Euripus*, Athens, 1882. Miaoulis acquired a good deal of knowledge, especially on the methodology of hydrodynamic measurements, from the well-known Rear Admiral and hydrographer of the British Royal Navy Arthur Mansel. Miaoulis had the chance to cooperate with him during the admiral's stay in Greece, having the task to perform a series of observations near Euboea, and to examine the famous Euripus problem. The Euripus problem is a classical one in the history of physical oceanography. It consists of the alternation of the currents' direction in the narrows of Chalkis. The cooperation of Miaoulis and Mansel took place during the years 1871 and 1872, when they made simultaneous measurements in both harbors in Chalkis. As Miaoulis informs us in his book, Mansel had used regular observations of sea level and current speed and direction since 1866. Miaoulis's work on the Euripus problem is cordially dedicated to Mansel, not only because he was the first to use scientific methods in order to resolve it, but also because it gave reliable results, becoming thus the standard reference to this subject for many decades. Even Defant, in his classical *Physical Oceanography* refers, among others, to Miaoulis's conclusions in order to support his own views. Well known European oceanographers like Endros, Sterneck, and Defant who used Miaoulis's results in their works, became aware of him through the English translation of *On the Tides of Euripus* by N. Contopoulos, published in Athens, in 1884. Since such translations were not a standard practice during the late 19th century, we might argue that this was an outcome of the great significance of Miaoulis's work for European oceanographers, who had probably been informed about it either by Mansel personally or the British naval authorities in general.

For the measurements of current speed and direction, Miaoulis did not content himself only with practical observations, but he also used a scientific instrument, the so-called Mussey's currentmeter. He also had read the relevant literature, which seems to represent the basic oceanographic knowledge of the time. For example, he compared his results with a theory proposed by A. Forel, the Swiss limnologist (1841-1921), a translation of which published in the newspaper *Ora* (The Hour) on 7 February 1880.

Miaoulis disagreed with the mathematical formula proposed by Forel and claimed that "if the erudite physiologist Mr. Forel studies the tides of Euripus using my tables, he will be forced to reconsidered his formula".

Miaoulis, rather unexpectedly, gives also a rough description of the sea water circulation in the area of the strait of Gibraltar and supports the idea that the same pattern of circulation exists in the Bosporus. The proposal about the main current driving the circulation in the northern Aegean is still under consideration by modern oceanographers and has been proved correct in principle.

It is also interesting to note that Miaoulis took meteorological observations because he correctly believed that the winds alter the direction of the currents. Although he did not define how this alteration takes place, this does not diminish his significant contribution to the establishment of systematic oceanographic studies in Greece.

Besides the book *On the Tides of Euripus*, which is the most widely known, Miaoulis wrote another book concerning predictions of the tides in the Corinth canal, which were supposed to appear after the opening of the canal was completed. Although I could not find any information about the authority that entrusted Miaoulis with such oceanographic studies, there are reasons to believe that he was a pioneer in physical oceanography, working on a voluntary basis and not as researcher participating on a national project about the study of the Greek seas. Anyway, we must keep in mind that a general planning policy for the development of science was completely absent at that time in Greece.

Miaoulis writes, giving the impression of a slight disappointment:

> *"Six years have been passed since the publication of my book on the tides of Euripus; during all this period, I did not hesitate to examine and study the rise and fall of the sea heights, the current speed and direction near the shores of Greece, whenever my Service allowed it to me"* .

Conclusions

We have started to uncover the scientific activity of the Hellenic Navy officers during the second half of the 19th century. We have begun to shape a picture, still blurred though, for the "noble" character of science in the small aristocratic military circles of that period. Besides the recording of relevant activities, the investigation of the reasons that caused them is an interesting subject to deal with.

Are they just personal researches, had they chosen to follow lonely paths, which today become easily recognizable exactly because they took place in a barren, if not hostile, cultural environment?

Or do these efforts consist in a cohesive force, which, having well-defined ideological and philosophical criteria, aims at making of the Hellenic Navy not only a well-trained navy, compared to that of the nation's rivals, but also a weighty factor in the internal affairs of Greece?

The latter supposition seems more probable, if we take into account the common course of the above-mentioned officers, in their education, their career and their eventual achievements.

These officers were inspired to the utmost by the picture they have formed about the French and English Navy while staying abroad. It is a picture in which an omnipotent military authority is connected with that one of a powerful country, a picture in which the terms 'nationalism' and 'militarism' become equivalent.

Compared to similar situations in Europe, Hellenic Navy officers did not ask for a higher funding, since they recognized that this would be very difficult, due to the unstable financial and political situation of the Greek state.

On the other hand, they asked that the naval budget be based on a long-term action plan. Nevertheless, they considered that in order to achieve their aims, officers should be experts and, therefore, had to be scientists.

These opinions seemed to have faced the opposition of those officers who were not equal to the task or who were just unwilling to try harder for their personal education and the development of the Navy.

Let us characterize the latter as drones, for being miserable and insecure, they formed a caste that opposed bitterly the pioneers of the scientific development of the Navy. We have to study more extensively those pioneers, as we believe that there is a very interesting material for further research. A research that would better clarify these first suggestions. But we must keep in mind that such a detailed research requires time, and time, according to Zochios, one the heroes of our story, is a "Divine Present".

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