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PREFACE

The year 2020, verging to a close, is one of the most difficult and hardest years in the life of mankind over the last century. Unfortunately, it is in the 20th year of each century for the last several hundred years that human civilization has been suffering from another global pandemic (to say nothing of local and regional pandemics)… Several pandemics of plague killed at least 300 million people, and the highest incidence in Europe occurred in 1720–1722. In 1817–1824, the First Cholera Pandemic spread across the world. One hundred years later, in 1918–1920, fifty million lives worldwide were claimed by the Spanish flu (H1N1). For a year now, starting in December 2019 and throughout 2020, the entire world is fighting the 21st century pandemic – the global COVID-19 outbreak caused by the SARS-CoV-2 coronavirus. Despite all the difficulties that humanity faces today, life goes on, and the world scientific community is persistently looking for ways to get out of the latest pandemic trap. The world has learned the lessons of pandemics and learned to use the acquired knowledge and scientific legacy of past generations. This led to a quick response to the challenges that life presents us. In December 2020, at this writing, several pharmaceutical companies have already announced the invention of vaccines and the final stages of their trials. We hope that our esteemed authors and readership will witness yet another victory of science over the world's evil.

10 years ago to the day, creation of the History of Science and Technology journal began. Therefore, we would like to summarize some of the work undertaken over the years.

The first issue of History of Science and Technology was published in 2011. The founder of the journal was the State Economy and Technology University of Transport. State Economy and Technology University of Transport was one of the three universities in Ukraine that mainly trained specialists for the railway industry. It is the teachers, students and staff of the State Economy and Technology University of Transport who became the primary authors of the first journal issues. Therefore, in the first years after the journal was created, its focus on the study of the history of the development of railway transport and related areas was apparent. Back then the journal was titled History of Science and Technology: Collection of scientific papers of the State Economic and Technological University of Transport.

Printed versions of the journal were regularly distributed in libraries of higher

educational institutions and research institutions of Ukraine. The electronic version of the full-text issue of the journal (without division into separate articles) was posted on the University library website.

Gradually, the journal began to gain popularity, and as far back as in 2013–2015 it received a large audience of readers and authors across regions and organizations from all over Ukraine. Accordingly, the themes of the articles changed, being no longer limited to rail transport, but extended to the study of the history of all branches of science and various technologies instead.

In 2016, the journal History of Science and Technology replaced its founder. It was the State University of Infrastructure and Technologies which was established through the decree of Ukrainian government dated February 29, 2016 by way of merger of two metropolitan higher educational institutions – Kyiv State Maritime Academy named after hetman Petro Konashevych-Sahaidachnyi and State Economy and Technology University of Transport. Accordingly, the name of the journal has changed into History of Science and Technology: Collection of scientific papers of State University of Infrastructure and Technologies.

The next stage in the life of the journal was the creation of its separate website in March 2018. Since then, work has begun on a deeper reform of the journal, which continues to this day. History of Science and Technology journal is constantly changing. Thus, steps have been taken to improve the design of the journal and bring it into line with internationally recognized standards. The composition of the journal's editorial board has undergone significant personnel changes. In April 2019, it underwent state re-registration of the print media and acquired its current name – History of Science and Technology journal.

However, fundamental steps have been taken towards filling the journal with original and high-qualty scientific content that would be of interest not only to the Ukrainian reader but also to foreign reader. Strict analysis in the selection of articles, strict plagiarism policy, independent double-blind peer review, as well as numerous other steps and innovations, have affected the number of published articles. If in 2019 approximately 25% of submitted articles were rejected, in 2020 this figure reaches almost 60%.

Although hopefully, a change in quality of articles for the better followed the change in their number. They have really become interesting to the international world community, as evidenced by statistics on daily visits to the journal's website by representatives from around the world. The journal generated interest among authors from different countries and continents. In the first issue of History of Science and Technology for the year 2020, articles by authors representing universities and research

organizations from Ghana, Canada, USA, Spain, Russia and Ukraine were published.

Thus, in the second issue of 2020, History of Science and Technology journal introduces its readers to articles by authors from around the world, namely Azerbaijan, India, Indonesia, Italy, Spain and Ukraine.

While summing up our 10 years' work, we would like not to be limited to bare figures. Thus, History of Science and Technology has published 10 volumes and 17 issues over the years, which include more than 400 articles by various authors. And of course, each of these published articles has undergone a great deal of work by authors, editors, reviewers, proof-readers, print workers, etc. All these people primarily have always been trying to make History of Science and Technology journal interesting for you, our Readers!

Our team will keep working enthusiastically and persistently on it!

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A petrochemical study of Mughal plasters of Quila-I-Ark, Aurangabad with respect to technology and repair

Abstract. *This paper reports the mineralogical composition of western India's 16-17th century Mughal plasters of Quila-I-Ark, Aurangabad to prepare compatible repair mortar and document ancient Indian lime technology. Analytical studies were undertaken for aggregate grain size distribution, thin section analysis, Fourier Transform Infrared Spectrometer (FTIR), X-ray diffraction (XRD), and chemical composition of the plasters by x-ray fluorescence (XRF analysis). The analysis revealed the inclusion of large size basaltic aggregate grains mostly sourced from the water channel of nearby Harsullake. Some of the plaster works show prominent inclusion of small size grains pointing different periods of construction. Creamy white zeolites were found specifically added in the mortar mix to maintain a certain level of humidity during the dry season. The zeolite is highly porous and breaks easily both in dry and wet conditions. The calcite rich limestone with traces of magnesium was sourced as raw material for the plasters. Based on mineralogical composition and binder/aggregate ratio, three phases of historical constructions were documented. FTIR and thin section analysis showed the mixing of some proteinaceous adhesive juice in the lime for improvement in rheological and waterproof properties. The high quantity of large size aggregate grains ensured better carbonation of lime and the source of aggregates remained the same for all phases of historical constructions. The cementation index (C.I.) and hydraulicity index (H.I.) vary between 0.10 to 0.96 and 0.20 to 3.43, respectively showing the plaster is aerial lime with traces of magnesium.*

The plaster is feebly hydraulic as the hydraulic component calculated varies between 0.88 to 6.10 percent in different samples. A moderate strength plaster with a lime/silica ratio close to 0.33 was prepared for most phases of construction except a few isolated locations. The analytical data will now help to prepare compatible mortar with identical additives for a major repair.

Keywords: *ancient mortar; aggregates; non-hydraulic; mineralogy; organic additives; provenance*

Introduction.

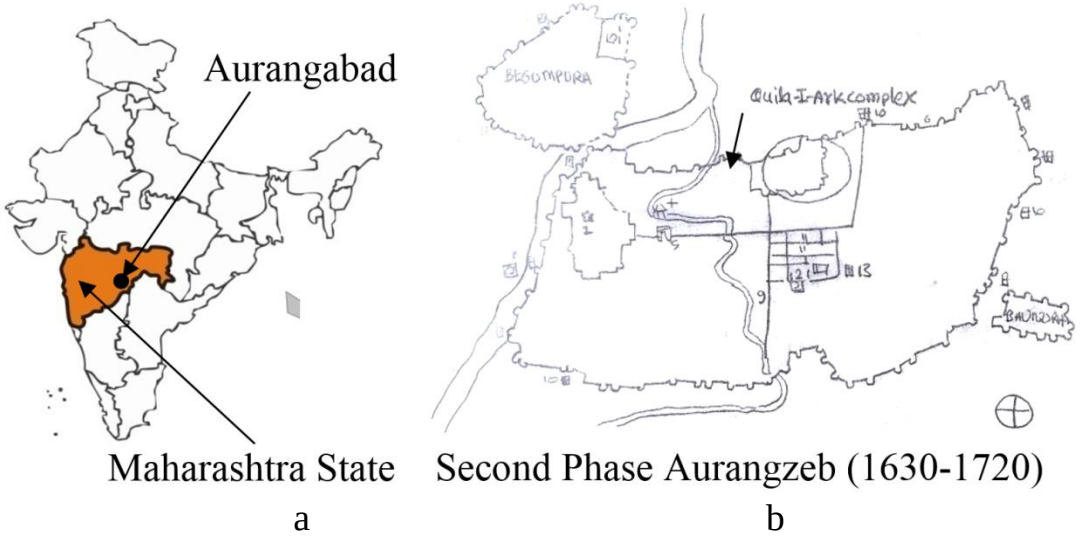
For architectural conservation of ancient lime works, a thorough knowledge of all the physicochemical properties of ancient lime is desired to prepare compatible repair mortar matching in composition & microstructural characteristics. The conservators of historic mortars try to gather information about mortar composition, possible causes of damage, and different phases of building constructions based on mortar characterization (Papayianni, 2009; Jedrzejewska, 1960; Cliver, 1974). The other important areas of investigations for the preparation of compatible repair mortars are the hydraulicity of the binder, the aggregate/binder ratio, the grading of aggregate grains, and their nature (Leslie & Gibbons, 1999). From the analytical reports on ancient mortars, the archaeologists particularly look towards the chronology and spatial distribution of raw materials and the final product to gather adequate information about the socio-economic conditions of the dynasty, the provenance of the raw materials and the process of burning and mixing of mortar ingredients (Leslie & Hughes, 2002; Viaene et al., 1997). Due to topography and uneven wall surfaces, very often the plaster is applied in thickness. This helps in the slow removal of water from the pores of stone/brick walls to save the inner building materials. Very often in historical periods, the plasters have been applied in several layers with a distinctive difference in the materials for each layer having different thermal and hygric expansion coefficients. The high percentage of open pores in mortar layers and high hygroscopicitycontribute to the removal of water from the underlying building materials. The porosity and pore structures in ancient plasters are related to grain size distribution and the binder/aggregate arrangements within the plaster. The size and distribution ofpores are also linked to the carbonation rate, dimensions of the calcite crystals, and those of aggregates. Lime mortar with large size aggregates shows better carbonation due to the easy accessibility of atmospheric carbon dioxide (Singh, Sanjeev, & Singh, 2020). In general, the porosity of ancient plasters and mortars varies between 20% to 45% in most cases. However, the high heterogeneity in composition and high porosity may also affect the durability of the plasters by making them easily attackable by external damaging agents. This further contributes to the deterioration of underlying building materials by stimulating access to damaging agents. The environmental deterioration of lime mortar is mainly caused by the chemical dissolution of micro-crystalline binding calcite when the pore dimensions are adequate. The calcium carbonate with its equilibrium pH of 9.93 is far from neutral. When in contact with water having dissolved

CO_2, the solubility of calcite will increase until reaching an equilibrium. Anydissolution of binder lime will further cause enhancement of porosity and permeability and a decrease in mechanical strength. The leaching of calcium salts from the plaster surfaces will also disturb the aesthetic look of the historical constructions. The burning of limestone and slaking conditionsin general play an important role in the reactiveness of lime and long-lasting slaking in the pits enhance durability (Davey, 1961; Boynton, 1966). From the analysis of many ancient Indian plasters & mortars of different archaeologist periods (Singh, Kumar, & Sabale, 2018; Singh, Waghmare, & Vinodh Kumar, 2014; Singh & Sharma, 1995; Singh, Ganorkar, Rama Rao, & Role of chemistry in archaeology, 1992), it appears that the technicians were well aware of the grading of aggregates (Malinowski, 1981; Baronio, Binda, & Lombardini, 1997; Malinowski, & Garfinkel, 1991), the proportion of lime to sand and selection of aggregates of suitable size and quantity as filler for plasterworks. To further improve the rheological, mechanical and waterproofing characteristics of the plasters, organic additives, vegetal fibers, animal hairs, etc. were also added as reinforcement in Indian plasters. The nature and type of inorganic aggregates found in Indian plasterworks are very diverse because they were selectively sourced from different geological formations including several types of sand resources and crushed rock formations etc. Any study on the mineralogy of the aggregates will reflect their geological origin and give valuable information about their provenance. The aggregates may or may not react with the binding calcite thus modifying the setting, aging, and hardening properties of the mortar. The historic mortars may be hydraulic or aerial binding lime depending on the amount, size, and characteristics of aggregate grains used as fillers. A great improvement in the mechanical property of the mortars was noticed on the addition of pozzolanic admixture in mortar mix (Singh, Sanjeev, & Singh, 2020) that may also considerably reduce the porosity of the plasters.

Until 1970–1980, wet chemical analysis was mostly used in the characterization of ancient mortars (Jedrzejewska, 1960; Cliver, 1974; Papayianni, Pachta, & Stefanidou, 2013). With the advancement of many investigative techniques, the mortar is now characterized by chemical and microscopical techniques that have refined our present understanding about its composition, original material, and possible provenance (Cuezva et al., 2016; Miriello et al., 2013; Schiavon & Mazzocchin, 2009). In the present work an attempt has been made to characterize the 16^{th}–17^{th}century lime plasters of the Mughal monument of Quila-I-Ark of Aurangabad, Maharashtra using petrological, chemical and instrumentation techniques of FTIR, XRF, XRD. The main purpose of this investigation is to prepare compatible plasters with identical aggregates and additives for major repair of the fort plaster.

Quila-I-Ark.

Aurangabad, the cultural capital of western India Maharashtra state is located in the Sahyadri hill range of the Deccan plateau (Fig. 1a). The world-famous rock-cut caves of Ajanta-Ellora is situated close to Aurangabad.



a b

Figure 1. Aurangabad, the cultural capital of western India Maharashtra: a – location of Aurangabad; b – fortification wall around Quila-I-Ark.

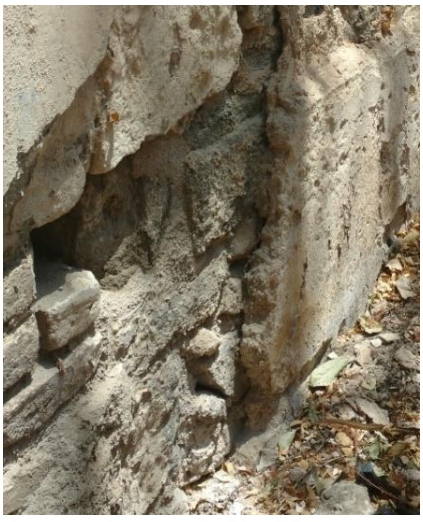
On appointment as viceroy of the Dakhan in 1653 for the second time, the Mughal king Aurangzeb made Fatehpur his capital and called it Aurangabad (Jayavanta, Patel, & Kamathe, 2015). On arrival ofShivajiMahraj in 1666 and Maratha warriors in 1682, a fortification wall around the city was constructed to protect from the sudden attack of Marathas (Fig. 1b). The Aurangzeb himself arrived in 1692 and ordered the construction of a magnificent palace to the north of the city near the great water reservoir, the ruins are now seen in the Quila-I-Ark. Shortly after the death of Aurangzeb, the Nizam-ul-Mulk arrived at Aurangabad in 1720 to establish his dynasty in Dakhanbut in around 1724 he transferred his capital from Aurangabad to Hyderabad (Beed district, 1969). During the political reign of Aurangzeb (1618–1707) various monuments and fortified Quila-I-Ark were constructed with three-layered moat walls for the city. The Quila-I-Ark was the court of Aurangzeb with several princes and noblemen in attendance and comprises of several structures like Diwan-e-Khas, MardanaMahal, Shahi Masjid, fortification walls, and five gates. The unplanned and hazardous developments around the fort complex and encroachment have now ruined the whole distinctive characters of the area. Many ancients structures have fallen or ruined due to the growth of trees and shrubs (Fig. 2). The ancient plasters are falling and building fabric is slowly collapsing for want of restoration.

Materials & Methods.

On visual inspection and observations under a magnifying lens, it is seen that lime plaster is applied in two layers. The inner thick rough plaster layer and outer smooth layer (Fig. 3).

a

b

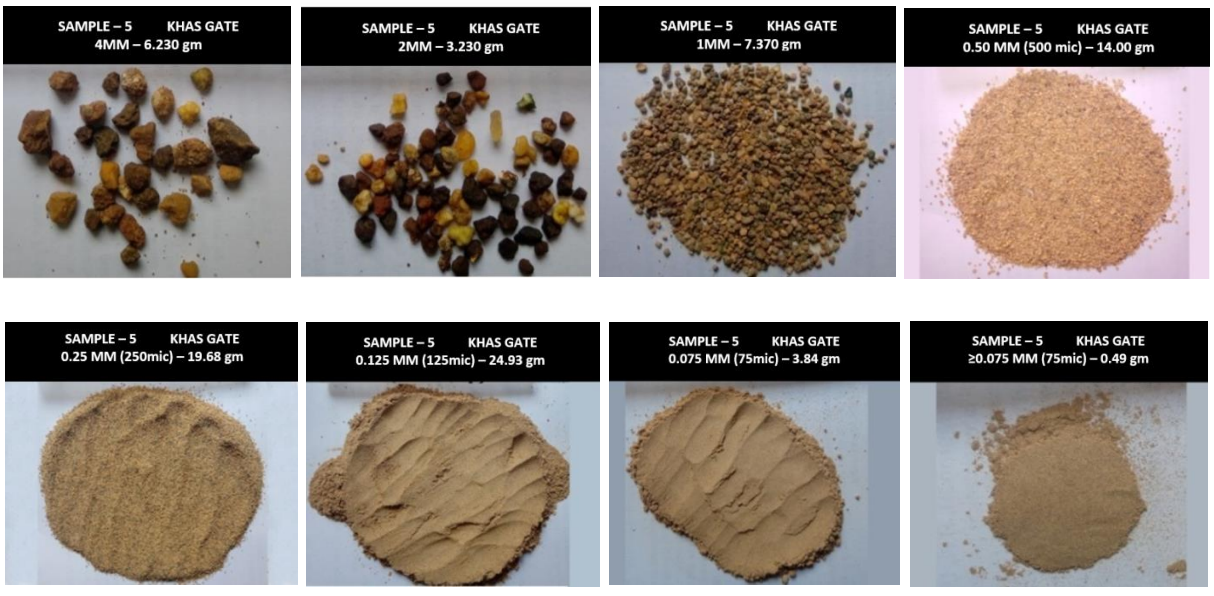


c

Figure 2. Quila-I-Ark: a – general view of Quila-I-Ark; b – growth of trees and shrubs on the monument; c – view showing layers of damaged plasters.


SAMPLE - 2 JANANA MAHAL
4 MM - 5.460 gm
SAMPLE - 2 JANANA MAHAL
2 MM - 5. 240 gm
SAMPLE - 2 JANANA MAHAL
1 MM - 8. 680 gm
SAMPLE - 2 JANANA MAHAL
0.50 MM (500 mic) - 17. 660 gm
SAMPLE - 2 JANANA MAHAL
0.250 MM (250 mic) - 16. 440 gm
SAMPLE - 2 JANANA MAHAL
0.125 MM (125 mic) - 12. 380 gm
SAMPLE - 2 JANANA MAHAL
0.075 MM (75 mic) - 4. 50 gm
SAMPLE - 2 JANANA MAHAL
⩾0.075 MM (75 mic) - 0. 310 gm

a


SAMPLE – 5 KHAS GATE
4MM – 6.230 gm
SAMPLE – 5 KHAS GATE
2MM – 3.230 gm
SAMPLE – 5 KHAS GATE
1MM – 7.370 gm
SAMPLE – 5 KHAS GATE
0.50 MM (500 mic) – 14.00 gm
SAMPLE – 5 KHAS GATE
0.25 MM (250mic) – 19.68 gm
SAMPLE – 5 KHAS GATE
0.125 MM (125mic) – 24.93 gm
SAMPLE – 5 KHAS GATE
0.075 MM (75mic) – 3.84 gm
SAMPLE – 5 KHAS GATE
≥0.075 MM (75mic) – 0.49 gm

b

c

d

Figure 3. Acid insoluble aggregates in the plaster samples: a – No. 2; b – No. 5; c – No. 6; d – No. 7.

The samples for analysis were collected from different locations of the monument as shown in table 1. These plaster samples represent different phases of the historic construction of the monument. The samples were collected from the edges of damaged plasters with the help of small chisel by rejecting any external contamination. The samples were immediately packed in a sterilized container for further laboratory investigations.

As no inclusion of calcareous grains as filler was noticed in the plaster, the aggregate analysis was performed by dissolving the known weight of the plaster in 25% dilute hydrochloric acid. The plaster sample was first gently broken using mortar and pestle taking due precaution not to break any aggregate grains. The sample was subsequently dissolved in 25% dilute hydrochloric acid and left overnight and filtered using a vacuum. The wet residue was again dissolved in hydrogen peroxide solution overnight followed by slow evaporation on a hotplate. The aggregate was washed with distilled water, centrifuged, dried at 105^0C, and subsequently weighed that gave actual sand content of the plaster. The insoluble residue was subsequently mechanically sieved with ISO565 series sieve. The sieved aggregates were used to estimate grain size distribution and grain shape analysis for the plaster.

Table 1. Showing the location of collected lime plaster samples.

Sample No.	The lime plasters samples for analysis were collected from the following points of Quila-I-Arch
1	Outer wall Shahi Masjid
2	Arched room at the wall near Jananamahal
3	Wall near Moti Masjid
4	Zebunnissa palace wall
5	Khas gate, Quila-I-Ark
6	Wall of Mardana Masjid
7	Wall of Moti Masjid

Due to the complexity and heterogeneity of historic mortars, the thin section is the first step for the mineralogical characterization of the plaster. The study of the polished section under the reflected light microscope is very useful in identifying many minerals & hydraulic phases. The preparation of fault free thin section of uniform thickness requires great precision. For thin section preparation, the sample was first dried at 80^0C to remove any entrapped moisture and to avoid the formation of microcracks during sample preparation. The sample was impregnated in low viscous resin under vacuum and a thin section was prepared for grinding & polishing to get a uniform thickness of 30mμ (Table 2). The thin section was observed under Carl Zeiss Jenpol polarising microscope. The thin section images were used for the petrological–mineralogical characterization of the mortar constituents as well as microscopic observation of different mineral phases in the matrix.

Table 2. Grain size analysis of lime plaster Quila-I-Ark (wt%)

Size	Sample 2	Sample 5	Sample 6	Sample 7
4 mm	22.26	22.88	6.230	5.46
2 mm	8.54	4.61	3.23	5.24
1 mm	7.36	4.38	7.37	8.68
500 μm	5.31	5.14	14.00	17.66
250 μm	3.41	8.04	19.68	16.44
125 μm	9.908	19.36	24.93	12.38
75 μm	6.320	8.25	3.84	4.50
≤75 μm	1.240	1.04	0.49	0.310

All the lime plaster samples were analyzed under Micro XRF (Artax 200 Bruker, Germany) at National Research Laboratory for Conservation of cultural property (NRLC), Lucknow. The instrument was operated at 50kV, 700mA current, and data collection time was 300 live seconds. At least four measurements were taken and the data averaged. The results are reported in table 3 in the form of major oxides. The hydraulicity index (H.I.) and cementation index (C.I.) of soluble silica of the plasters were determined as per equation suggested by Elsen et.al. (Elsen, Van Balen, & Mertens, 2012) and Boynton (Boynton, 1966), respectively. As reporting chemical analysis data in standard oxide form does not reflect the true nature of any plaster, it is essential to estimate the mineralogical composition of the plaster based on its chemical composition. In the present work mineralogical composition of plaster has also been evaluated from its chemical composition and data listed in table 4–6.

Table 3. Chemical composition of lime plasters Quila-I-Ark – Aurangabad (wt%)

Sample No	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5	TiO_2	MnO	LOI	Total
1	41.59	6.08	3.96	24.22	2.78	0.23	0.19	0.09	0.69	0.06	19.34	99.23
2	45.41	7.77	6.62	18.24	3.01	1.45	1.04	0.99	0.42	0.13	15.33	100.41
3	08.03	2.38	1.81	45.86	1.88	1.05	0.84	0.04	0.28	0.04	37.75	99.96
4	07.09	1.56	1.32	48.20	1.38	0.03	0.79	0.03	0.56	0.04	38.82	99.82
5	59.54	3.71	1.03	17.21	1.66	0.30	0.45	0.08	0.12	0.03	17.21	101.34
6	60.15	4.91	0.52	18.43	0.71	1.18	1.24	0.12	0.07	0.02	13.57	100.92
7	56.91	4.63	0.53	18.83	1.72	0.12	1.05	0.06	0.07	0.02	15.78	99.72

The lime plaster samples were analyzed under fouriertransform infrared spectrometer (FTIR) (Model agilent 600) at the Archaeological Survey of India (ASI) laboratory at Aurangabad. The KBr pellet technique was used in the FTIR recording of spectra in the spectral range of 400–4000 cm^{-1}. The resolution of the instrument was 4 cm^{-1} and the number of scans was 32 within the standard wave number. The precision of the instrument was ±5 cm^{-1}.

The mineralogical composition was obtained by analyzing the plaster samples by X-ray diffractogram (Model PAN analytical X per PRO). The single-crystal X-ray diffractogram was operated at 40 keV, 40mA current using Ni fitter with an optimized diffraction angle at 50–90^0 (2θ). The XRD analysis was performed at the advance instrumentation center, IIT, New Delhi.

Table 4. Aggregate and a soluble component of the plaster (in percentage)

Sample No.	Acid soluble component	Insoluble HCl	Total	Cementation Index (C.I.)	Hydraulicity Index (H.I.)
1	46.60	52.63	99.23	0.69	1.91
2	39.40	60.89	100.29	0.96	2.81
3	86.89	13.50	100.39	0.11	0.26
4	85.90	12.25	98.15	0.10	0.20
5	33.56	64.86	98.42	0.45	3.41
6	32.45	67.23	99.68	0.61	3.43
7	36.85	63.15	100.00	0.41	3.02

Table 5. Hydraulic and other components of the plaster (in percentage)

Sample No.	MgCO3	Hydraulic	$CaCO_3$	Quartz	Non-hydraulic	Total
1	5.83	6.10	35.91	23.45	29.18	100.47
2	6.35	5.94	27.27	23.99	36.90	100.45
3	3.94	0.88	81.09	2.68	11.82	100.41
4	2.90	1.46	83.76	0.47	11.78	100.37
5	3.48	2.82	28.28	51.40	13.16	99.14
6	1.49	4.32	29.06	47.78	18.45	101.10
7	3.60	2.30	31.57	48.37	14.78	100.62

Table 6.% mineralogical composition of the plaster

No.	R_2O_3	N-H R_2O_3	SiO_2 Ins_{HCl}	$CaCO_{3+}$ $MgCO_3$	CaO/ SiO_2	MgO/ CaO	CaO_{Silic}	CO_3^{2-}
1	51.63	0.56	0.79	41.74	0.58	0.11	3.55	25.71
2	59.8	0.62	0.75	33.62	0.40	0.16	2.97	13.09
3	12.22	0.97	0.59	85.03	5.71	0.04	0.44	28.82
4	9.97	1.18	0.58	86.66	6.79	0.03	0.73	29.90
5	64.28	0.20	0.92	31.76	0.29	0.10	1.41	11.51
6	65.58	0.28	0.89	30.55	0.31	0.04	2.16	11.56
7	62.07	0.24	0.90	35.17	0.33	0.09	1.15	12.53

Results and Discussion.

1. Aggregate Analysis.

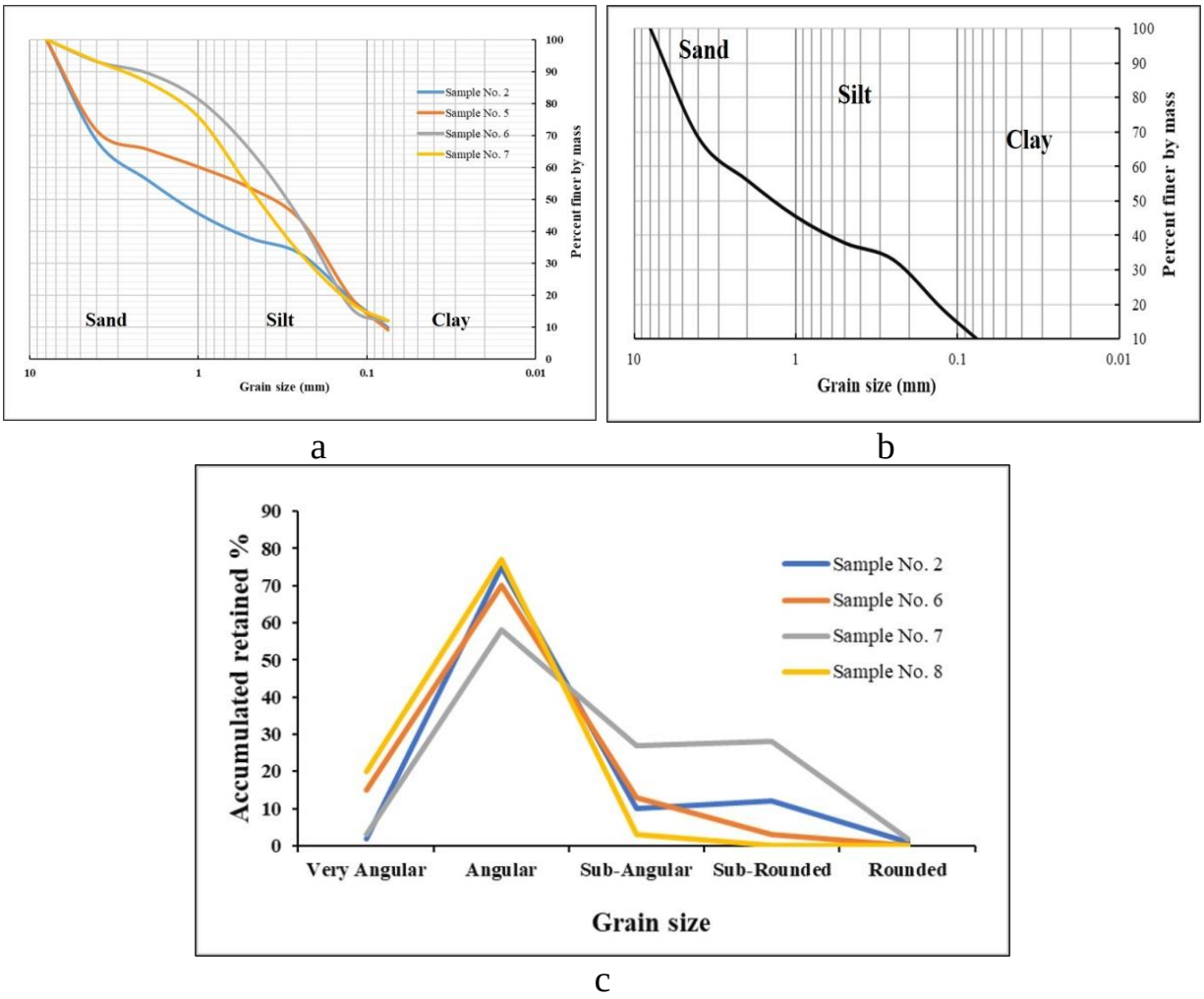
The acid-insoluble part of the plaster was mechanically sieved to examine the size of the aggregate grains.The plaster samples 2, 5, 6, and 7 were subjected to aggregate analysis, and insoluble fractions separated through sieve analysis are shown in figure 3. All the samples showed coarse to medium grained inclusion of aggregate grains as filler. The coarse grain aggregates vary in size from 4 mm to 1 mm and mostly derived from weathering of basaltic rocks of local origin. From figure 3 it is observed that all the fort plasters were preferably mixed with greyish brown, light brown to creamy white colored unsorted aggregate grains of local origin. The creamy white aggregates soak water and changes to reddish-brown color. The creamy white aggregate also crushes very easily both in dry & wet conditions and shows porous nature. Aurangabad and its surrounding are the dry regions of Maharashtra having acute drinking water deficiency. The climate is mostly dry with day temperature reaching up to 38–40^{0}C in the summer season. The hot climatic condition may desiccate the lime works of the region and cause loss to the plasters. It appears that the technicians deliberately added the hygroscopic creamy white porous aggregates to retain moisture for the long survival of plasterworks. The increased moisture in the plaster has also facilitated a better carbonation reaction. The creamy white aggregates have been identified as zeolites of local origin (Singh & Arbad, 2015). All the aggregate grains mixed in the plaster are the decay product of amygdaloidal basalt of light brown to reddish-brown color. The other finer fragments of aggregate grains are in the size range of 500 to 75 micron with particles < 75-micron size is very less in the quantity (Fig. 3).

The amount of various size aggregate grains is shown in table 2. As the Quila-I-Ark was constructed in different historical periods, we find non-uniformity in the number of aggregate grains mixed in plaster works. Wherein samples 2 & 5 showed large addition of big size aggregate grains (1 mm – 4 mm) mostly in the range of 31.87– 38.16 wt%,the plaster samples 6 & 7 show high addition of aggregate grains in the size range of 125 to 500 micron (58.61 to 46.48 wt%). The addition of a varied quantity of aggregates grains of different grain sizes indicates different phases of construction though the source of aggregates remained almost the same. It is also observed that in the majority of the cases aggregate grains mixed during the plaster preparation vary from 64.33 to 79.77 weight percentage per 100 gm of plaster sample.

2. Granulometric Analysis.

The grain size distribution is a powerful tool to describe site geomorphic settings, interpretation of fluid dynamics in the natural environment and to distinguish local sediment transport mechanisms (Huggett, 2007). Grain size analysis also helps to understand the size and shape of aggregate grains, the source of aggregate grains, depositional environment, and provenance. The grain size distribution of plaster samples 2, 5, 6 & 7 is shown in figure 4(a-b). The majority of the grains are of coarse sand to medium silt size and the percentage of clay size grains is very negligible. This

indicates that the inner plaster layer is mostly rough with coarse size aggregate grains of local origin. The coarse grains have helped in better carbonation of lime besides increasing mechanical property. From the grain shape analysis of the plaster (Fig. 4c), it is observed that the majority of the grains are angular to sub-angular with very angular to sub-rounded grains quite less in the plaster.



a b

c

Figure 4. Characteristics of the composition of plaster: a – grain size distribution of the plasters; b – average of grain size distribution; c – grain shape analysis of the plasters.

From the microscopic view of the fort plasters, it is observed that aggregate grains were derived from weathered basaltic rock of Sahayadri range of hills. The source of sediments is in-situ deposits of local origin probably sourced from the water channel of nearbyHarsullake situated at the foot of the hills near the fort. The aggregates were probably surface in-situ deposits of water channel originating from the surrounding basaltic hillock. The aggregate grains show angular to sub-angular shapes denoting that the sediments have traveled less distance from their source of origin. The sediments belong to fluvial in origin and traveled to short distance as no round-shaped grains identified. Microscopic observation of sediments shows the major presence of

plagioclase, orthoclase, and silicate minerals. This indicates the basalt as the pre-existing rock.

3. Thin Section Analysis.

The thin section analysis of plaster samples 2 & 3 is shown in figure 5(a-f).

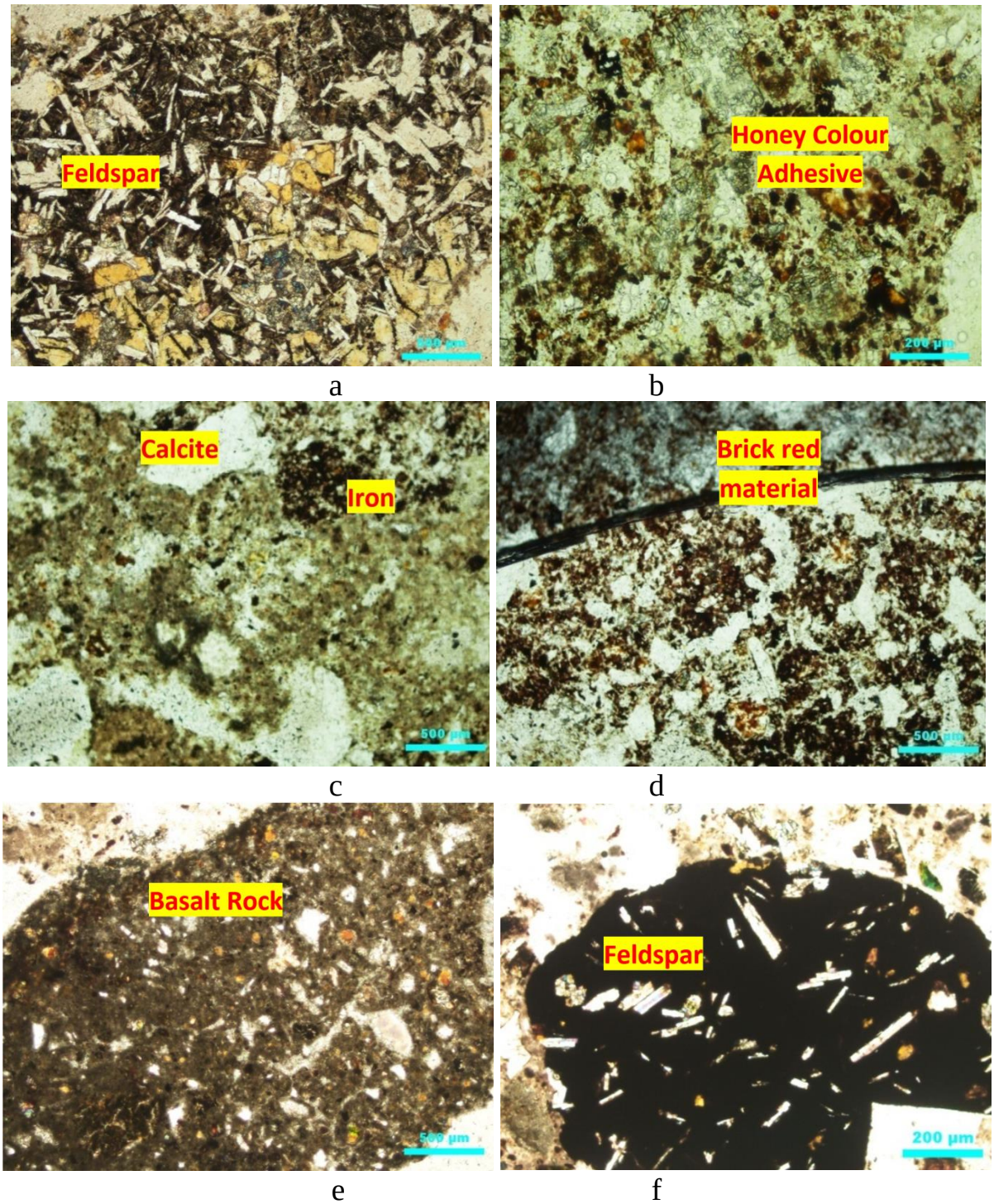


Figure 5. Thin section analysis of plaster:a-d – sample No. 2; e-f – sample No. 3.

Calcite is the main binding material for the plaster and figure 4c shows the calcite grains in the plaster. The calcite is white buffy to crypto-crystalline under a thin section. An opaque brown iron oxide mineral in the thin section is seen forming part of cementing material. Figure 5(a, e, f) shows the abundantly present feldspar grains of basaltic origin as aggregate in the plaster. Most of the grains are plagioclase feldspar distributed in the calcite matrix. Fig. 4b shows a honey color organic additive mixed in the plaster.

The presence of organic adhesive in the plaster was also confirmed through FTIR analysis. Figure 5d shows the presence of a brick red color material in the plasterworks which could not be identified. The plaster is mainly composed of calcite, feldspar, and local origin basalt rock aggregates. Calcite is the ground matrix in the plaster.

4. Chemical composition of the plasters.

The chemical composition of plaster samples 1 to 7 is shown in table 3 in the form of major oxides (wt%). From the wt% of silica three phases of historical construction for the fort are estimated. Samples 1 & 2 show silica in the range of 41.59–45.41wt%, in sample 3 & 4 silica wt% is 7.09–8.03, and in the rest of the samples, the SiO_2percentage is in the range of 56.91 to 69.15 wt%. The samples showing low content of sand is also marked by high wt% of CaO. The CaOwt% in samples 1 & 2 is between 18.24–24.22, sample 3 & 4 is 45.86–48.20 wt% and in samples 5–7 between 17.21 to 18.83 wt%. There is considerable wt% of alumina denoting the addition of aggregates rich in plagioclase feldspar. The iron content found in the plaster is between 0.52 to 6.62 wt% due to the addition of ferruginous sand as filler for the plasters.

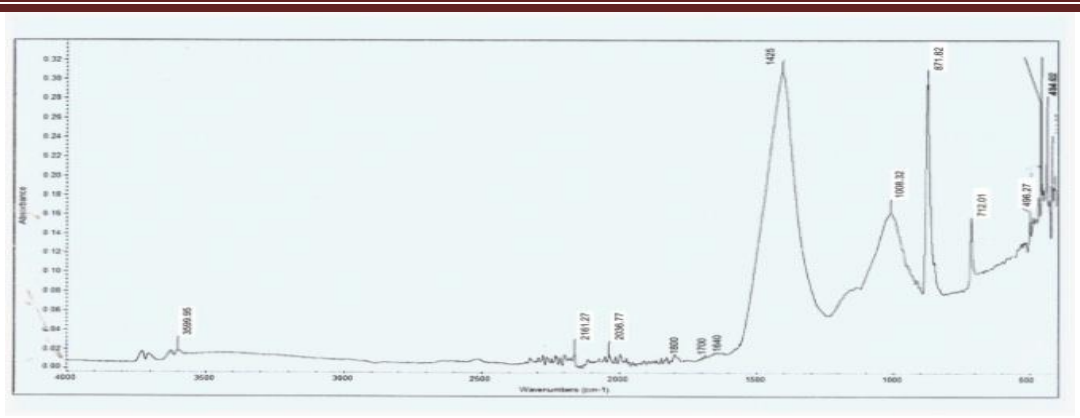
Since chemical composition does not give desired information about the nature and characteristics of binder & fillers in the plasters, a detailed mineralogical composition was sought. To derive the mineralogical composition of the plasters based on chemical composition data, the modified three equation system suggested in the literature was used (Singh, 1993; Charola et al., 1984).

The plaster samples were sprayed with phenolphthalein indicator and no color change was noticed indicating the absence of any uncarbonated lime. The hydraulic silicate present in the plaster was differentiated from the non-hydraulic by dissolution in 1:4 HCl solution and the value is shown as $Ins._{HCl}$. The loss on ignition (LOI) of the plasters was used in the calculation of calcium and magnesium carbonate. It was assumed that traces of magnesium present in the plaster has completely carbonated. The cementation index (C.I.) and Hydraulicity index (H.I.) of the plaster are shown in table 4. The various components of the plasters obtained through the three equation systems are shown in Table 5–6. SiO_{2flux} corresponds to all hydraulic (H) and non-hydraulic (N.H.) components. CaO_{silic} is the calcium bound to hydraulic silicate. The non-hydraulic components are the main source of iron and alumina in the plaster and the ratio of $N\text{-}H/R_2O_3$almost gives a constant value for most of the samples. This indicates that the source of non-hydraulic components for the Quila-I-Ark plasters remained almost the same in different phases of construction. The ratio of SiO_2/Ins_{HCl}

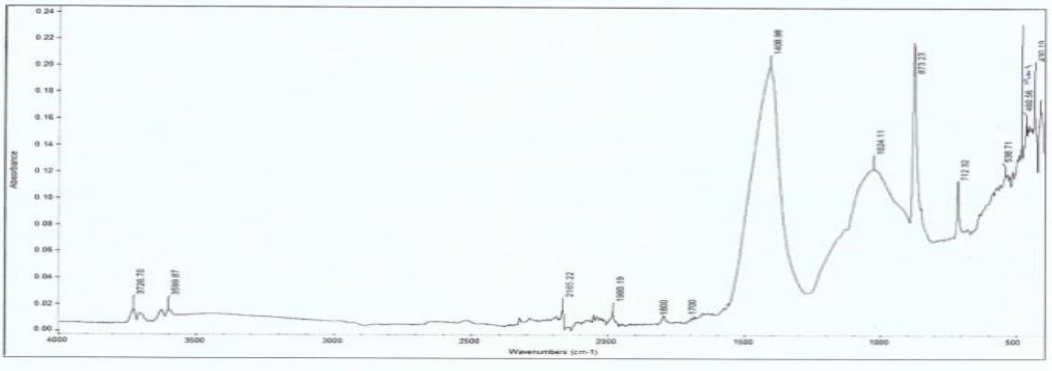
varies between 0.58–0.92 further confirming the source of aggregates for the plasters remained the same. The R_2O_3 content of the plaster (Table 6) samples 3 & 4 is the minimum (9.97–12.22 wt%) indicating preparation of low mechanical strength plaster vulnerable to damage. These samples also show high content of $CaCO_3$ + $MgCO_3$ as the values lie between 85.03–86.66%. The CaO/SiO_2 ratio of the plaster samples 1, 2, 5, 6 & 7 varies between 0.29 to 0.58and in most cases close to 0.33 for a moderate strength plaster. Sample 3 and 4 show the low addition of filler in the lime mix. The MgO content in the plaster varies between 0.71 to 3.01 wt% (Table 3) showing the use of carboniferous limestone with traces of magnesium as raw material for the plaster works. The hydraulic component in the plaster (Table 4) varies between 1.46 to 6.10% indicating the plaster as mostly non-hydraulic. The cementation index (C.I.) for soluble silica (Table 5) varies between 0.10 to 0.96 and the low value indicates formulation of non-hydraulic aerial lime for fort plasterworks. The hydraulicity index (H.I.) value of the plaster is quite low indicating the use of aerial lime. The quartz content of samples 3 & 4 is very low (0.47 to 2.68%) indicating preparation of low mechanical strength plaster in some phases of historical construction (Table 5). The plaster with less amount of silica also shows low content of non-hydraulic aggregate and a high amount of lime that leads to the preparation of plaster of low mechanical strength. The value obtained for CO_3^{2-} showed a large variation for sample 3 & 4 compared to other samples (Table 6). The MgO/CaO ratio lies between 0.03 to 0.11(Table 6) indicating the use of carboniferous limestone with traces of magnesium as raw material for the plaster.

5. FTIR Analysis of the plaster.

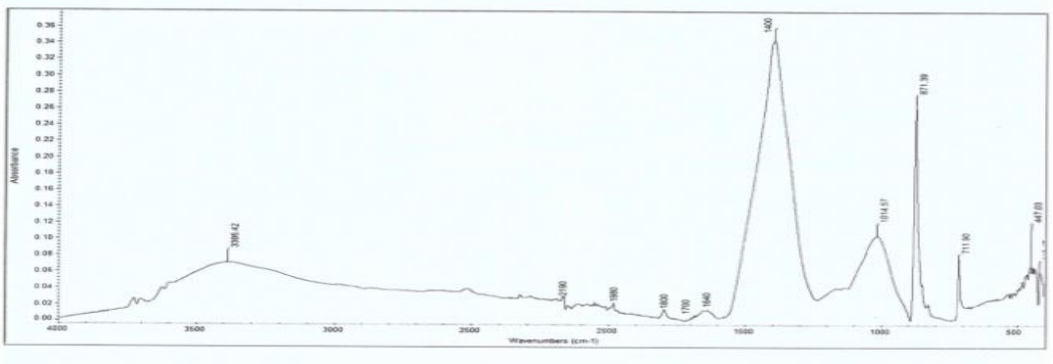
The lime plaster samples 2, 3, 5, 6 were observed under Fourier Transform Infrared Spectrophotometer for qualitative information about the functional groups in the plaster, and the spectra are shown in figure 6. The peaks around 3400–3600 cm^{-1} is mostly due to OH stretching and bending vibrations of hygroscopic water. The most characteristic peaks of calcite are observed at around 712, 872, and 1400 cm^{-1} in the spectra. The characteristic band of silicates is observed between 1008–1024 cm^{-1} in the plaster. A small peak at around 1640 cm^{-1} is observed in the spectra representing the amide group. The peaks around 1640 cm^{-1} point towards the addition of proteinaceous organic adhesive mixed during the plaster preparation. The FTIR analysis correlates to the thin section analysis of the plaster wherein honey color adhesive material was observed. The peak around 1800 cm^{-1} is that of calcite. Two very small peaks centered around 1980 cm^{-1} and 2165 cm^{-1} are observed in all the samples representing the presence of =C-C bending and C=C stretching respectively. These may be due to the presence of aromatic groups in the plaster as part of the addition of some adhesive materials as we also find a very small peak at around 1700 cm^{-1} in the samples. The peaks around 496 cm^{-1} and 432 cm^{-1} represent iron mineral derived from the addition of ferrugineous aggregate as filler in the plaster.



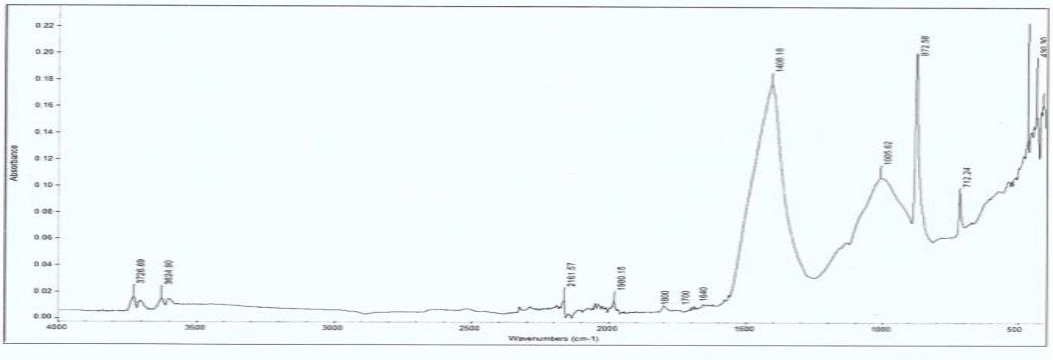
a



b



c

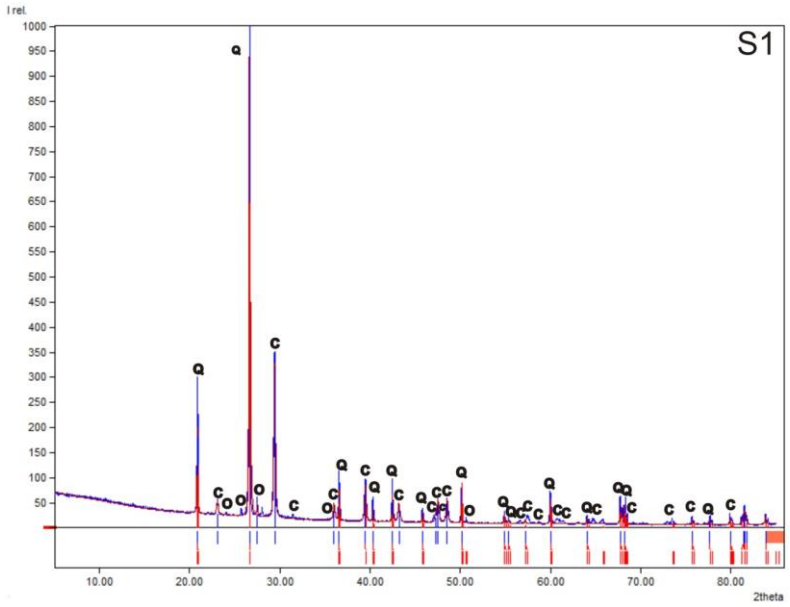


d

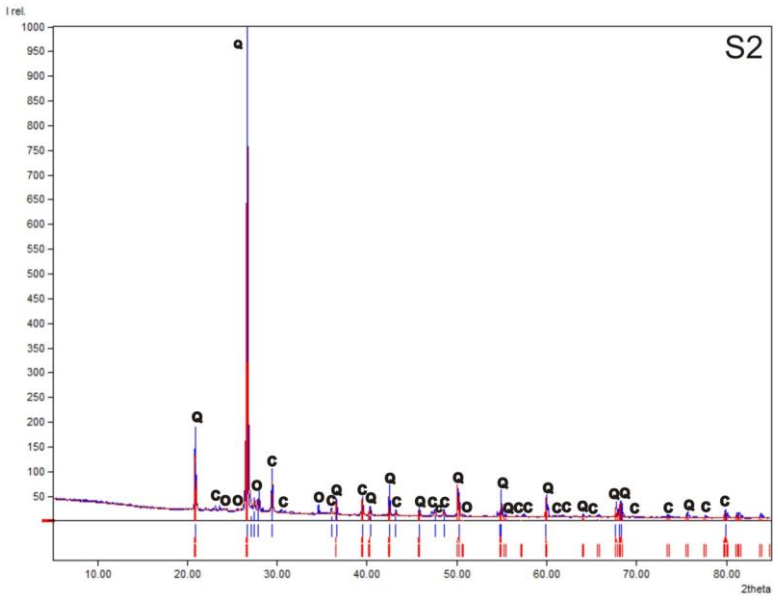
Figure 6. FTIR spectra of lime plaster sample: a –No. 2;b – No. 3;c– No. 5;d– No. 6.

6. XRD Analysis of the plasters.

The XRD analysis of plaster samples 1 & 2 is shown in figure 7(a&b). From the XRD pattern of the sample, it is observed that binding material for the plaster is represented by calcite. The small quantity of dolomite analyzed by chemical analysis of the plasters could not be recognized in the XRD pattern due to its poor crystallinity (Boggs, 2011). As the plaster of Quila-I-Ark is feebly hydraulic no peaks for calcium silicate hydrate and calcium aluminate hydrate could be observed. The other important peaks observed in the diffraction pattern are quartz and orthoclase. The plagioclase feldspar is due to the addition of basaltic aggregate in the mortar mix. The XRD pattern of the plasters supports the thin section analysis.



a



b

Figure 7. XRD pattern of lime plaster samples:a – No. 1;b – No. 2.

Conclusion.

The lime plasters of Quila-I-Ark were analyzed with the purpose to prepare compatible repair mortar. Analytical data revealed at least three phases of historical construction with contrast variations in a binder to aggregate ratio. The fort plasters with high calcite content and less of aggregate were weak and found extensively damaged. The mineralogical composition indicated that the source of aggregate for the plaster works remained the same, however, the quantity of filler varied in various phases of construction. The plaster is aerial lime of very low hydraulicity and inclusion of coarse size aggregates ensured better carbonation. Creamy white color zeolites were particularly added in the plaster mix to maintain humidity in the dry season. The aggregates are weathered basaltic stone grains mostly sourced from the water channel of surrounding Sahyadri hills. The analytical data will help to prepare compatible plaster for major restoration.

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Declaration of interest.

The authors declare no conflict of interest.

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Нафтохімічне дослідження Могольських штукатурок Кіла-Е-Арк, Аурангабад, з точки зору технології та ремонту

Анотація. *У цій статті повідомляється про мінералогічний склад штукатурок Великих Моголів в Західній Індії 16–17 століть з Кіла-Е-Арк, Аурангабад для приготування сумісного ремонтного розчину і документування давньоіндійської технології виробництва вапна. Були виконані аналітичні дослідження для вивчення розподілу зерен за розмірами, аналізу тонкого*

перетину, інфрачервоної спектрометрії з перетворенням Фур'є (ІЧСПФ), дифракції рентгенівських променів і хімічного складу пластів за допомогою рентгенівської флуоресценції. Аналіз виявив включення великогабаритних зерен базальтових частинок, що надходять в основному з водного каналу озера Харсул, який знаходиться поблизу. На деяких штукатурках видно включення дрібних зерен, що вказують на різні періоди будівництва. Кремово-білі цеоліти були спеціально додані в будівельну суміш для підтримки певного рівня вологості протягом сухого сезону. Цеоліт дуже пористий і легко ламається як в сухих, так і у вологих умовах. Вапняк з високим вмістом кальциту зі слідами магнію використовувався в якості сировини для штукатурки. Ґрунтуючись на мінералогічному складі і співвідношенні поєднувач/заповнювач, були задокументовані три фази історичних будівель. ІЧСПФ і аналіз тонких зрізів показали змішування певної кількості білкового розчину, що клеїть, з вапном для поліпшення реологічних і водонепроникних властивостей. Велика кількість великих зерен заповнювача забезпечувала кращу карбонізацію вапна, і джерело наповнювачів залишалось незмінним на всіх етапах історичних будівель. Індекс цементації і індекс гідротрансформації варіюються від 0,10 до 0,96 і від 0,20 до 3,43, відповідно, показуючи, що штукатурка являє собою повітряне вапно зі слідами магнію. Штукатурка слабо гідравлічна, так як розрахунковий гідравлічний компонент коливається від 0,88 до 6,10 відсотка в різних зразках. Для більшості етапів будівництва, за винятком декількох ізольованих місць, була підготовлена штукатурка середньої міцності з співвідношенням вапна/кремнезему, близьким до 0,33. Аналітичні дані тепер допоможуть приготувати сумісний розчин з ідентичними добавками для капітального ремонту.

Ключові слова: *древній розчин; наповнювачі; негідравлічні; мінералогія; органічні добавки; походження*

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Нефтехимическое исследование Могольских штукатурок Кила-Э-Арк, Аурангабад, с точки зрения технологии и ремонта

Аннотация. *В этой статье сообщается о минералогическом составе штукатурок Великих Моголов в Западной Индии 16–17 веков из Кила-Э-Арк, Аурангабад для приготовления совместимого ремонтного раствора и документирования древнеиндийской технологии производства извести. Были*

выполнены аналитические исследования для изучения распределения зерен по размерам, анализа тонкого сечения, инфракрасной спектрометрии с преобразованием Фурье (ИКСПФ), дифракции рентгеновских лучей и химического состава пластов с помощью рентгеновской флуоресценции. Анализ выявил включение крупногабаритных зерен базальтовых частиц, поступающих в основном из водного канала близлежащего озера Харсул. На некоторых штукатурках видны включения мелких зерен, указывающих на разные периоды строительства. Кремово-белые цеолиты были специально добавлены в строительную смесь для поддержания определенного уровня влажности в течение сухого сезона. Цеолит очень пористый и легко ломается как в сухих, так и во влажных условиях. Известняк с высоким содержанием кальцита со следами магния использовался в качестве сырья для штукатурки. Основываясь на минералогическом составе и соотношении связующее/заполнитель, были задокументированы три фазы исторических построек. ИКСПФ и анализ тонких срезов показали смешивание некоторого количества белкового клеящего раствора с известью для улучшения реологических и водонепроницаемых свойств. Большое количество крупных зерен заполнителя обеспечивало лучшую карбонизацию извести, и источник заполнителей оставался неизменным на всех этапах исторических построек. Индекс цементации и индекс гидротрансформации варьируются от 0,10 до 0,96 и от 0,20 до 3,43, соответственно, показывая, что штукатурка представляет собой воздушную известь со следами магния. Штукатурка слабо гидравлическая, так как расчетный гидравлический компонент колеблется от 0,88 до 6,10 процента в разных образцах. Штукатурка средней прочности с соотношением извести/кремнезема, близким к 0,33, была подготовлена для большинства этапов строительства, за исключением нескольких изолированных мест. Аналитические данные теперь помогут приготовить совместимый раствор с идентичными добавками для капитального ремонта.

Ключевые слова: *древний раствор; заполнители; негидравлические; минералогия; органические добавки; происхождение*

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Liberalisation of telecommunications and broadening of the value chain in Southern Europe. Telefónica, 1982–2000

Abstract. *This article deals with the opening of telecommunications to competition and its determinants in Spain, a country seriously committed to the monopoly. It is framed in the general scenario of an accelerated technological change driven by new materials, components and transmission systems, a sharp regulatory change and an extension of the value chain with new products and services, in particular data, mobile telephony and cable. Such properties fit perfectly with the time axis chosen which comprises the two last decades of the 20th century and coincide with a phase in which the protagonist company is facing the challenge not only of liberalisation but also of a profound change in the parameters of the market. The study focuses on Telefónica's response to new regulatory and market requirements. Methodologically, it revolves around the multidisciplinary nature, which integrates the approach of the history of technology understood as a system (Thomas P. Hugues and Melvin Kranzberg) and the economic and business history (Nathan Rosenberg). The text is structured in four sections that examine the persistence of the monopoly of Telefonica and liberalisation, the axes of Telefónica's transformation through global and strategic plans and the broadening of the value chain, focussed on the cable market. Some preliminary historical and technical issues and key elements in the evolution of the sector are addressed. The text attends to the relations between the market structure inherited from the monopoly and the process, from which the advantages of Telefónica with the rest of the companies emanate. The research rests mainly on primary sources of the company studied, twice as valuable because they are difficult to access by researchers and perfectly determined to grasp the company's strategy, as well as on reports from major international institutions and secondary literature. The conclusion deals with the methodological consideration of the close link between supply and demand-related factors.*

Keywords: *liberalisation of telecommunications; Telefónica; cable telelevision; value chain*

Introduction.

In the two last decades of the 20th century, a rapid and profound technological change and a vast movement of deregulation turned the world industry upside down. New materials – optical fibre – the emergence of electronics, satellites and the convergence between telecommunications and computing led to the development of new equipment and the Internet. It came over an extension of the value chain with new products and services, in particular data, mobile telephony and cable.

The operators reacted in a variable way to the opening of markets in-depth to a large extent because they were going through different situations. A review of 356 publications on the internationalisation of telecommunications services revealed a growing body of contributions, covering mainly settlement and regulatory policy, strategic alliances and incumbent reactions to deregulation, as well as in-depth market opening. Fixed-line telephony was the dominant segment in most contributions, while mobile telephony or broadband Internet segments were only included in more recent work (Jakopin, 2008). This is a powerful reason to investigate such a situation in the case study.

We should start with some preliminary historical and technical issues. At the time we focused our research, the cable had already been running for many years. Before that, we considered some key elements in the evolution of the sector.

The cable offers the most efficient vehicle for linking subscribers to a broadcasting centre as well as for connecting individuals belonging to the same network. The cable communication system is the broadband transposition of the telephone signal transport system, a distinctive feature that makes it the most successful technology for receiving, exchanging and processing information (Frèches, 1987).

Coaxial cable television is the classic technology for image and sound transmission. It consists of several pairs of copper wires of varying thickness that carry electrical signals from the network output point to the subscriber. As the Encyclopaedia Britannica points out, commonly known as community antenna television (CATV), these cable systems use a “community antenna” to receive broadcast signals (often from communications satellites), which they then retransmit via cables to homes and establishments in the local area subscribing to the service. Subscribers pay a specified monthly service charge in addition to an initial installation fee.

The original coaxial cable networks were replaced by those using optical fibre, which, being based on light signals instead of electrical signals, has a double advantage: higher capacity and higher speed (Frèches, 1987). Cable began as a rural television service for residents who lacked the over-the-air programming options of urban residents. The supports for this service were microwave radio and satellites. The cable then spread to urban areas because of the diverse programming and as another source of affordability (Wheeler, 1981; Frèches, 1987). Thomas E. Wheeler was the president of the National Cable Television Association. The cable was born in Pennsylvania in the 40s by chance: the difficulties that a television sales franchise holder (Peter Walsonavich) encountered in capturing the television broadcasts

transmitted by the hertzian route led him to link up by receiving cable to an antenna located on top of one of the surrounding mountains and to provide free cable television service to his customers (Magoun, 2007, p. 116). The pioneer of commercial coaxial cable television would have been Robert J. Tarlton in the late 1940s, along with other residents of Lansford (Mullen, 2008, p. 40). In the US, the cable penetration rate as a percentage of TV households grew from 14% in 1975 to 24% in 1980 and 67% in 2003. In the early days of cable, many aspects of the service were regulated by the authorities, including the terms and conditions of the franchise and subscriber fees. In 1984, the Cable Policy Act imposed some limitations on the regulation of tariffs by the franchise authorities. Eight years later, in response to rising rates, the Consumer Protection Act required the FCC to regulate to ensure reasonable rates for basic service, the lowest level of cable service, which includes local broadcasting (General Accounting Office, 2003, p. 7).

As early as the start of the 1970s, some of the key players – the Sloan Commission – advocated that cable TV should offer "abundance", or greater choice. By abundance, they meant bringing in programmes from other cities and opening up the field of pay-TV, as well as choosing between network news and cable news services. Abundance would also mean reserving certain channels for areas of public interest, such as welfare, health, consumer services and public information. The Sloan Commission's (Sloan Commission on Cable Communications, 1971) recommendations included: the diversity of entertainment programme systems – mass and specialised – the variety of channels by purpose – government, quasi-government, educational services and compulsory public access channels. Cable systems should transmit local public broadcasting stations; public television stations should be allowed to operate cable franchises without market restrictions; local franchising authorities should give ownership preference to community institutions; interesting view from the mainstream press (New York Times, December 19, 1971, p. 10).

In Europe, cable TV networks for liberalised services (1994/1995) were used in only one country (UK) and were not used in four countries (Belgium Denmark Germany Portugal). There were variations in France (no voice services), Greece (no cable TV networks), Ireland and Luxembourg (no legal provision), Italy (no cable TV networks, legislation pending), the Netherlands (limited use) and Spain (no but legislation pending) (Eijk, 1995).

European Public Telecommunications Operators or PTOs controlled an increasing share of the cable subscriber market (from 50 % to 59 %), a trend similar to that of the OECD countries, where the operators share of cable TV subscribers in monopoly Public switched telephone network (PSTN) markets grew from 54 per cent in 1990 to more than 60 per cent in 1994 (Little, 1997, pp. 20–21).

As was the case with most national markets for controlled access and conditional access services, the pay-TV markets were dominated by a small number – one or, at most, three or four main companies – that were highly diversified, largely intertwined,

strong and operating on an international or regional basis (European Audiovisual Observatory, 2004).

Over the years, the development of the digital television market in general, and of the pay-TV market in particular, has been driven by four main factors. These consisted of an increase in the number of media/market concentrations together with vertical integration of upstream and downstream markets; new bottlenecks and market closures and a change in the way digital products are distributed by bundling content and services into platforms and packages (European Audiovisual Observatory, 2004). Vertical integration refers to the extension of a company's activities through more than one successive stage of the production process or value chain (Little, 1997).

The millennium started with difficulties for the whole industry as the deteriorating economy complicated the transition to digital television, both in terms of rising programme rights costs and the huge investments needed (Lange, 2005, p. 13).

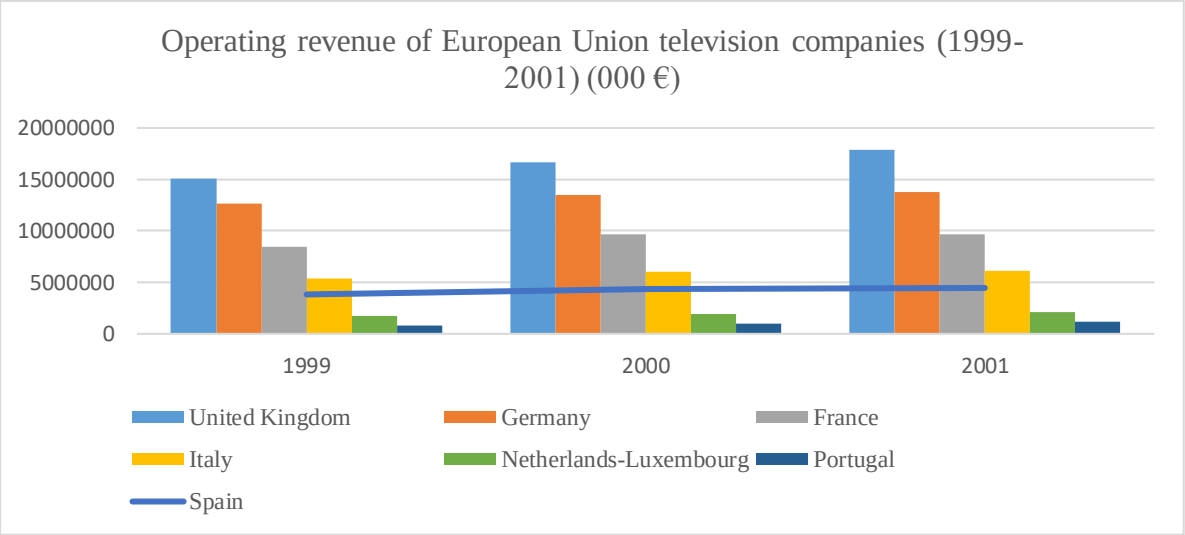

Figure 1. Operating revenue of European Uion television companies (1999–2001) (Lange, 2005, p. 13).

Overall, growth varied from country to country according to a score broadly led by the United Kingdom (16.6 billion in 2000), compared with 13.5 in Germany, 9.3 in France, 5.9 in Italy and 4.3 in Spain (Table 1). In turn, huge disparities among national financial situations existed. In Spain, public enterprises, both state-owned and autonomous community-based, accumulated significant structural deficits. Despite enjoying substantial margins, the two private channels financed by advertising (Telecinco and Antena 3) suffered from the negative impact of competition between the two digital satellite TV platforms (Vía Digital and Canal Satélite) before their merger was enormous (Lange, 2005, p. 8).

Research methods, Results and Discussion.

Methodologically, the research falls within the scope of a case study, which is granted full validity despite its detractors. It is in keeping with all those who clearly

distinguish the case study from other research techniques such as the survey in its nature of inquiry of a single instance (Dul & Hak, 2008, p. 4).

The resaerch revolves around the multidisciplinary nature, which brings together two great historiographic traditions: those represented by Kranzberg, on the one hand, and Rosenberg, on the other. The first approaches the history of technology understood as a system and the second the economic, management and business history.

In his landmark work Networks of Power, Thomas P. Hugues (Hugues, 1983) laid the foundations for the study of technology embodied in large systems – hence the meaning of "large technical systems", LTS – and unveiled the mysteries of what had hitherto been considered a black box. This systemic conception, led by Hughes with a rather sociological approach, was also cultivated by Melvin Kranzberg (Kranzberg, 1986) by equating technological systems with technological packages, so called because they are composed of various components shaped by economic and socio-cultural patterns. Nathan Rosenberg (1982) explored it also previously by from the evolutionary economics of technological innovation, which is shaped by science, industry and economics. Unlike Hughes, who focused on electricity networks, Rosenberg studies aspects of innovation in telecommunications (Rosenberg, 1982). Within the LTS stream, ISDN, as an instrument of integration of separate communication networks, was present in the discussion on the generalisation of Hughes' approach to even more advanced stages in the expansion, scaling up or merging of LTS (Mayntz & Hughes, 1988, p. 15).

By adopting an LTS approach, Nina Wormbs (Wormbs, 1997) traces the development and change in the networks used for radio and television distribution in Sweden from the 1920s to the 1990s. The Swedish broadcasting network is conceived as a socio-technical system composed of both "hard" and "soft" components – purpose built systems, material technology, institutional framework (ownership structure, organisation and standards). In this sense, cable TV is considered a subsystem together with AM, FM, TV, cable and satellite broadcasting systems.

Within the framework of these multidisciplinary approaches, the study contrasts strongly with the dominant literature in Spain, which stands out for its unidisciplinary scope and focuses on regulatory and legal issues – Giordano and Zeller (1999), Montes (2016) and Pérez Martínez and Feijóo González (2000) while less so in the business field (Fernández, 2000). The text is structured in four sections that examine the persistence of the monopoly of Telefonica and liberalisation, the axes of Telefónica's transformation through global and strategic plans and the broadening of the value chain, focussed on the cable market. The research rests mainly on primary sources of the company studied, as well as on reports from major international institutions and secondary literature.

Telefonica: persistence of the monopoly and liberalization.

Perhaps the most accurate diagnosis of the trajectory of Telefónica de España – the new name adopted by the historic Compañía Telefónica Nacional de España in

1988 – in the last quarter of the 20th century is contained in the speech of its president, Cándido Velázquez Gaztelu, who set out his programme for the transition from monopoly to leadership. At that time, Telefónica had accumulated fundamental transformations experienced in the 1980s with the creation of the circulating holding company and the beginning of international expansion according to different styles, which were difficult to fit into a single model (Table 1) (Statement by Cándido Velázquez Gaztelu at the meeting of the Board of Directors on 20 December 1995, Minutes of the Board of Directors (Libros de Actas del Consejo de Administración, LACA, 20 December 1995). The new structure of the company was defined by the continuity of the decentralization and the management advocated remodeling the organization in only the essential. The results for 1988 showed that Telefónica was perfectly prepared for the investment challenges that the future demanded (LACA, 21 December 1988).

In 2000, Telefónica presented itself as a global company, leader in telecommunications, Internet and media with a strong local presence. It was, in turn, the leading operator in telecommunications, media and Internet in the Spanish/Portuguese speaking world; one of the ten largest telecommunications companies by market capitalisation, the most liquid telecommunications company in Europe and the fifth in the world and one of the global telecommunications companies with the greatest geographical diversification, source of income and value.

Telefonica could boast of a long history of transformation in response to new needs. In 1976, the first stage of regional decentralisation had been completed, which affected Catalonia and was intended to shift the bulk of operational management and the capacity to contribute plans and programmes of action to the company's overall plan to the regions. After twenty-two years, Telefónica adopted new managementand model by services market segment. It included five lines of action, namely Telefónica de España, Telefónica Internacional, Telefónica Móviles, Telefónica Media and Telefónica Intercontinental (Compañía Telefónica Nacional de España, Memoria, 1976, p. 36; Compañía Telefónica Nacional de España, Memoria, 1998, p. 178).

In 1999, by the conversion into an affiliate or subsidiarisation of the basic telecommunications area in Spain, in particular the fixed telephony business, and the transfer of the personal and property assets to Telefónica de España, the essential part of the restructuring process was completed. The Telefónica Group comprised an integrated group of companies which carried out their main activity in the telecommunications, media and entertainment sectors. It was made up of Telefónica, S.A., the parent company, and various subsidiaries and investee companies. The geographical scope of this activity extended to Spain and abroad, while the form in which it was carried out was either directly, in the whole or in part, by the Company, or through companies or other legal entities with an identical or similar corporate purpose. In short, as analysts have pointed out, the model adopted is characterised by a versatility that blends the operational autonomy of the different sectors of activity with horizontal policies (From & Eliassen, 2007).

Table 1. The companies of the Telefónica Group, 1985 (Telefónica, Memoria, 1985, pp. 153–154).

Direct holdings				
	Share capital (million pesetas)	% Telefónica	Telefónica Results (million pesetas)	Staff
AMPER S. A.	2400	84,375	391	987
Cables de Comunicaciones	782	49	109	395
CETESA	434	100	61	879
COSESA	700	100	442	385
ELASA	300	100	87	494
ENTEL S.A.	350	100	157	718
GRAFIBUR S.A.	325	100	6	104
H.R.M.	500	100	31	315
INDELEC	300	30	86	46
INTELSA	2600	49	481	2225
SECOINSA	3125	92,875	3007	1133
Standard Eléctrica	17604	20,99	138	15127
SINTEL S. A.	1100	100	457	3121
Telefónica Internacional de España	200	100	1	3
Telefónica Sistemas	100	100	40	22
Telettra Española	2800	51	125	1764
TEMASA	600	100	4	2
TEPESA	100	56	18	31
THM	200	73	68	27
TYD	225	100	62	120
Urbana Ibérica S. A.	330	100	33	1
Indirect holdings				
	Share capital (million pesetas)	% Telefónica		
CETESA-TELYCO	50	33		
COSESA-SAPEC	40	35		
ENTEL-IBERMÁTICA-SADIELSA		266		
SINTEL-TECNITEL Co.(Miami)		10000$		
SECOINSA-SADIEL		56		
Telefónica Internacional de España Telefonica International		1.750.00 dm		
Compañía Financiera de Telefonía Española B. V.*		25.000 florines		
Telefónica Hispano-Americana*		600000 $		
AT&T Microelectrónica de España	65 $	20		
In progress				
TELCOR S. A.	6 $	35		
CARTOGRAFÍA DIGITAL	300	70		

* Direct participation of Telefonica International.

In detail, the main companies in core activities were the following: Telefónica de España (basic telecommunications in Spain), Telefónica Servicios Móviles, S.A. (mobile services, in particular mobile telephony in Spain), Telefónica Internacional S.A. (carrying out and managing investments in the telecommunications sector in the Americas), Telefónica Intercontinental S.A. (carrying out and managing investments in the telecommunications sector outside Spain and the Americas), Telefónica Media S.A. (media and entertainment), Telefónica Data S.A. (integral provision of data transmission services for companies), Terra Networks S.A. (access and services related to the Internet and interactive services in general), Atento Holding S. A. (call centre) and Telefónica Publicidad e Información S. A. (guides) (Telefónica, Memoria consolidada correspondiente a los ejercicios terminados el 31 de diciembre de 1999 and 1998, pp. 90–93).

The pillars of Telefónica's transformation: global planning.

Following the formulation of the 1983–1986 Four-Year Concerted Plan and its approval by the Government, comprehensive planning took place, culminating in the 1985–1988 Four-Year Plan (Secretaría General de Economía y Planificación, 1985). It aimed to unite everyone's efforts and direct them towards achieving the triple objective of developing services, modernising infrastructures and boosting the industrial sector related to the demand for equipment. As a result, the three-fold service objective involved to "phone" Spain, promote innovation and undertake the management of multipurpose networks. They meant, respectively, developing and extending the basic telephone service, updating the telephone service by incorporating peritelephony services and expanding other telecommunications services (mobile telematics, business communications) and, as a third objective, having an infrastructure suitable for transmitting not only voice but all types of products. These plans inevitably called for a series of management objectives, including the modernisation of infrastructures and their management methods through more integrated and versatile management, with the implementation of technical solutions for advanced operation – call it digitalisation – and internal mechanisation, as well as a more agile and efficient framework of relations with the subscriber.

In the end, the 1985–1988 Plan entailed a management tool of the future to updating services and overcoming possible technological gaps. Its final objective was to reduce diseconomies, to give rise to new procedural formulas and to reach the efficiency levels of the most advanced countries. The Plan thus became an instrument that required very close coordination, a reduction in the time taken to make material resources available and technically qualified, and an organisational development that was permeable to the new management formulas in the dynamic environment of the melting of classical regulation, new social demands and cutting-edge technologies. In its report on the draft LOT to the Government, Telefónica stressed the need to maintain the unity of the network and its management and to liberalise the terminals (LACA, 30 April 1985).

Telefónica applied severe economic and financial reorganisation measures, which can be summarised in four basic pillars. They spanned from cost containment and an active financial policy, with successive capital increases and debt diversification, to the adaptation of depreciations to the duration of the telephone plant, and the strong trend towards self-financing of investments. Increasing self-financing and repeated capital increases bore fruit, visible in strong repayments, responsible for the improvement of the liability structure, as well as the consolidation of the working capital. The self-financing/investment ratio rose from 50.9 in 1982 to 66.6 in 1985 (Compañía Telefónica Nacional de España, Memoria 1985, p. 6).

CTNE's foreign currency debt at the beginning of 1984 was PTA 213587 million, of which 34% was in Swiss francs, 19% in German marks, 38% in US dollars, 7% in pounds and the remaining 2% in five other currencies. Approximately 80% of the foreign debt was in the form of international syndicated loans with multi-currency clauses. At the time, the trend towards a reduction in the weight of currencies with a higher expected cost was beginning to emerge. One year later, the participation of foreign capital in the CTNE was between 3.08% and 8%. Measures were taken to control foreign investment in CTNE shares (LACA, 30 January and 6 March 1985).

The effervescence to which the country devoted, after the great events of 1992 – the Olympic Games and the fifth centenary of the arrival in America – affected the whole of the territory. The fruits of the Star Programme for the dissemination of the telephone in rural areas were reaching all its corners. Work began on the Access Network plan, which first totalled PTA 862.8 million, with the capital city taking the lead with 55.6% and, at a certain distance, the province most directly involved in some of the pomp and circumstance, i.e. Seville in the south with 17.9%. In the second round, the work on the interior and exterior plant was increased by 590.35 and 1669.2 million pesetas (Table 2).

The strategic plans of Telefónica in 1991–1997.

Given the relatively long time needed to implement new services and to mature the investments required to meet growing demand in quantity, quality and diversity, the five-year Strategic Plan has been consolidated as our fundamental instrument for planning the Company in the medium and long term.

Maintaining its basic lines in terms of strategic objectives, priorities and policies, the forecasts and specific objectives have been outlined, incorporating the modifications that have been considered appropriate according to the evolution of the market situation for telecommunications services. The Strategic Plan is updated every year, always maintaining a five-year time horizon.

The priority objective of the Plan, and consequently of the programmes derived from it, continued to be the improvement of quality. In fact, in the 1991–1995 Plan, the main quality objectives were brought forward by one year, to achieve in 1992 levels that were perfectly comparable with the most advanced countries, although in 1991 these objectives will already be achieved in most provinces. The objectives of reducing

the waiting list were also brought forward in time, so as to reduce it to a purely residual level as soon as possible.

Table 2. Access network programme. Work on the internal and outdoor plant which was expected to be accepted or available in 1992–1993 (million pesetas) (LACA, 25 July 1992; LACA, 26 May 1993).

Provinces	Investment 1992	Investment 1993	Total investment
	million pesetas		
Andalusia (south)			
Málaga	25.20	–	140.20
Granada	18.50	–	100.1
Almería	–	39.6	237.9
East coast			
Valencia	61.80	–	309.8
Castellón	–	38.9	194.3
Centre			
Madrid	–	35.7	162.3
Cuenca	3.05	–	15.25
La Rioja	9.10	–	45.8
Basque Country			
Vizcaya	–	160.9	804.8
Catalonia			
Gerona	–	30.2	141.6
Canary Islands			
Las Palmas	–	21.2	398.3
Tenerife	–	–	538.1
Aragon			
Zaragoza	–	–	22.3
Total	117.95	326.5	2.475.1
Outdoor plant projects in 1993			
Barcelona	–	–	61.4
Córdoba	–	–	22.4
La Coruña	–	–	7.8
Jaén	–	–	16.1
Sevilla	–	–	29.7
Reserva	–	–	91
Total	–	–	273.7

With a clear awareness of the demands posed by the liberalisation of telecommunications and the establishment of a new competitive framework, corporate

organisation was strengthened. The position of CEO (formerly Managing Director), who had a long tradition in the company, was re-established, and the financial area would continue to depend directly on him. The areas of Economic Analysis and Studies, Strategic Planning, Subsidiaries and Participated Companies, and Communication and Corporate Relations were brought together in a General Directorate of Corporate Planning. A General Resources Department was also created, grouping together the areas of Human Resources, Intervention and Accounting and Information Systems (Telefónica, Memoria 1990, pp. 10–11).

The incorporation of Spain into the European Community imposed a supranational regulation, based on the separation of the regulatory functions, reserved to the State, and the operational functions, assumed by the operators. The inclusion of this guideline in the 1987 Telecommunications Law called for new bases for the relationship between the State and Telefónica. A new concession contract, replacing the one signed in 1946, returned all the sector's regulatory functions to the government and defined a new framework for the company's activity. Telefónica maintained its monopoly of the basic telephone service, although now subject, as is the case with Spanish legislation, to the guidelines of the EC (Telefónica, Memoria 1991, p. 4). Years before, the EEC's advisers had considered three options for restricting the provision of cable TV: maintaining the status quo; lifting restrictions on certain PTOs and/or giving dominant PTOs rights to provide cable TV capacity over telecommunications infrastructure.

The breadth and depth of the changes brought to light the profound business transformation in which Telefónica was immersed to achieve a strategic positioning in the face of the new regulatory, economic and social conditions in which our business activity is carried out.

Telefónica focused on maintaining its leadership capacity in the national market and on contributing to the development of Spanish and European society in a highly competitive environment. The first condition was to be identified by its current and potential customers as the preferred vendor of telecommunications services in a market that is increasingly open to competition. The already initiated selective strategy of objectives and management formulas maintained the same end, based on the double formula of continuous quality improvement and lower production costs, together with an active marketing policy adapted to each line of business in search of a segmented demand.

The new slogan was therefore called competitiveness or submission to the test of validation of its economic efficiency by the market. Indeed, Telefónica already saw a framework of full competition in place with the definition of deadlines for the granting of new mobile phone licences and the entry of new operators in market segments such as business services, terminals and international communications. Active marketing slogan: "selective and segmented offer: to each market segment the precise solutions it requires" (LACA, 12 June 1992).

These objectives had unavoidable organisational consequences. The next step was the announcement of an organic and functional restructuring to encourage businesses that were opening up to the competition by giving them greater administrative autonomy, streamlining management and improving efficiency. The new General Directorate of Business Communications, the strengthening of TS1, Telefónica Servicios S.A. as a leader in mobile services, the reinforcement of the coordination of commercial activities and the exploitation of existing synergies between various services were all aimed at this direction (LACA, 25 November 1992).

Then it fell to Telefónica Sistemas (TS), which the parent company wanted to be more closely linked to it. Telefónica Sistemas became an instrument to consolidate and strengthen Telefónica's offer in the business communications market. The way forward consisted in bringing together around this subsidiary a new group of companies with the capacity to respond to the growing and complex demands of business customers. In its first steps, the plan would start with two TS subsidiaries of different characteristics and scope. One would cover the engineering field to offer satellite communications to businesses and commercial television, among other purposes; the second would have the task of providing advanced information and intercommunication services. The list of advanced services included e-mail, data, card management and database access (LACA, 4 February 1993).

The reorganisation was accompanied by a two-pronged strategic plan for the years 1993–1997, the first in the context of the advanced convergence plan and the second in the field of information systems. This five-year plan aimed, among other things, to improve the financial results with a better balance between the different businesses, to achieve a corporate image in the eyes of the customer as a competitive, responsible, solid and agile seller, and to provide quality services at a reasonable price. If we want to be strict, both plans included and extended a 1990–1994 Plan, whose most significant variation was in a better adjustment of investments and in the reduction of waiting lists, and the subsequent 1991–1995 Strategic Plan, which was tentative and somewhat voluntarist, and which contributed the novelty of prioritising the stimulation of traffic, public telephony, especially that owned by others, and the allocation of resources with a view to productivity, while seeking to improve the rate of revision of investments and the operating margin (LACA, 28 November 1990).

In the core business, Telefónica's task was to establish definition criteria and ensure profitability and offer tailor-made products and services for large customers with the application of several policy categories. To begin with, it was necessary to identify the large customers and the most important multinational companies in search of strategic revenue sources. In a further step, attention had to be paid to vertical industry sectors, such as banking, airlines and distribution companies, among others. It was also necessary to establish a specific approach for all activities that would subsequently be coordinated (one structure, not project management). Not least, it was necessary to rely on the cross-functional matrix to use change and mobility to overcome corporate inertia. Closing the list of policies was the requirement to select

preferred contractors to help correct Telefónica's weaknesses and to broaden horizons towards software activities.

In this strategy, internationalisation occupied a prominent position within a more general plan, always understood as a presence in other markets and as an international operator ready to forge global alliances. This close link between internationalisation as a part of a strategic plan goes far beyond its simple inclusion in a list of objectives or plans and, in our opinion, has not generally received sufficient attention. Calvo (2016) has devoted an extensive analysis to internationalisation.

The plan, which estimated a 31% increase in net line demand, provided for uneven growth in the different service segments, with greater intensity in mobile telephony, which would be multiplied by 3.55 compared to 1.13 in basic telephony lines and 1.74 in the Ibercom–ISDN network. Estimates indicated that the Ibercom–ISDN network would increase 1.74 times in 1997 from 571000 in 1993 and mobile telephony would more than triple from 325000 (LACA, 27 January 1993). The communication standard Integrated Services Digital Network (ISDN) was called in Spain RDSI (Red Digital de Servicios Integrados).

The second major issue was the Strategic Plan for Information Systems, this time of a four-year nature (1993–1996), in response to the inadequacy of the plans in force to support Telefónica's corporate and operational strategy in the face of the challenges posed in a competitive environment. The strategic objectives of the Plan were the introduction of new services, improvement in quality, customer service, consolidation of business areas, cost reduction and security of the systems themselves, all aimed at making the information systems support Telefónica's strategies and operations. As a logical consequence, it was necessary to stop investing in old systems and to define a new strategy for the Information Systems divided into fundamental areas. Two of them – those of the commercial and network areas – were already defined and structured, while the third – resources – was in a preliminary phase. In the Commercial area, the new billing system was noteworthy, which aimed at the automatic collection of consumption and detailed, staggered billing by client, together with a large client module, supported by databases, designed with advanced software engineering and planned to obtain short-term results. In the area of network information, the objective was an integrated planning system, completing the operating systems, automatic management and connections with the commercial system. The choice of international standards, in short, would allow the maximization of the return on investment and the automation of the operation and management of the network. In the definition of the priorities, the planning, management and control of investments; operation and maintenance structure; circuit management (ATLAS); automatic flow management (traffic); geographical information systems and plant maintenance systems were all considered. The Resources area aimed to complete computerisation, simplify administrative processes, integrate with network and commercial systems, coordinate strategies and platforms of the Telefónica group and improve decision-making and management control processes. Here the most important projects were purchases and

warehouses, human resources, management information, costs, budget control and commitment to third parties. By one estimate, the 1993–1997 Information Plan would increase sales of additional services, shorten installation and breakdown repair times, improve the profitability of investments, reduce financial expenditure and contain staff and personnel costs (LACA, 27 January 1993).

Telefónica encouraged a strategy in the definition of the corporate identity and global image to respond to the challenge of liberalisation, internationalisation, globalisation, new competitive scenario, expansion of the offer of new products and services. The objective was to maintain the leadership in the Spanish telecommunications market and to reinforce the commercial and service attitude. In substance, it sought to reinforce the character of a private company, to superimpose on the image of voice telephony that of advanced and diversified technology and, finally, to preserve the real value of roots and service to the country historically led by Telefónica in telecommunications. He recommended an evolution without radical change because "Telefónica is a renewal in continuity"; "we cannot draw a blank canvas of the unquestionable historical role that Telefónica has played in the technical progress of Spain". The modification of Telefónica's corporate symbols was approved (LACA, 4 February 1993).

It is now necessary to break away for a while from the chronological account to bring in an element of great scope, namely the concerted action between the company and the state in the extension of the telephone service to suburbs and rural areas.

The action specifically dates back to the dawn of the democratic era. In 1978, a government order on this sector of demand for telephone service sought to combine criteria of strict economic profitability with arguments of a political-social nature to extend telephone service to the whole nation. A 1981 decree, accompanied by the usual regulations, established a plan to install public telephones in municipalities without telephone service with a population of 50 or more inhabitants. Its development involved the public administrations, state or otherwise, and the Spanish National Telephone Company (State public administrations, provincial councils and island councils). A step forward was taken three years later, when the collaboration of the territorial entities that made up the Nation–State (Autonomous Communities) and of individuals was definitively promoted in the extension of the service, with special emphasis on collaboration with Telefónica, which became a lever and the main stimulus for regulated actions with their calendar. The acute awareness of the problems of the telephone service was materialised in a constant presence in the annual budgets of a large part of the autonomous entities. For its part, Telefónica signed agreements for the extension of the telephone service between 1986 and 1991 with territorial bodies and individuals. The 1988–1991 Government Plan included a large number of objectives – 8443 new urban areas, 5700 public service telephones and a waiting list of some 44000 requests from the suburbs. Due to their geographical dispersion, the average costs were high and the resources insufficient. In any case, the 1991 plan to extend the service to rural areas brought the public telephone to towns with 50 or more

inhabitants and the urban service to all towns with more than 100 inhabitants. Telephone service extension agreements signed between 1986 and 1991 with local authorities and individuals respectively: 15 and 14 in 1986; 96 and 306 in 1987; 62 and 473 in 1988; 84 and 334 in 1989; 85 and 328 in 1990 and 84 and 689 in 1991 (Telefónica, Memoria 1991, p. 6).

At the end of the first quarter of 1993, the Government approved the Operational Plan for the Extension of the Rural Telephone Service 1993–1996 (Table 3). As an example of its objective of universalising telephone service, it involved the installation of 427364 telephone lines and 13790 public telephones using TMA cellular access technology. In another aspect of its scope, it required an investment of ptas. 103.100 million, three quarters of which was borne by Telefónica and the rest by the local authorities. The aim was to universalize the service so that all citizens living in rural areas could have telephone service at the same prices and within the same time frame as citizens living in urban areas (LACA, 28 April 1993; BOE, 12 May 1993, pp. 14088–14100).

Table 3. Operational Plan for the Extension of the Rural Telephone Service 1993–1996 (BOE 12 May 1993, pp. 14088–14100).

	Investments needed (millions of current pesetas)				
	1993	**1994**	**1995**	**1996**	**Total**
Subscription lines	24.500	24.200	25.600	25.700	100.000
P. S. T.*	1.200	1.600	200	100	3.100
Total	25.700	25.800	25.800	25.800	103.100
Financing					
Telefónica	19.275	19.350	19.350	19.350	77.325
Outside	6.425	6.450	6.450	6.450	25.775
Total	25.700	25.800	25.800	25.800	103.100

* P. S. T. – public service telephone.

The 1993 Annual Employment Plan aimed to bring the level of employment in line with the needs of the Strategic Plan, with a ceiling of 74100 employees and to increase line productivity per employee by 3.2% (LACA, 24 March 1993).

An important element were the new telephone tariffs, which received differentiated treatment according to categories. The average increase of 2.1% was 5.3% for metropolitan calls and 4% for long-distance calls. Intercommunity calls, mobile calls and telematics tariffs benefited from reductions of 2%, 12.6% and 4% respectively (LACA, 28 April 1993).

It seems clear that one of the mainstays of Telefónica's transformations was the liberalisation of telecommunications promoted by the government on the initiative of the EEC, which had already been largely achieved, and to which the operator was favourable, under the decisions of the Spanish government (LACA, 24 July 1996). In

response to Airtel's complaint, Telefónica stated that it was unaware of the problems raised by the granting of the second mobile telephony operator's concession (Retevision).

As a result of organisational restructuring in 1994, Telefónica was configured as a corporate nucleus and eight business areas. It then transferred the business to specific subsidiaries, with the consequent assignment of assets and management systems. To do so, it had to obtain the approval of the General Secretariat of Communications, the national regulatory body attached to the administration. The reorganisation had a threefold objective, starting with that of meeting the challenges arising from the liberalisation of telecommunications, which was reflected in the complete opening up of the voice and infrastructures services market. It was followed by ensuring that the managers of the various businesses took full responsibility for the results. Finally, a Group management committee would ensure an overall view of all the businesses. The reorganisation was extended the following year with another partial one as it exclusively affected the international communications management as a preliminary step to the creation of an independent company (LACA, 22 February 1995; Telefónica, Memoria, 1994, pp. 32–35; Telefónica, Memoria, 1995, p. 8). Telefónica decided to adjust its territorial organization to that of the Spanish state in autonomous communities and to carry it out gradually. In addition to the already constituted territories – Galicia, Extremadura and the Canary Islands – five new territorial units were proposed – Aragon, Castile-La Mancha, the Basque Country, Andalusia and Castile-Leon (LACA, 31 January 1996).

The novelty of the 1996 reorganisation consisted of identifying customers and segmenting markets to differentiate up to five business units – General Public, Companies, Telefónica Móviles, Telefónica International and International – capable of meeting consumers' needs on time. The units enjoyed full organisational autonomy in such fundamental matters as product design, prices and advertising campaigns. The Corporate Centre, and more specifically the Management Committee, which was responsible for submitting proposals to the Executive Committee and the Board of Directors, was responsible for coordinating all areas. Prominent businessmen and jurists joined the Board of Directors (Merger Court Report, 1996, p. 13). Content and tone of the measures strongly resembled what had already happened to Ericsson. In a comparative view, after more than a century devoted almost exclusively to telecommunications, especially in plant equipment, Ericsson undertook a restructuring and expansion of its product range, with a pronounced market orientation (Svedberg, 1981, p. 150).

Despite recent restructuring, the new landscape of the liberalisation process and opening up to competition and legal requirements, resulting from legislative decisions or the principle of neutrality in network management, called for further major organisational changes. The reason for the intensification of restructuring, more explicitly related to financial restructuring, in certain periods, was discussed Donaldson (Donaldson, 1994).

Telefónica aspired to encompass in its strategic plans not only the need to improve quality, brand image and infrastructure, but also the new demands arising from the changing environment. In this sense, it needed to identify its activities to individualise and break down the different businesses it managed, while also separating the services that covered common management needs, the so-called areas or corporate services. To express this in terms used at the time, the aim was to prioritise the autonomous management of these businesses, counteracting the centrifugal force of this autonomous management with the centripetal nature of the existence and operation of the corporate areas. Decentralisation, autonomy and efficiency formed the links in the chain (Telefónica, Memoria 1994, p. 10). Experts argue that decentralisation brings in a centrifugal force, requiring management to impose a centripetal force in the form of policies if it expects to maintain control over decentralised units (Adizes, 2004, p. 66).

The change implied a clear separation between the responsibilities of the corporate areas and those of the management of the businesses themselves, which were divided between Telefónica and independent companies. As a result, subsidiaries were assigned to either the corporate core or the business areas, depending on the nature of their function.

The identification of businesses, one of the stepping stones in the planning of a portfolio strategy, revealed the existence of eight units, including three in telephony – basic, integrated by infrastructure and commercial areas; mobile and public use; international communications, data transmission; international business; information and advertising; and multimedia services. Of these, only basic telephony and international communications remained within the scope of Telefónica de España, while the remaining areas became independent companies.

In the new design, the corporate nucleus had the task of coordinating the strategy of the group of companies and guaranteeing its balanced growth and development, the appropriate management of financial resources and the optimum use of human resources. It would consist of a general secretariat, coordination, planning, administration and resources and finance and management control (LACA, 30 November 1994). The planning of a portfolio strategy also includes the evaluation of the existing distribution of the company's business units, identification of the desired future balance of the portfolio and implementation (Leontiades, 1987, p. 40).

In truth, the reorganisation pursued a combination of the versatility and flexibility of the autonomy of its business units with horizontal policies, an organisational philosophy of activities by lines applied by European operators years later by the Belgacom Group in 200 (From & Eliassen, 2007); business units: Hollensen (Hollensen, 2012).These acknowledged that the business unit, and not the divisional or corporate level, is the appropriate one for the construction of a value chain, which is why it can be described as a competitive strategy. According to Chandler's vision, there appear to be clear symptoms of the transition from a multi-functional multi-unit company to a multi-divisional company that separated the strategy from operation and, consequently, from centralisation and division by function to division by product

characteristic (Chandler, 1990). It seems appropriate to point out that some specialists describe internationalisation as an alternative to the diversification strategy and the multi-divisional structure (Binda, 2013, p. 162). The debate between universalists – a single economic and managerial organisation – and institutionalists – national differences – remains polarised. In 1993, even French and German firms were at or near the level of three-quarters of the divisionalization reached by American firms in 1969. A slow but clear advance of the continental countries towards the Anglo–Saxon organisational model together with the universal collapse of the centralised functional organisation appear as the main characteristics (Whittington & Mayer, 2000, p. 37).

It should not escape the observation that Telefónica's transformation from a telephone operator into a communications company, providing services to a wide range of customers, ran parallel to its expansion (Kalotay, 2004).

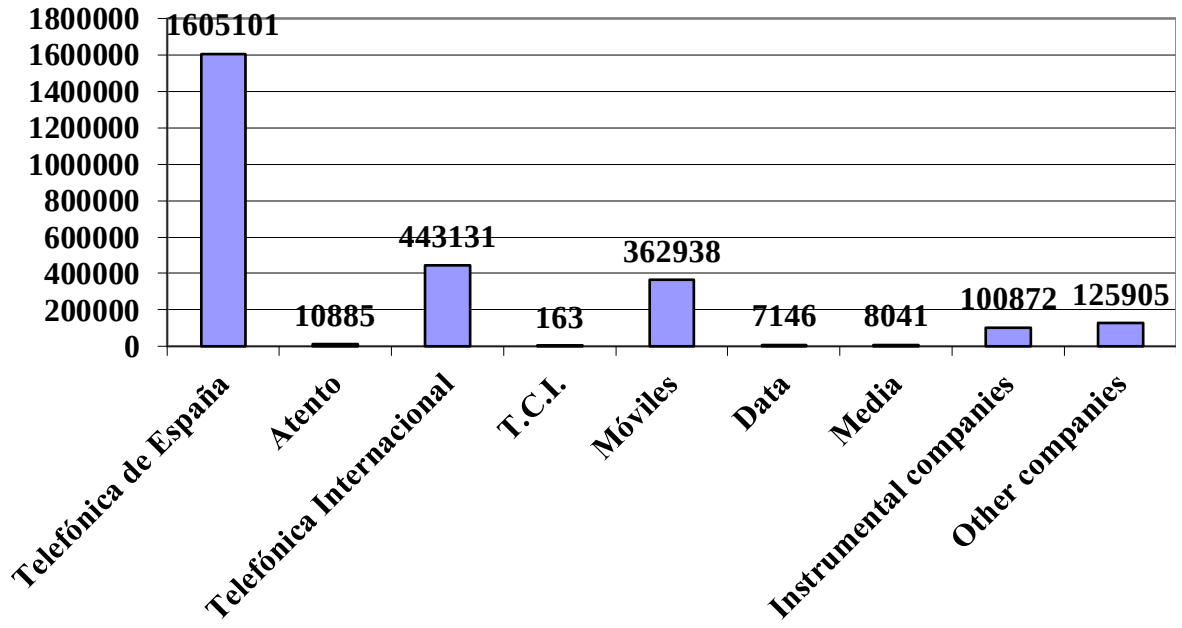

Figure 2. Income structure of Telefónica by operations by 1999 (million ptas.) (Based on Telefónica, Memoria, 1999, p. 200)

The reorganisation culminated in the Operation Veronica, which led to the Group being organised into business lines that are now global in scope, with a vocation for world leadership within each area of activity. In 1995, the operator closed the first phase of Operation Veronica, by which – following the successful completion of its takeover bids for Telefónica de Argentina and the Brazilian companies Telesp and Telesudeste Celular – it gained control of 96%, 87.5% and 89.3% respectively of these companies. At the dawn of the new century, this operation would culminate in the consolidation and strengthening of Telefónica's presence in Latin America, substantially in the markets already conquered (Calvo, 2016).

In the new structure, the ordering of assets by business replaced the previously prevailing criterion, i.e. by country. Three business units opened in 1998 – Terra, Telefónica Publicidad e Información (TPI) and Telefónica Media – and were joined the following year by two more – Telefónica Móviles and Telefónica Datacorp – and, successively, by four new ones – Atento, Katalyx (Business to Business), Telefónica Internacional and Emergia (underwater fibre optics). The Telefónica Group was thus shaped as an integrated group of telecommunications, media and leisure companies headed by the parent company Telefónica, S.A. This reinforced the corporate strategy aimed at optimising the synergies of the coordinated action of the different areas. This had allowed the successful implementation of shared policies through the advanced purchasing system, cost optimisation systems –Shared Services Centres–, coordinated information systems strategies, the first global human resources actions carried out with the TIES plan, as well as the coordination and development of actions in the field of institutional relations (Telefónica, Memoria, 1999, pp. 11–12). The new organisational structure tried to meet the Group's objectives, in particular an increase in the value of the business and its return to shareholders. Five priorities were established: development of the organisational model of an integrated telecommunications group, the transformation of the telecommunications business in Spain, undisputed consolidation as a leader in the mobile phone business and optimisation of the portfolio of other subsidiaries. This was a new customer-oriented organization based on management by business units with three basic pieces. The Corporate Centre's mission was to guarantee the strategic orientation of the Group, which comprised the areas of Management Planning and Control, Institutional Relations, Corporate Finance, Regulation and the General Secretariat of the Board; five business units – Companies, General Public, TISA, Mobiles and International-, focused on markets, customers and products and with objectives based on profit and loss accounts; two shared resource units – Infrastructure and Businesses–, to support the business units and to provide common services. Moreover, four committees were set up: a management committee, with an executive role and an instrument for defining policies and resolving key issues relating to the whole Group; a financial committee, for risk management and balance sheet; a basic telephony committee and a resources committee. At one point in the reorganisation, Telefónica Latinoamericana was the business line responsible for fixed telephony assets in the area. The sums managed and saved in one year within the advanced purchasing system, which began in 1998, exceeded 1.5 billion and 200,000 million pesetas respectively (Telefónica, Memoria, 1999, p. 58).

In 1996, Telefónica noted a list of positive and negative factors arising from its competitive position. Among the former, the improvement in quality to the level of that of competitors, the maintenance of productivity levels and the achievement of leadership in operating margins, the favourable evolution of profitability on own resources, the firm international positioning due to its establishment in Latin America and incorporation into Unisource, together with the spectacular improvement in public

opinion, stood out. The list of negatives included the risk associated with tariff imbalances, the low perception of the quality-price ratio, the relatively low generation of income from new services in comparison with other advanced operators and the imbalance in profitability both by business areas and by services in basic telephony (LACA, 20 December 1995; the strategic plan 1996–2000 was studied during several meetings in the central emblematic of Buitrago: LACA, 29 November 1995). The quality of the service improved between 1990 and 1997. In response to increased competition, Telefónica reduced concession times for international leased lines to an average of 44.7 days; fault reports per 100 lines fell from 9.87 to 8.48 per month (OECD, 2000, p. 297).

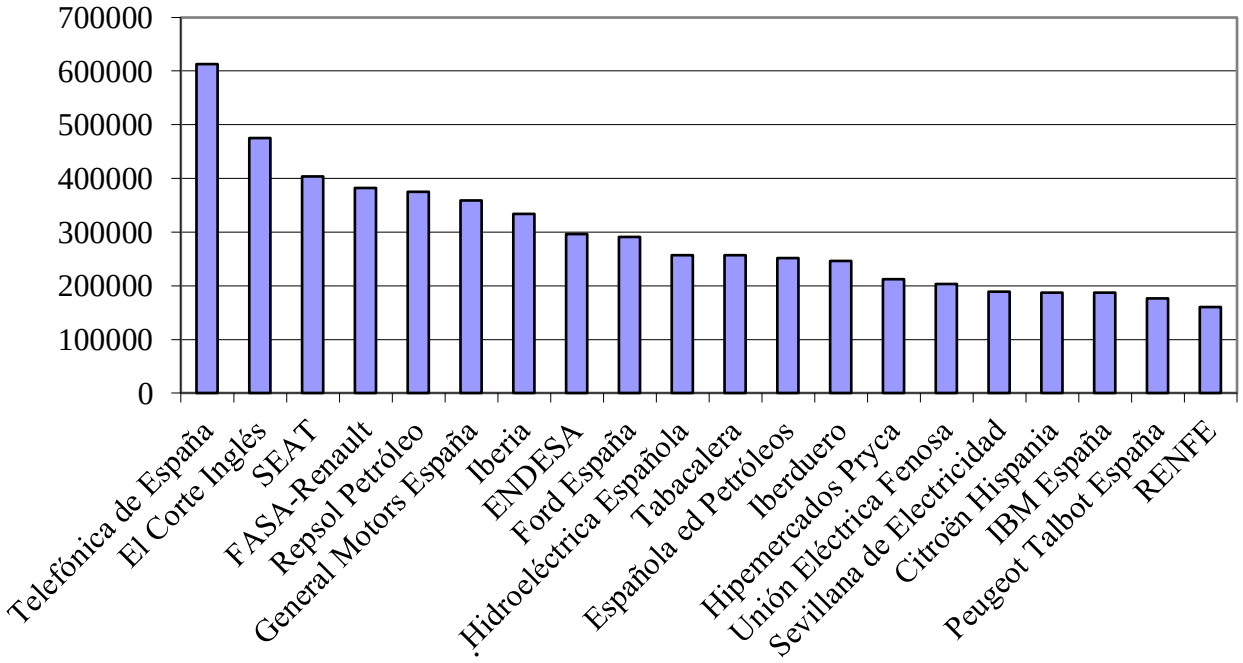

Figure 3. The 20 largest non-financial companies in Spain, 1998 (million ptas.) (Binda, 2013, p. 249)

With the 1996–2000 Strategic Plan, in a context of change in the country's political orientation with the arrival of the right-wing government, it sought to maximise the value of the company for the shareholder by conquering leadership in a context of growing liberalisation of the sector. Achieving this required improving efficiency in the operation of traditional businesses, paying special attention to high-growth and emerging businesses, without neglecting improvements in costs, economic profitability and financial (LACA, 20 December 1995).

Broadening the value chain: the cable market in Spain and Telefónica.

So far, we have provided an overview of the structuring of an operator in a context of telecommunications liberalisation. We now turn to one of the aspects: the

Telefónica's responses to the extension of the value chain by a new product – cable –, one of the aims of the article.

If we go back to the beginning, in Spain, Law 42 1995, of 22 December, on cable telecommunications authorised cable operators to provide services in a specific sector of telecommunications, those provided through cable networks. These included sound broadcasting services and image transmission services of an interactive nature, the latter being the main core of the service as it was considered to be the fastest-growing. Cable telecommunications were a state-owned public service by the general principle enshrined in the Telecommunications Law itself. The cable telecommunications service was to be provided by territorial demarcations of variable scope – municipal district, the grouping of various municipal districts – and was to be achieved by public tender. The awarding of the contract empowered the concessionaire to provide this service and to establish the network for this purpose, for the provision of other telecommunications services and even as a carrier service for services provided by third parties. The company was authorised, by a series of requirements and conditions, to provide these services in all areas, which are inseparable from the basic telephone service. The law, therefore, combined respect for the privileged position enjoyed by Telefónica de España under the contract with the State with the existence of the necessary competence in the provision of these services. The Law limited the number of cable operators in each territorial district to one, in addition to Telefónica de España, SA. This restriction was motivated by economic considerations, since the operation would not be viable in the event of a proliferation of operators, given the high amount of investment to be made. In the development of this service, the establishment of formulas for cooperation between industrial companies, research centres and service operators was to be encouraged to ensure the best use of the technology available (BOE, 306, 23 December 1995, pp. 36790–36796). See for details of the complex elaboration of the Law the Minister of Public Works and Transport Response to Socialist Deputy Ms Anna Balletbó (Journal of Sessions, Congress of Deputies, Commissions, 13 MAY 1992, 187, p. 9,201). In 1996 a Memorandum of Understanding was reached on Telefónica's contract with the State: LACA, 30 October 1996. Political debates on the Cable Law (Montes, 2016).

In the Spanish cable industry, three elements of activity coexisted, namely the disparate nature, the complementary nature and the presence of obstacles to internalisation. The first can be explained by the absence of all the skills of a company to carry out its activity. It applies to the nascent cable industry in Spain because this industry involved a multiplicity of activities, each of which had to function perfectly. After all, this systemic nature meant that the goodness of the service offered depended on all the links in the value chain. The same applies to the second, which is a nuance of the previous one. Finally, the third is entirely applicable to Spain because the main obstacle is financial, resulting from the significant investment required for this activity.

A close connection exists between the development of cable companies and the liberalisation of telecommunications. The operators who entered the fixed telephony

market as a result of the liberalisation of the sector by breaking up the monopoly – Retevisión – and the duopoly – Lince Telecomunicaciones – participated directly in the capital of the cable operators or through shareholding partners in both (Fernández, 2000, pp. 177–186).

The group of companies set up to operate in cable television was originally made up of 14 consortia established on a territorial or more general basis. The list included Cableuropa, Cablevisión, Cable TV Europa, three Andalusian entities (Sevillana de Cable, Cable del Guadalquivir and Jerez de Cable), Telecable (Asturias), Santander de Cable, Telecable Compostela, Burgos Sistema de Cable, Grupo Cable, Operadora Cable Sistema, Zaragoza de Cable and Marbella Cablevisión. They were made up of twelve financial institutions (BCH, BBV, Banco de Santander, Banesto, Banco Pastor, Caja Círculo Católico, Caja Cataluña, Caja de Pontevedra, Caja de Vigo, Caja de Orense, Caja Galicia and Caja Cantabria), four energy companies (Iberdrola, Sevillana de Electricidad, Unión Fenosa and Electra del Viesgo), media and infrastructure companies, local authorities and other service companies (Annexe 1). In terms of size, the cable market in Spain was made up of three strategic groups of cable operators: modest, intermediate and large operators. The characteristics of this last group include a majority of financial partners and a small presence of foreign companies (Miguel & Fernández Peña, 1998).

They have been setting their targets on Spain since at least 1994. It is interesting to follow in the footsteps of some of them. In order to focus on the most significant one, US West did not hide its intentions to invest in Spain in an interactive communication network with the new cable TV law. The changes introduced by the PP government in the cable legislation coincided with the aspirations of US West in its Spanish landing. It was the first of the regional companies resulting from the break-up of the US multinational giant AT&T to diversify into cable television on a large scale through its 25.5% investment in Time Warner Entertainment (a joint venture with Time Warner, Toshiba and ITOCHU) (Spain and Talbot, 1995, p. 888).

In the plans, US West's main partners in Cable i Televisió de Cataluña (CTC) – Banco Santander and ENDESA – were to form the nucleus of Retevisión when it was privatised. US West and its partners were to bid for all tenders in Spain. Initially, if US West, through CTC, won the three Catalan regions, as it expected, it would be involved in a global investment of Ptas 130 billion. In exchange, it would bring the cable to 2.5 million homes, a very interesting critical mass, which would allow us to offer many specific services and contents, in the expression of a high directive of the North American US West in Spain – Maureen O'Ryan. She believed that the imminent appearance of digital television did not mean that cable had become obsolete. Through Cable i Televisió de Catalunya (CTC), this company initially cabled 20000 homes in Barcelona and was the technological partner of Euskaltel, which would act as the second largest Telefónica in the Basque Country. On the shape of telecommunications in Catalonia (Martí-Recoder, 1991).

Over time, the number grew as requests for public service provision were extended to new territorial districts. In Madrid, two more consortia soon emerged: Madrid Sistemas de Cable (France Télécom, Bank of America, Banco de Santander and BCH, among others), which submitted bids to the three regions into which the cable tender was divided, and CYC Telecomunicaciones Madrid, a consortium made up of six large business groups in the three regions (Unión Fenosa, Endesa, the Zeta Group and Telecom Italia, among others). CYC won the contract for the three districts and its projects included providing the cable service to 700000 Madrid residents in September, offering a telephone service and some television channels to at least 150000 households from October, and cabling the entire region in six years. In order to lay the cable, the company wanted to make an agreement with the Canal on the use of its pipes, with the City Council on the use of its underground galleries and traffic lights, and with the electricity companies on the use of their conduits (El País, 14 February 1998, 6 and 12 March 1998). The two large business consortia – Madrid Sistemas de Cable and CYC Telecomunicaciones Madrid – which competed for the cable network in Madrid submitted bids to operate and were severely disqualified. Cableuropa, one of the shareholders of Madrid Sistemas de Cable, accused its opponent CYC Telecomunicaciones Madrid of inflating its investment proposal. In the meantime, he said that if his group lost the tender, the duopoly of Telefónica and Retevisión would be consolidated and tariffs would not fall (El País, 23 January 1998).

Supercable Andalucía, which included up to eight electrical, financial and audiovisual companies, won the contract to provide the public cable telecommunications service in the territorial demarcation of Andalucía III.

Sevillana de Cable, Get-Grupo Eléctrico de Telecomunicaciones, Montes de Piedad y Caja de Ahorros de Ronda, Cádiz, Almería, Málaga and Antequera – UNICAJA–; Caja San Fernando; Monte de Piedad y Caja de Ahorros de Huelva y Sevilla; Procono y Supercanal de Cable de España (BOE, 79, 2 April 1998, p. 11.281). The new ones also included Huelva de Cable y Televisión.

The cable started to develop more slowly than expected in the different districts. Business circles attributed the delay above all to bureaucratic problems – building permits from the local authorities – and supply problems – the arrival of new competitors not originally foreseen. It seemed possible that they would be granted some kind of moratorium on the deployment of their network in areas of lower density or that they would be awarded a licence to provide their services by radio access, at a lower implementation cost (Pérez Martínez & Feijóo González, 2000, p. 226). Various initiatives for cabling in Spanish cities took place in a context of very intense liberalisation, but in the absence of regulation, and of technological development in telecommunications, together with a position taken by the Constitutional Court (Journal of Sessions, Congress of Deputies, Commissions, 558, 20 September 1995, p. 16.974).

The deployment of cable networks by region was concentrated strongly in Andalusia, with more than half. This autonomous community had transferred its radio

and television services, which it had managed since 1987 through the Empresa Pública de la Radio y Televisión de Andalucía as a public law entity (BOE, 14–16 January 1988, pp. 1593–1597). The provinces with the most cable networks were Seville (72), Córdoba, Huelva (34), Granada (33), Alicante, Jaén and Malaga (28) and Cádiz (24); outside Andalusia, Murcia (54) and Alicante (28) stood out.

A key element in Telefónica's aspirations to become the fifth largest operator in the world lay in its participation in audiovisual businesses (Telefónica, Memoria 1997, p. 8). Shortly after the beginning of the 1990s, still under the chairmanship of Cándido Velázquez Gaztelu, Telefónica set out to take up positions in the television segment. With this in mind, it drew up plans for the organisation and operation of businesses related to cable television systems, project development and the provision of audiovisual and interactive multimedia services.

Telefónica endeavoured to gain an advantage in the cable TV market before the market was regulated. To this end, it reached an agreement in early 1995 with the country's largest cable group – Promotora de Informaciones SA (Prisa) – whereby the operator provided the cable TV infrastructure and Prisa the content (Político, 17 July 1996). On that front, and by an initial formula for entry, it formed a partnership with Canal + to set up a cable television company called Cablevisión in July 1992, which remained inactive in the absence of an appropriate legal framework. In July 1995 Canal Plus and Sogecable S. A. carried out a concentration consisting of the acquisition of joint control of Cablevisión. The entry of a large number of companies of varying sizes, as well as public entities, into the cable market despite this legal vacuum led the shareholders of Cablevisión to reactivate the company. In a precedent-setting agreement between Telefónica and Canal Plus, by a decision of 9 November 1994, the European Commission vetoed the creation of Media-Service, MSG, a joint venture between the dominant telephone operator in Germany, Deutsche Telekom, Bertelsmann and a major multimedia group, because of the concentration involved and the detrimental effect on equality of opportunity. The decision to suspend MSG was made on the basis of the Basic Treaty of the European Community: Commission Decision of 9 November 1994 relating to a proceeding pursuant to Council Regulation (EEC) No 4064/89 (IV/M.469-MSG Media Service), 94/922/EC. The agreement on MSG was extremely similar to, and even shorter than, that made by Telefónica and Canal Plus. Barcelona City Council has signed an agreement with US West, one of the telephone operators in the United States and the largest shareholder in the Time Warner group, to cable the Catalan capital (El País, 30 July 1995).

From this cornerstone, they created a series of companies that shared the same approach, partners, share capital and even the basic name. All of them had a local or regional scope and in all cases Telefónica participated with 51% of the share capital, which was always valued at 100 million pesetas. We are talking about two companies in Catalan-speaking territory – Societat General de Cablevisió Balears and Societat General de Cablevisió Lleida, one in the Basque Country – Sociedad General de Cablevisión Bizkaia-, one in Navarre – Sociedad General de Cablevisión Navarra-, one

in Murcia – Sociedad General de Cablevisión Murcia- and two in Andalusia – Sociedad General de Cablevisión Sevilla and Sociedad General de Cablevisión Cádiz. Under a second entry formula, Telefónica acquired 29% of the capital in Sociedad General de Cablevisión Madrid and Cablevisión Barcelona from Sociedad General de Cablevisión (LACA, 20 December 1995).

The development of cable television was not without conflict. We have evidence of this in the Small Claims Trial for Unfair Competition against Telefónica and Sociedad General Cablevisión brought by Cableuropa S. A. and the Order of the Court of First Instance No 55 of Madrid, which granted the interim measures requested by Cableuropa, while Telefónica's request for clarification was rejected (LACA, 26 June 1996). The reply extended to the concessions, as was the case with the concession granted to Huelva de Cable y Televisión for the provision of the public cable telecommunications service in the territorial demarcation of Huelva. The Contracting Committee fully accepted the technical and economic criteria of the technical report drawn up by the Technical Services of the Ministry of Development, which stated that the two evaluated bids met the minimum technical requirements established and that the partial scores obtained by the bids submitted. The offer presented by Huelva de Cable y Televisión obtained a higher score (Congress of Deputies, BOCG, D-314, 13 August 1998, p. 233). Without doubt, the fiercest battle for cable was caused by the government's concession to the PRISA group, which was denounced by the competition – Antena 3 TV – and the opposition press as being detrimental to the free competition - collusion and abuse of a dominant position – and to the very development of the cable and information highway industry in Spain and representing the handing over to Canal + of exclusive rights to cable television programming without compensation, the marketing of all the content that would circulate on Telefónica's information highways and the use of the Canal + decoder, which is also considered a technologically obsolete product (El Mundo, 29 July 1995). The strategic agreement between Canal Plus and Telefónica for the development of cable television led to the creation of Cablevisión in July 1992. Canal Plus justified the new company in a notification from the Ministry of Transport, Public Works and the Environment to Telefónica that it could start operating under the cover of a ruling by the Constitutional Court (Release of Canal Plus, 27 July 1995). The Government supported the decision of Compañía Telefónica de España, S. A., to start cable television broadcasting through its subsidiary Cablevisión before the approval of the corresponding bill. The executive justified the decision by the doctrine of the Constitutional Court, which, moreover, limited cable activity to the local level. Appearance by the Minister of Public Works, Transport and the Environment (Journal of Sessions, Congress of Deputies, Commissions, 558, 20 September 1995, p. 16.974). On 8 February 1996, the European Commission notified the Spanish Competition Court, Telefónica and Canal Plus that the agreement of both companies distorted free competition in Spain (Annexe 2). The Commission described the creation of Cablevisión as an operation with a Community dimension, which also raised serious doubts as to its compatibility with the common

market. It also launched an in-depth investigation into the effects of the creation of Cablevisión, before taking a final decision on the authorization, prohibition or licensing under conditions of Cablevisión: European Commission, Press Release, 22 July 1996. Telefónica's alliance with Canal Plus in respect of Cablevisión: the President of Telefónica requested the rapid resolution of the case: LACA, 24 July 1996. On the disputes in the sector (Pérez Gómez, 2011).

Three rulings in the proceedings initiated by complaints from three local cable television companies – Burgos Sistemas de Cable, Santander Sistemas de Cable and Jerez Sistemas de Cable – were in favour of preventing Telefónica from providing services with its infrastructure. The decisions specified Telefónica's obligation to establish the necessary infrastructure to support the various services. Besides, the National Telecommunications Plan provided for the implementation of broadband ISDN from the basic network. In Telefónica's opinion, preventing it from providing services was contrary to the principle of optimising this network and to the doctrine of the Constitutional Court, which favours the freedom to offer local cable television services, and to one of the clauses of the contract with the State (LACA, 29 November 1995).

Conclusion.

This article has analysed the opening up telecommunications to competition and its factors in Spain, a country very committed to the monopoly, in the general context of an accelerated technological change, a sharp regulatory change and an extension of the value chain with new products and services, in particular data, mobile telephony and cable. The study, interdisciplinary in nature and backed on primary sources, has focused on Telefónica's response to new regulatory and market requirements.

The evidence presented leads to the conclusion that the extension of the value chain ran in parallel with successive reorganisations of Telefónica to respond to market demands. Furthermore, the availability of infrastructure has allowed the former monopoly to launch itself on the market before it was regulated, while the absence of regulation has hampered the emergence of new initiatives.

The evidence also reveals a widening of the financial base of new companies that clearly go beyond the traditional field of telecommunications.

Annexe 1. Consortia established to operate in cable television (1995) (Comisión del Mercado de las Telecomunicaciones; Giordano and Zeller, 1999, p. 216).

Cableuropa: BCH, BBV, Banco de Santander, Corporación Industrial Banesto, IBV (Iberdrola BBV) and Multitel Cable (Lince Telecomunicaciones).

Cablevisión: Telefónica, Telecartera, Prisa and Sogecable.

Sevillana de Cable: BCH, BBV, Banco de Santander, Banesto, CAT, Nuintel, Multitel, Sevillana de Electricidad, Sodian and Instituto de Fomento de Andalucía.

Jerez de Cable: Sevillana de Cable, Multitel, Joly de Comunicaciones, CSM (Israeli investor group of communication), Banco Santander, El Corte Inglés, Corporación Municipal Jerez, Taridan and Diario de Cádiz.

Santander de Cable: Electra del Viesgo, Caja Cantabria, Editorial Cantabria, UIH, Ayuntamiento de Santander, Banco Santander and Diario Montañés.

Telecable Compostela: El Correo Gallego, Intelsis and Daviña.

Burgos Sistema de Cable: Caja Círculo Católico, Ical Cable, Diario de Burgos, UIH and Multitel.

Cable del Guadalquivir: Telefónica, servicios multimedia, Abengoa, Grupo Z-Antena 3 televisión, El Monte, Trébol internacional, AF División Imagen and Medios de comunicación sevillanos.

Cable TV Europa: Multimedia Cable, (Catalana d'Iniciatives), Time Warner-US West and TCI.

Grupo Cable: Banco Pastor, Caja de Pontevedra, Caja de Vigo, Caja de Orense, Caja Galicia, Grupo Z, Antena 3-TV, Voz de Galicia, Telefónica, Unión Fenosa and Televés-Intelsis.

Operadora Cable Sistema: Telefónica, Caja Cataluña, Cirsa Group and Antena 3-TV.

Zaragoza de Cable: Bell Canada, Jones Intercable, Mercury, Multitel, Ibertele, Tecnodeasa and Multimedia.

Marbella Cablevisión: Milisat, Int. Network TV and Ayuntamiento de Marbella.

Annexe 2. Disputes arising from the agreement between Telefónica and Canal Plus.

The Court of Competition examined the notification of the concentration submitted in October 1995 by Telefónica, Canal Plus and Sogecable S.A. and submitted a proposal to the Minister for Economic Affairs and Finance to order that the file be referred to the Court for its opinion, on the ground that it might impede the maintenance of effective competition in the Spanish cable telecommunications market. In December 1995, Jerez de Cable SA and Santander de Cable SA denounced Telefónica and Canal Plus for having entered into the abovementioned strategic agreement restricting competition and, moreover, Telefónica for abuse of a dominant position, because they considered that the provision of local cable television services infringed the contract which it had concluded with the State in 1991. The Court found for the most part that the notified operation constituted a strategic alliance of a cooperative nature without the character of an economic concentration from the point of view of national competition law. On the other hand, the European Commission did see an economic concentration with a Community dimension but took the view that the strategic agreement signed between Telefónica and Sogecable/Canal Plus could be separated from the concentration relating to Cablevisión and analysed at the time from the point of view of Articles 85 and 86 of the Treaty on European Union. In view of this situation, and after analysing three possibilities, the Court decided to submit a

report to the Minister of Economy and Finance for referral to the Government, setting out up to five conclusions, the last of which was of a recommendatory nature. To begin with, the Court denied that the operation was an economic concentration from the perspective of the LDC. It also released the Government from the obligation to rule on the operation until a formal decision of the European Commission on the Community or national dimension of the operation was taken. Thirdly, if the Commission refused to intervene because the concentration did not have a Community dimension, the Court considered that the Government should order the opening of disciplinary proceedings in respect of those facts. Fourthly, the Court considered that the operation could not and should not be authorized because the notified agreements would have various adverse effects on free competition in various fields. They would prevent the emergence in Spain of a competitor to Telefónica in the cable business, close the market to potential competitors of Eurodec in the decoders sector, Cablevisión in the supply of services to cable operators and Canal Plus in the programming field. The end result would be reduced consumer choice and increased prices (Merger Court Report, CNMV, C21/95: CABLEVISION, 14 March 1996).

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Лібералізація телекомунікацій і розширення ланцюжка доданої вартості в Південній Європі. Telefónica, 1982-2000 роки

Анотація. *Ця стаття розглядає історію конкуренції телекомунікаційних систем в Іспанії (країні, яка має серйозні монополістичні тенденції) і фактори,*

що визначають цю конкуренцію. Стаття аналізує загальний сценарій прискорення технологічних змін, викликаних новими матеріалами, компонентами і системами передачі, різкими змінами в законодавстві і розширенням ланцюжка створення вартості за рахунок нових продуктів і послуг, зокрема баз даних, мобільного телефонного зв'язку і кабелю. Зазначені вище властивості ідеально вписуються в обрану тимчасову вісь, яка охоплює два останніх десятиліття 20-го століття і збігається з етапом, на якому конкуруючі компанії зіткнулися з проблемою не тільки лібералізації, але й глибоких змін параметрів ринку. Основна увага в дослідженні приділяється розгляду відповідних кроків компанії Telefónica на нові нормативні та ринкові вимоги. Методологічно дослідження має мультидисциплінарний характер, який об'єднує підходи історії техніки, що розуміється як система (Томас П. Хьюз і Мелвін Кранцберг), і історії економіки та бізнесу (Натан Розенберг). Текст складається з чотирьох розділів, в яких досліджується збереження монополії Telefonica і лібералізація, осі трансформації Telefónica через глобальні та стратегічні плани і розширення ланцюжка створення доданої вартості з упором на кабельний ринок. Розглянуто деякі попередні історичні та технічні питання та ключові елементи еволюції сектора. У статті розглядаються відносини між ринковою структурою, успадкованої від монополії, і процесом, з якого виникають переваги компанії Telefónica в порівнянні з іншими компаніями. Дослідження ґрунтується в основному на первинних джерелах вивченої компанії, які вдвічі цінніші, бо вони важкодоступні для дослідників і повністю ілюстративний для розуміння стратегії компанії, а також на звітах великих міжнародних організацій та вторинної літературі. Автор приходить до висновку про наявність тісного зв'язку між факторами попиту і пропозиції.

Ключові слова: *лібералізація телекомунікацій; Telefónica; кабельне телебачення; ланцюжок значень*

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Либерализация телекоммуникаций и расширение цепочки добавленной стоимости в Южной Европе. Telefónica, 1982–2000 годы

Аннотация. *Эта статья рассматривает историю конкуренции телекоммуникационных систем в Испании (стране, которая имеет серьезные монополистические тенденции) и факторы, определяющие эту конкуренцию. Статья анализирует общий сценарий ускорения технологических изменений, вызванных новыми материалами, компонентами и системами передачи, резкими изменениями в законодательстве и расширением цепочки создания стоимости за счет новых продуктов и услуг, в частности данных, мобильной телефонной связи и кабеля. Указанные выше свойства идеально вписываются в*

выбранную временную ось, которая охватывает два последних десятилетия 20-го века и совпадает с этапом, на котором конкурирующие компании столкнулись с проблемой не только либерализации, но и глубокого изменения параметров рынка. Основное внимание в исследовании уделяется рассмотрению ответных шагов компании Telefónica на новые нормативные и рыночные требования. Методологически исследование имеет мультидисциплинарный характер, который объединяет подходы истории техники, понимаемой как система (Томас П. Хьюз и Мелвин Кранцберг), и истории экономики и бизнеса (Натан Розенберг). Текст состоит из четырех разделов, в которых исследуется сохранение монополии Telefonica и либерализация, оси трансформации Telefónica через глобальные и стратегические планы и расширение цепочки создания добавленной стоимости с упором на кабельный рынок. Рассмотрены некоторые предварительные исторические и технические вопросы и ключевые элементы эволюции сектора. В статье рассматриваются отношения между рыночной структурой, унаследованной от монополии, и процессом, из которого проистекают преимущества компании Telefónica по сравнению с остальными компаниями. Исследование основывается в основном на первичных источниках изученной компании, которые вдвое более ценны, потому что они труднодоступны для исследователей и полностью иллюстративны для понимания стратегии компании, а также на отчетах крупных международных организаций и вторичной литературе. Автор приходит к выводу о наличии тесной связи между факторами спроса и предложения.

Ключевые слова: *либерализация телекоммуникаций; Telefónica; кабельное телевидение; цепочка значений*

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Stages of technological improvement of the process of continuous casting of iron-carbon and copper billets

Abstract. *In the article there are presented the stages of improvement of the process of continuous casting. It is revealed, that at the each stage of technological improvement of the process of continuous casting, the damage parameters of billets were reduced. Improvement of the process of continuous casting leads to the improvement of the mechanical properties of the billets and the performance of continuous casting machines. The first stage is shown as the process of transition of the number of experimental developments into quality, during which the casting of billets passed from an unstable process to a stable one. The second stage is characterized by the creation of new improved continuous casting processes. So, besides the existing machines of the vertical type, radial, curvilinear and horizontal casting machines were invented. By the end of the twentieth century, this technological process reached the limit of the possibilities for increasing the quality of performs, and the productivity of continuous casting machines. It is shown that the third stage is intended for continuous casting of copper alloys and is based on the influence of the frequency of the movement of the billets and the reverse movement of the perform during overcoming the static friction force. It was determined that for the frequency of*

movement of billets made of copper alloys, which are in the range of 2.5 ... 7.5 min^{-1}, the direction of its movement during overcoming the static friction affects the mechanical properties of the billet. The fourth stage - causes an increase in the mechanical properties of the billet *due to the use of inertia forces in the alternating movement of the* billet*. It was revealed that at the fourth stage the mechanical properties of the* billets *increased most effectively, and the linear performance increased from 0.4 ... 0.8 to 2.5 ... 4.0 m/min, and in some cases to 5.0 ... 7.0 m/min*.

Keywords: *continuous casting of billets; reverse and forward motion; copper alloys; damage parameter*

Introduction.

Currently, the process of continuous casting is gaining immense popularity. For example, in 1990, when analyzing the usability of this process, it was shown that in all industrialized countries, from 88 to 95% of all the smelted metal and alloys were cast on continuous casting machines. Over the past 20 years, the linear productivity of continuous casting of steel billets has increased from 0.8...1.0 to 4.0...6.0 m/min. Today many scientific researchers of continuous casting are concern with the ways of improvement of the mechanical properties of the billets, which lead to high linear productivity of continuous casting machines without reducing the quality of the billets. These and other similar questions determined the relevance of this study and prompted to analyze the entire history of improving the continuous casting process from the point of view of the development of technological capabilities of the continuous casting process, which arose in parallel with the development of the science of damage to materials, namely the theory of continual damage.

We propose to divide the entire path of development of the continuous casting process from its origin to the present day into four stages.

1. The first stage - the transformation of the number of experimental developments that combine the design of machines and technological processes of continuous casting during the transition from an unstable process of production of billets into a stable process.

2. The second stage: expansion of opportunities for the continuous casting process within the created interval of the rheological state of the billet, due to the current cyclogram of the operation of the continuous casting machine and reaching the limit of possibilities for increasing the quality of the billets and the productivity of continuous casting machines.

3. The third stage is an insignificant increase in productivity of a horizontal continuous casting machine (HCCM), an increase in the mechanical properties of billets from copper (and non-ferrous) alloys and a change in the rheological state of the billets due to a change in the direction of movement of the billet during overcoming the friction and static force frequency of movement from 2.5 to 7.5 min^{-1}.

4. The fourth stage causes a change in the rheological state of the billet and an increase in the mechanical properties of the billets by reducing the parameter of its

damageability, which depends on a significant increase in the frequency of movement of the billet to 120...150 min^{-1} and the use of inertial forces during alternating movement of the billet aimed at mechanical effects in the emerging billet.

Thus, the main task of our work is to confirm the coincidence of the next reduction in the damage of the billet and the declared next improvement of the continuous casting process, as well as to show the connection of the reduction in the damage of the billet with some changes in the control of the speed of the billet and the direction of movement of the billet in the cycle.

Experimental and theoretical methods.

For the first time, the technology of producing billets was created and patented in 1826. In the work (Schwarzmeier, 1962, p. 62) it is indicated that the patent under No. 3023 under the name "Lead pipes" was obtained by J. Lying in the United States of America in 1826. The process of continuous casting efficiently differs from the process of casting into molds in that the billet is continuously moving along the stationary water-cooled wall. As a matter of fact, an analog of the conveyor production of billets was developed, which according to calculations made it possible to significantly increase the productivity of the created machine and increase the yield of casting from 65...70% to 90...94%.

At the end of the 19th century, the growing demand for industrial billets required manufacturers to create a new technological process for producing billets with higher productivity of the manufacturing process and a higher density of billets and usable casting yield. The disadvantage of the process with non-stop motion of the billet was that fatigue processes were not studied in the billets located in the crystallization temperature range, which led to the appearance of micro cracks and their rapid development. As a result, a billet was obtained, which cannot be further processed or a breakage" of the billet was obtained in the plane perpendicular to the axis of the billet, which caused the termination of the casting process. During the time from the first patent to the continuous casting method to the present day, the continuous casting process has evolved from an unstable process to a stable, automated continuous casting process.

Periodically, industrial enterprises impose demands on producers of billets to increase the productivity of continuous casting machines and improve the quality of billets. Apparently, these requirements were once again voiced in the 30s, the results were obtained in the middle of the 50s. This can be confirmed by the quotation by V. Schwarzmayer, who in 1957 in the preface to the German edition of the book «Continuous Casting» wrote the following: « ... in the last 25 years, several methods have been practically applied, further improved by certain companies» (Schwarzmayer, 1962, p. 68).

The horizontal continuous casting machine built by the Ukrainian Research Institute of Metals for the Leninskaya Kuznitsa plant in the 1980s looked like this, Fig.1. At that time, the "movement – pause" cyclogram was laid in the HCCM, as in

all continuous casting machines of the former USSR. This machine worked from 1984 to 1991.

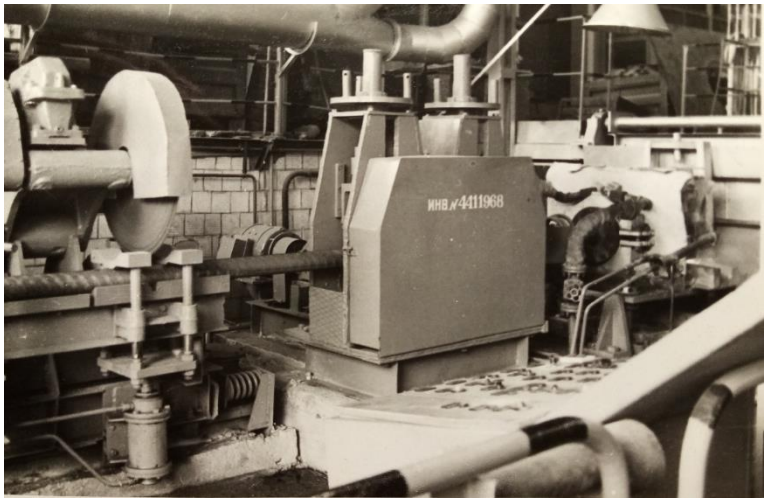

Figure 1. Horizontal continuous casting machine for copper alloy billets (Author's photo).

The main method for determining the damage parameter of copper alloys billet of the BrT5Z5L5, BrO10P, and BrAl9I3C made on a horizontal continuous casting machine at the frequency of the billet movement in the range of 2.5...7.5 min^{-1} and at different directions of movement of the billet during overcoming the force of static friction. Most often, to determine the damage parameter of continuously casted billets, the following operations were performed:

- production of billets for copper alloys samples of the BrT5Z5L5, BrO10P and BrAl9I3C with various technological parameters of the continuous casting process according to the following scheme on an experimental machine for horizontal continuous casting (Fig. 2).

Figure 2. Experimental machine of horizontal continuous casting of copper alloy billets «Energoprom» LLC (Author's photo).

At this horizontal continuous casting machine, bronze billets of BrT5Z5L5 with a diameter of 0.5 m were obtained at various frequencies of the movement of the billet. It was necessary to conduct statistical studies to determine creep. 30 samples were made for each frequency of the movement of the billet listed in the Table 1.

Table 1. Planning the modes of movement of billets for making samples for testing.

Name of copper alloys	Billets movement frequency, *f*, min^{-1}	The direction of movement of the billets while overcoming the static friction force	Number of billets for samples, pcs
BrO5Z5C5	2,5	Reverse	30
	5,0		30
	7,5		30
	2,5	Progressive	30
	5,0		30
	7,5		30

– tensile test according to GOST All-Union State Standard 1497-84 (Metals, 1984);
– creep test according to GOST All-Union State Standard 3248-81 (Metals, 1981).

For a better understanding of the processes occurring in the sample during testing, in table 2 we give the chemical composition of bronzes of various grades, from which the test samples were made. For convenience, in this table, each chemical element is designated by generally accepted chemical symbols.

Table 2. The chemical composition of the applied bronzes.

Bronze grade	The chemical composition of the main components, (wt%)						
	Sn	Al	Zn	Pb	Fe	P	Cu
BrO5Z5C5	4.0–6.0	–	4.0–6.0	4.0–6.0	–	–	additives
BrO10P	9.0–11.0	–	–	–	–	0.4–1.1	additives
BrA9I3C	–	8.0–10.5	–	–	2.0–4.0	–	additives

Thus, as it was shown by experiments of testing samples on an AIMA 5-2 machine, as the temperature increases (T_L) from (0.3...0.5) T_L to (0.9...0.95) T_L, the creep rate of the viscous portion of the billets, which is located in the mold, increased tens of thousands of times. Given these conditions, for the implementation of these tests, a new way to test samples at temperatures (0.9...0.95) T_L and improved standard equipment were developed and patented (Fig. 3), (Khoroshylov, Ponomarenko, & Shatahin, 2006a; Horoshilov & Ponomarenko, 2007).

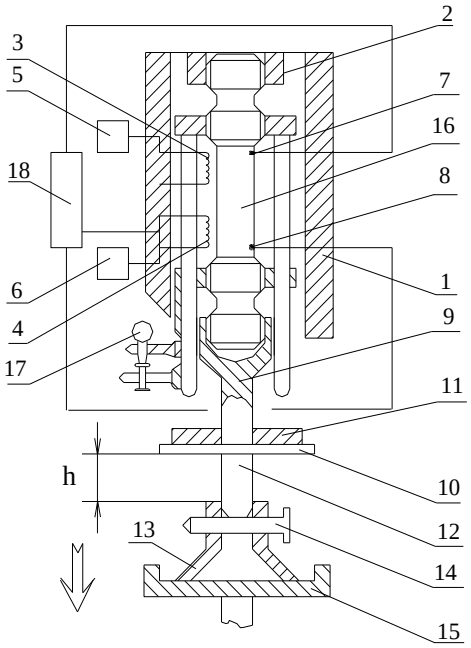

Figure. 3. Scheme of an improved machine for testing specimens of copper alloys in the temperature range (0.9–0.95) T_L (Horoshilov & Ponomarenko, 2007): 1 – cylindrical heat-shielding casing; 2 – top link; 3,4 – upper and lower electric heaters, respectively; 5,6 – temperature regulators for the upper and lower electric heaters, respectively; 7, 8 – upper and lower thermocouples, respectively; 9 – thrust of direct loading; 10 – cargo; 11 – vertical rod; 12 – support; 13 – horizontal bar; 14 – plate of thermal stress compensator; 15 – sample for testing; 16 – deformation indicator 17 – block for comparison of temperatures from thermocouples.

At this horizontal continuous casting machine, bronze billets of Br T5Z5L5 with a diameter of 0.5 m were obtained at various frequencies of the movement of the billet. It was necessary to conduct statistical studies to determine creep. 30 samples were made for each frequency of the movement of the billet billets in the Tab. 3.

Table 3. Planning the modes of movement of billets for making samples for testing.

Name of copper alloys	**Billets movement frequency *f*, min^{-1}**	**The direction of movement of the billets while overcoming the static friction force**	**Number of billets for samples, pcs**
BrO5Z5C5	2,5	Reverse	30
	5,0		30
	7,5		30
	2,5	Progressive	30
	5,0		30
	7,5		30

Statistical processing of the results of measurements of creep indices in the crystallization temperature range (Horoshilov, Mel'nichenko, & Segal, 2017):

– to determine the damage parameter of samples from the indicated grades of copper alloys that are in the crystallization temperature range (0.9...0.95) T_L, we use the Bailey-Norton and Rabotnov-Kachanov formula (Bailey et al., 1968; Kachanov, 1958; Orowan, 1952; Rabotnov, 1959):

– there is a special technique for determining the coefficients for equations (1) and (2), described in (Breslavskij et al., 2007; 2008), and according to which experiments should be carried out according to the data presented in Table 4.

Table. 4. Timing of destruction of samples at two boundary temperatures T_1 and T_2 and two boundary pressures σ_1 and σ_2.

№	Temperature T, °C	Pressure σ, MPA	Time t, s
1	T_1	σ_1	Specific experimental values
2	T_1	σ_2	Specific experimental values
3	T_2	σ_1	Specific experimental values
4	T_2	σ_2	Specific experimental values

Since in the crystallization temperature range, creep is the main mechanism of deformation and fracture, then from the data presented in Table. 2 (at the time of destruction time known from experiments) there is a method for determining the coefficients n, k, β_0, which is described in (Breslavskij et al., 2008):

– processing the results of experimental studies to determine the creep of the samples before their destruction obtained at various technological parameters of the continuous casting process were obtained by the following method described in (Horoshilov, Mel'nichenko, & Segal, 2017);

– based on experimental studies to determine the degree of increase in the mechanical properties of the billet as by increasing the duration of the pause (with the cyclic movement of the billet), and due to a complex action: increase the frequency of movement of the billet and the direction of movement of the billet during overcoming the static friction force (Khoroshylov, 2013, p. 22).

Results and its discussion.

The main condition by which we will determine the emergence of a new stage in the improvement of continuous casting is a slight decrease in the damage parameter of the billets. Reducing the damage parameter allows you to change the rheological state of the billet, which allows you to improve the mechanical properties of the billet, and this in turn allows you to improve the performance of the continuous casting machine.

Due to the fact that in the process of continuous casting there are two opposite actions, that is why the following rule can be applied to this casting process: changes in the mechanical properties of the billets (by reducing the damage parameter) follow

the change in the sequence of technological operations. This rule is valid for any stage of technological improvement of the continuous casting process.

The first stage is the stage of unstable operation of continuous casting machines, turning the number of experimental studies from the first quarter of the nineteenth to the sixties of the twentieth century into an increase in the stability of the continuous casting process, the quality of the billets and an increase in the productivity of continuous casting machines. Despite the fact that the first patent for the design of the machine and the implementation of the continuous casting process was obtained in the first quarter of the nineteenth century, however, a more meaningful improvement to the process already created was started only in the end of XIX till the beginning of XX.

The most active in those years was the work on mastering the process of continuous casting in Germany. The first patent in Germany, according to (Schwarzmeir, 1962, p. 9), was a mold for casting wire, which in 1883 was received by E. Levanser (1882) from Paris. Thus, from 1883 to 1913, 36 patents were registered in Germany, with many applicants from such countries as Britain, the United States, and France. It could only mean that in the four countries there was a powerful industrial complex, which allowed itself to build patented continuous casting machines. At that time, the theoretical and practical issues of reducing the rate of fatigue in metals and alloys did not find wide applications in industry. The time for the emergence of progressive methods for casting billets came only when it was necessary to organize the production of billets on an industrial scale from alloys, to which higher demands were placed on their mechanical properties.

In 1914, a patent (Person, 1913) for a method and device for the vertical semicontinuous casting of tubular billets with the help of a crystallizer that billets reciprocating movements. This method was simultaneously patented in Germany, Britain, the USA and Austria. Vertical continuous casting with a "swing" of the mold formed a separate direction, which was constantly improved and began to appear in other countries (Person, 1913). It should also be noted that, until 1963, vertical-type continuous casting machines were used on an industrial scale, in which the billet was formed and cut on a vertical section.

It must be said that the significance of this technical solution Person "mold swing" will be disclosed later. In order to preserve the "swinging of the mold" in the vertical plane, the designs of the continuous casting machines will be changed. However, it is necessary to take into account the technological necessity, in which the vertical axis of the workpiece should be maintained at the inlet of the melt to the mold, and at the exit of the workpiece from the machine, it should have a horizontal axis.

In the same period, a patent was obtained for a method for the production of billets from metals prone to cracking, which was claimed in 1944, and obtained in 1953 (Schorndorf, 1944). In the same period, two more technical solutions registered in German patents were developed. So in 1939, H. Ruppik (Germany) filed a patent (Ruppik, 1939) for the method of continuous casting of steel billets, and in 1953,

P. P. Brenner received a patent (Brenner, 1942) for a method of casting billets of unlimited length.

From this it follows that at the first stage of technological improvement of the continuous casting process by the middle of the 50s, technical solutions were obtained that allowed reducing the damage parameter of the billet – these are patents (Brenner, 1942; Person, 1913; Schorndorf, 1944), on the basis of these technical solutions it is also possible to cast steel billets. There is also a British patent and a US Patent for a continuous casting plant (Mellen, 1915) with a priority date of 1915 and 1916, but after this message, there was no tangible development of events on the issue of continuous casting of steel due to the unsatisfactory stability of the continuous casting process. As the author (Shatagin, Sladkoshteev, & Vartazarov, 1974, p. 88) points out, with non-stop movement of the billet from copper alloys during continuous casting "even at very low casting speeds of the order of 0.05…0.13 m/min, the process was stopped at the very beginning due to the breakage of the billet (Fig. 4). On the basis of 60 experimental castings, it was established that the stability of the casting process is ensured when the billet moves with periodic stops. In the middle of the 60s of the XX century, the authors of work (Shatagin, Sladkoshteev, & Vartazarov, 1974, p. 76) developed the process of continuous casting of copper alloy billets for horizontal machines.

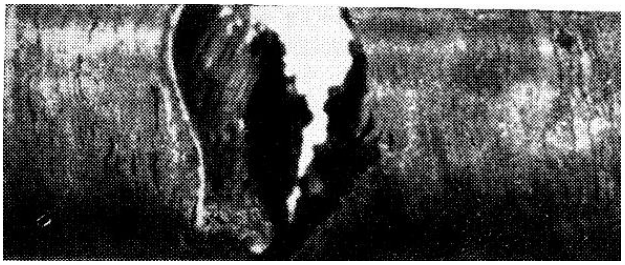

Figure 4. Billet, which was taken from the non-stop movement (Shatagin, Sladkoshteev, & Vartazarov, 1974, p. 76)

The second stage began in the period from the mid-60s to the 90s of the twentieth century. The active development of the developed technologies takes place. A brief classification of methods for the production of billets is presented in Fig. 5.

In the late 50s, articles were written on the issue of creep, damage, and long-term strength. In the 60s...70s the books of Y. N. Rabotnova, L. M. Kachanova and I. I. Malinin appeared (Katshanov, 1974; Malinin, 1975; Rabotnov, 1966). After that, the theory turned into a practical plane. Standardization of Bailey-Norton and Rabotnov-Kachanov on the determination of damage parameters for structural materials, systems at a temperature from 0.3 to 0.5 liquidus temperature (T_L) of the alloys under study.

In the 1980s, an idea emerged about determining the damage parameter of a viscous section of a solidifying billet in order to control the damageability of the billet using the technological parameters of the continuous casting process. To estimate the

value of the damage parameter at all stages of technological improvement of the continuous casting process, a unique method was used at all stages to determine the rheological state of the billet based on the Bailey-Norton and Rabotnov-Kachanov equations to estimate the damage parameter of continuously cast billets (Bailey et al., 1968; Kachanov, 1958; Orowan, 1952; Rabotnov, 1959).

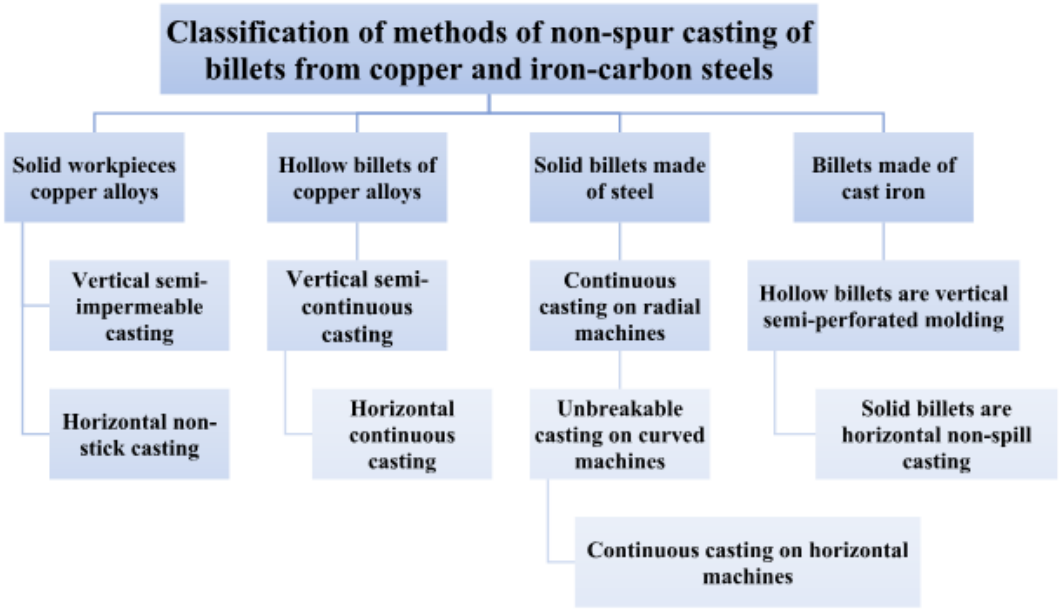

Figure 5. Classification of methods of non-spur casting of billets from copper and iron-carbon steels

Before determining the parameter of damage to the billet, depending on the continuous casting conditions, it is necessary to determine the forces acting on the billet on the experimental machine, and then on the testing machine at the temperature corresponding to the crystallization temperature interval, determine the creep rate with the corresponding force acting on the billet. After that, according to the method described in (Breslavskij et al., 2008), the damage parameter was determined.

For the calculation of stress fields, deformations, displacements, and a parameter of damage, software programs designed to solve creep problems under a two-dimensional stress state are usually used. The analysis of the obtained results shows that the processes of damage accumulation slow down with the further solidification of the local part of the billet (Breslavskij et al., 2007).

Analyzing (Shatagin, Sladkoshteev, & Vartazarov, 1974, p. 88) the basic technological parameters of horizontal continuous casting of 140 experienced castings of solid and hollow bronze billets, the authors indicate that «...with the periodic pulling of solid billets, it was possible to immediately increase the casting time to 13 hours and 12 minutes». For hollow billets, casting time increased from 12 minutes to 10 hours and 45 minutes.

In addition to the technical re-equipment of the metallurgical complex and an intensive experimental search in the developed countries of the World, in 1952, 1958, and 1959 the works of such scientists in the field of damage zone (destruction of metal structures) were published. Such scientists as E. Orowan, L. M. Kachanova and Y. N. Rabotnova, and in 1968, there were published the works of the following authors: P. B. Bailey. These works will further be the basis for creating formulas for determining the parameter of damageability of metal structures. One of the varieties of these formulas:

$$\varepsilon = \beta_0 \cdot \sigma^n \cdot \exp(k_1 \cdot T)\, t\,, \tag{1}$$

$$\sigma_* = \frac{K \exp(k_2 \cdot T)}{t_*} \tag{2}$$

where ε is a creep test sample, %; σ is a stress in the sample, MPa; σ_* is a long-term strength, which is the stress in the cross-section of the billet, leading it to destruction over time t_*. T – test temperature, °C; t is the current time, sec.; K, β_0, n, k_1, k_2 are empirical coefficients.

Based on experimental data, empirical coefficients were obtained (Breslavskij et al., 2007; 2008). For this purpose, experimental studies have been carried out in the temperature range of crystallization to determine the dependencies of damage (creep) as a function of temperature and time. As a result of these data, a methodology was developed for determining empirical coefficients. It is shown in the works (Breslavskij et al., 2008) and (Khoroshylov, 2013, p. 21), a change in the sequence of technological operations in the process of continuous casting, which led to a decrease in the parameter of damageability of the billet. The reasons preceding the change in the sequence of technological operations were that, after a pause, the beginning of the movement in the subsequent cycle was associated with overcoming the force of static friction. The tensile force acting on the billet during the overcoming of the friction force of rest (FFR), 2 times greater than the effort to overcome the force of sliding friction. This suggests that during the overcoming of the FFR, the rate of damage to the billet increases significantly. So, during the overcoming of the FFR, microcracks are likely to form, which develops during the overcoming of the sliding friction force, forming already visible cracks.

This results of experimental studies presented in the work (Khoroshylov, 2013, p. 22), in which the phenomenon of reducing the parameter of damage to the billet when using reverse movement while overcoming the static friction force with the frequency of its movement in the mold 2.5...7.5 min^{-1}, is identified.

At the same time, it was not previously taken into account that, after a pause during the start of the movement, the billet must overcome the force of static friction. As it was shown in the work (Khoroshylov, 2013, p. 23; Khoroshylov, Podolyak,

Kuryliak, Kipensky, & Lomakin, 2020) in which, during the overcoming of the friction force of rest in the cross-section of the billet, there are forces that are 1.42–2.0 times greater than the force of sliding friction. It is known that during the cyclic movement of the billet inside the mold, a force is applied to the billet, which is able to overcome the force of static friction. Therefore, the reason for the occurrence of microcracks lies precisely at the moment of overcoming the friction force of rest under the condition of the translational movement of the billet. After the formation of a microcrack during overcoming the force of sliding friction, the microcrack develops and turns into a crack.

In the work (Breslavskij et al., 2007), it was decided that in order to avoid the appearance of microcracks while overcoming the static friction force, it was decided to make a reverse movement. During the reverse movement, the overcoming of the friction force at rest occurs during the compression of the billet, this significantly reduces the possibility of microcracking. It was tested both on the experimental and industrial continuous casting machines at LLC «Energoprom», Kharkiv. During the tests of technological parameters of the continuous casting process, according to the researchers, the indicators of the speed and step size of the reverse movement of the billet were rational to use and were patented (Horoshilov et al., 2008; Khoroshylov, Ponomarenko, & Shatahin, 2006a; 2006b). However, the quality of the charge currently in circulation does not allow to obtain billets with acceptable mechanical properties that could be obtained earlier.

Refusal of non-stop movement of continuously cast billets became possible after obtaining a patent (Person, 1913), in which the technological process of vertical semi-continuous casting (intermittent casting) was developed using the reciprocating vertical mold and the design of a semi-continuous casting machine.

As the author of (Khoroshylov, 2013, p. 1) points out, the Ukrainian Scientific Research Institute of Metals (USRIM) V. Sladkoshteev, O. Shatagin played a major role in creating horizontal continuous casting machines for billets of iron-carbon and non-ferrous alloys. However, the first specialists in the USSR to create horizontal machines were the brothers A. N. Myasoedov and A. N. Myasoyedov (Myasoyedov, 1939), although their research is little known. Indeed, there are copyright certificates relating to this period of work USRIM (Sladkoshteev, Shatagin, & Krupennik, 1965; Sladkoshteev et al., 1967; Sladkoshteev, Shatagin, & Vartazarov 1968a; 1968b; Sladkoshteev et al., 1968) in which the sequence of inventive work of the institute is displayed.

A distinctive feature of the continuous casting of non-ferrous alloys is that the billet is in contact with the intermediate graphite bushing, in contrast to the fact that steel billets should be cast only in copper crystallizers. A graphite sleeve paired with a hardened billet of copper alloys has a friction coefficient (FC) of about 0.1, and a pair of copper (crystallizer) – low carbon steel (billet) FC – 0.36.

In the 1960s, in spite of the fact that the origins of the theory of continual damage appeared, the need to pause during continuous casting was heuristically justified, probably by V. T. Sladkoshteev and O. A. Shatagin. The sequence diagram with a

pause duration allowed the horizontal positioning of the mold, both for casting non-ferrous and for iron-carbon alloys. In those years, it was problematic to create a horizontal "swinging" mold due to the sliding joint of the metal receiver and the mold.

In addition, in the same years, machines with various technological processes for the production of pipes were also built for the casting of cast iron billets of standard length. So in 1964, work appeared on mastering the production of pipes on centrifugal casting machines, and four years later, in Belarus, a plant was built for continuous casting of cast iron pipes using the method of vertical semi-continuous casting with a "swinging" mold (Ivanov & Baranov, 1968, p. 176; Baranov, 1968, p. 124). The advantage of these processes is that the yield of continuous casting is 10...12% higher than that of centrifugal.

The desire to reduce the height of the vertical continuous casting machine has led to the creation of installations of radial and curvilinear types. On the radial caster, the mold and the secondary cooling device guides are located on an arc of a certain radius. At the end of the radial section, the billet passes through the correcting and pulling rollers and is brought to the horizontal position, in which cutting to measured lengths is performed. On a curvature-type caster, the mold and a part of the secondary cooling zone have a constant radius, then the radius increases, and the billet gradually straightens.

HCCM of radial and curvilinear types, in which the incompletely hardened billet goes to the horizontal section. This allows you to significantly increase the speed of continuous casting with large sections of the billets, since the cutting site can be located at a sufficiently large distance from the mold (30-35 m). The total height of such installations, as a rule, does not exceed 12 m (Kovrjakov, 2004, p.13; Nikiforov, Vdovin, & Piksayev, 2004; Yamaguchi, Sawai, & Nakashima, 2013, p. 7).

With the horizontal arrangement of the mold, it was decided to abandon its forward-return motion. In the cyclogram of the movement of the billet it was significantly increased the duration of the pause. From the data presented in the work (Berner & Kronmyuller, 1969, p. 89) on the basis of pilot industrial studies, the duration of the pause afterward began to exceed the duration of the translational movement of the billet in 3...4 times.

Refusal from the non-stop movement of continuously cast billets could theoretically be possible after the publication of papers: (Bailey et al., 1968; Kachanov, 1958; Orowan, 1952; Rabotnov, 1959) in which the mechanisms of crack development are considered and mathematically described and are estimated long-term strength using a sample with a crack perpendicular to the direction of stretching. Indicators that affect the damage to the billet are presented in this work. The most common type of damaged billet is a crack, it is caused by the creep of the test specimen, equation (1). In turn, creep is influenced by the stress in the cross section of the sample (fig. 2 item 16), temperature, which affects the strength properties of the test specimen and the time the voltage is applied to the sample. Equation (2) is the long-term strength of the material of the billet or sample, which in turn is represented by specific stress in the

cross-section of the billet. This voltage should lead to the complete destruction of the sample or billet over time (Breslavskij et al., 2008).

Ten years later, monographs on the subject of continuous casting of steel billets and billets of copper alloys were published (Shatagin, Sladkoshteev, & Vartazarov, 1974, p. 7; Shatagin & Sladkoshteev, 1976, p. 5), which identified the advantages and disadvantages of operating continuous casting machines.

The first stage of improving the continuous casting process (ICCP) implies two cases of changing the sequence of technological operations. In the first case, this is a change in the non-stop movement of the billet on a forward-return ("swing" of the mold) and the second case is a change in the non-stop movement of the billet on a cyclical movement, with time out for pause. In these two cases, the researchers gradually reduced the damage parameter of the continuously cast billet to a certain value corresponding to the level of technological development.

«Swinging» (alternating movement) of the mold is a translational-return movement of it, in which, despite the non-stop movement of the billet, the speed of movement of the mold relative to the billet has a variable value at which the minimum speed of their relative movement is zero. It should be noted that on a vertical continuous casting machine, the billet moves at a constant speed, and the mold makes up and down cyclical movements. When moving up the mold creates tensile stress in the billet, contributing to the appearance of deformations and microcracks in the frame of the billet, and when moving down the mold creates compressive stresses in the billet that contribute to the closure of microcracks. The “swinging” of the mold introduced into the first stage of the ICCP an increase in the frequency of the billet movement relative to the mold up to about 30...60 min^{-1} (once a minute), as well as the possibility of stopping the billet, due to which the movement of the billet appeared to be cyclical and decrease its destruction rate in comparison with the non-stop movement).

In addition, as indicated above, the translational movement of the mold due to the compression force can completely or partially close the microcracks that appear, which in turn improves the mechanical properties of the billets (Person, 1913). Therefore, in the same time period, a patent was obtained for a method for the production of billets from metals prone to cracking, which was claimed in 1944 and obtained in 1953 (Schorndorf, 1944).

As follows from the literature, in the period from the mid-10s to the 50s...60s of the twentieth century, the following stages of the first stage of the technological ICCP were carried out, which made it possible to reduce the damageability:

1. It became possible to carry out the reciprocating-progressive movement of the mold relative to the billet (Person, 1913);

2. Getting a method for producing a billet of unlimited length means the appearance of several things:

2.1. Firstly, billets of unlimited length from non-ferrous alloys can be obtained only on machines of the horizontal type;

– for horizontal casting, the cyclogram of operation of a horizontal continuous casting machine did not apply the “swinging” of the mold, and the movement of the billet was carried out according to the scheme: “movement – pause”;

– the appearance of a pause in the cyclogram made it possible to regulate the mechanical properties of the billets (the methods for regulating which are discussed below);

2.2. Secondly, for the continuous casting of steel billets, the design of a radial continuous casting machine was created. The design assumes to combine the positive qualities of the "swinging" mold and bring the technological axis of the billet (or slab) into a horizontal plane, which will allow obtaining billets of unlimited length.

The second and third stages of improving the continuous casting process are based on the development of patents (Person, 1913; Ruppik, 1940). Patent (Person, 1913) has allowed ensuring an acceptable quality of the billets and the speed of continuous casting on vertical continuous casting machines when the mold is “swung”. At present, vertical semicontinuous casting machines are still preserved for casting their cast iron hollow billets. However, there are drawbacks of a constructive solution with a vertical technological axis of the billet:

– this design limits the length of the cast billet.

– creates a danger in the delivery of molten metal to a height of more than 20...30 m;

The second patent (Ruppik, 1939) provided for obtaining billets of unlimited length. At the moment, there are two options for obtaining billets of unlimited length.

Benefits:

1. In the technological plan, instead of the non-stop movement of the billets, it was carried out:

– in the case of vertical continuous casting, the non-stop movement of the billet is replaced by alternating cyclic movement (“swing” of the mold);

– for the created horizontal process of continuous casting with the cyclic movement of the billet according to the “movement-pause” scheme, time was paused, and the duration of the pause was 3...4 times longer than the duration of the translational movement of the billet.

2. Changing the design of the continuous casting machine. After 1963, a horizontal continuous casting machine for casting non-ferrous and iron-carbon alloys was created in USRIM (Kharkiv). The height of the continuous casting machine for non-ferrous alloys had a height of 1.75...2.5 m. This allowed the horizontal continuous casting machine to be positioned in almost any workshop of the machine-building complex during its reconstruction.

Disadvantages:

1. Cracks continued to appear on the surface of the billets even after the introduction of a new technology, both when exceeding the allowable productivity for

this stage of improving the continuous casting process, and when using secondary materials in the manufacture of billets.

2. It has been determined that the appearance of cracks is influenced both by the composition of the charge of the billet and the modes of operation of continuous casting machines.

3. As it turned out later, the HCCM cyclogram with a pause limited the productivity of machines at 0.5...0.3 m/min, in the production of billets of copper alloys with a diameter of 0.08...0.1 m and up to 0.4...0.8 m/min in the production of steel billets square size 0.15×0.15 m.

Let us accept the following assumption that the third and fourth stages of development conditionally began in the 1990s...2000s with a change in the frequency of movement of the billet in the mold. In work (Valuev, 2014, p. 200) it is reported that as of 2000, "The experience accumulated all over the world showed that at higher casting speeds (V = 5.2 m/min) the quality of cast billets is the same or even better than when casting at normal speeds. This work was done by «Voest-Alpine-Stahl» (VAS, Austria).

The third stage refers to the improvement of the process of continuous casting of billets from copper alloys in conditions of an increase in the frequency of movement of the billet, and the fourth stage refers to the improvement of the casting process of iron-carbon metals and alloys. These stages are very different from each other.

To increase the productivity of horizontal continuous casting machines, new mold designs and continuous casting methods were developed for the Karaganda Metallurgical Plant (Kazakh SSR). So, in the 80s of the last century, the following copyright certificates were obtained by the staff of the foundry department of the Kharkiv Polytechnic Institute (Shatagin et al., 1985). This method was conceived as a method and device for increasing the productivity of the HCCM from steel to points above 1.0 m/min.

Substantial efforts of specialists from USRIM were subsequently concentrated on developing the concept of horizontal continuous casting machines for metal, which became widespread in non-ferrous metallurgy. It should be noted that the experimental studies, which resulted in obtaining author's certificates (Sladkoshteev, Shatagin, & Vartazarov 1968a; 1968b), were carried out on a horizontal continuous casting machine built by USRIM specialists at the Karaganda Metallurgical Combine.

Until the 80s...90s in all countries the use of the continuous casting process was expanded. For example, in the work (Adno, 2001, p. 63), the author indicated that over the last 4 thousand years, more than 11 billion tons of ferrous metals were produced in the world, of which more than 80% were in 70 years of the last century. In support of this, it was shown in the work (Reshenie nauchno-tekhnicheskogo seminara, 1996) that the volume of billet production by continuous casting in various countries is: the United States – 88.9%; EU countries – 93.7%; in Japan – 96.9%, Ukraine – 8% and (3.5% worldwide).

Around the same time, the work was appeared that emphasized the advantage of horizontal continuous casting machines in comparison with vertical machines on the part of managers of large firms in the developed countries of the world. It is indicated that, as of 1990, in the world, horizontal machines were used to produce 68% of round billets from steel 0.08…0.12 m in size (Shatagin & Sladkoshteev, 1976, p. 24).

The theory of continual damage, expressed in the form of the Rabotnov-Kachanov equations (Kachanov, 1974, p. 15; Malinin, 1975; Rabotnov, 1966, p. 7), appeared in the second half of the last century. According to the classical Kachanov-Rabotnova theory, the current state of internal damage of a sample can be represented using a single scalar parameter (damage parameter) ω, which is a monotonically increasing function with time $0<\omega<1$. The damage parameter is interpreted as a relative reduction due to the effective, load-carrying area of the cross-section distributed within the micro defects sample. Material degradation is explained as a gradual decrease in the effective area, which actually carries a tensile load and determines the resistance of the specimen to stretching. Since the mechanics of Bailey and Norton worked in parallel, this law was named after all the authors: Bailey-Norton and Rabotnov-Kachanov.

As part of the second stage, studies were conducted on the issue: changes in the parameters of the damageability parameter of copper alloy billets when the frequency of the billet movement in the mold varies from 2.5 to 7.5 min^{-1}, taking into account that the cycle of the billet motion begins with a reverse movement. Experimental studies have confirmed that when using a cyclogram of the movement of billets according to the scheme «reverse motion – translational motion-pause», the damageability of billets is much lower than that of billets made on the same machine, but according to the cyclogram: «translational motion – pause». On the basis of this, a technological process of continuous casting of copper alloy billets was developed, which was protected by utility models (Khoroshylov, Ponomarenko, & Shatahin, 2006b; 2006c).

The essence of changes in technological operations, presented in the work (Breslavskij et al., 2008), was to exclude the effect of tensile forces in the cross-section of the billet due to changing the direction of movement of the billet during overcoming the FFR, and then there is a translational movement of the billet to a predetermined length. Thus, we obtain the following sequence diagram of the motion of the billet: “reverse - translational movement - pause”. To understand the process by which the damage parameter decreases, we turn to Fig. 5 which shows that when the billet moves with a frequency of 7.5 min^{-1}, the following change in the damage rate occurs with a different direction of the billet movement during the overcoming of the FFR.

Thus, in the work (Breslavskij et al., 2007) it was concluded that due to the implementation of the reverse movement of the billet in time to overcome the FFR and increase the frequency of advancement of the billets in the range of 2.5...7.5 min^{-1}, a new approach was created to reduce the damage parameter of copper alloys in the range of 0.3 to 0.1.

It is known technological process of improving the quality of the billets and the performance of a horizontal continuous casting machine under similar conditions

during continuous casting of steel, which could later become a useful prototype for improving the efficiency of continuous casting of copper alloy billets, when the cyclic movement of the billet in the mold is carried out according to the scheme: movement - reverse movement-pause".

The third stage of improving the process of continuous casting is based on the influence of the frequency of movement of the billet on its damage parameter, as well as on the influence of the direction of movement of the billet in time to overcome the FFR on the damage parameter. It was determined that for the frequency of movement of billets located in the range of 2.5...7.5 min^{-1}, the mechanical properties of the billet (temporary resistance to rupture) are influenced by the direction of movement of the billet during overcoming the FFR.

Based on the statistical processing of experimental data obtained as a result of the determination of creep, presented in (Horoshilov, Mel'nichenko, & Segal, 2017), in Fig. 6, dependences of the influence of the frequency of motion of the billet 1 and 2 are plotted, as well as the direction of its movement during overcoming the static friction force on the parameter of damageability of the billet (Breslavskij 1998; Breslavskij et al., 2008). In addition, Fig. 5 shows the effect of dependencies 1 and 2 on the mechanical properties of the billets (dependencies 3 and 4).

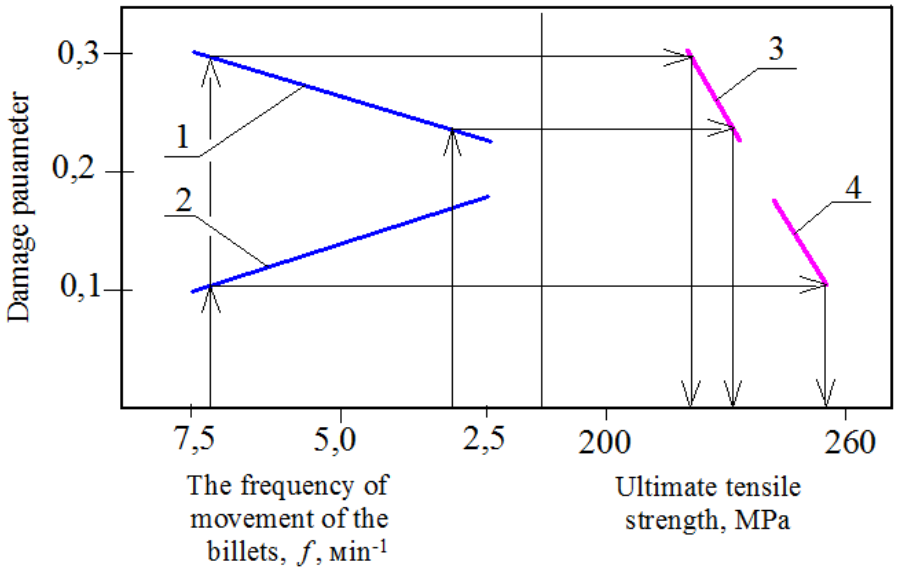

Figure 6. The effect of the frequency of movement of the billet with a diameter of 0.05 m on the parameter of its damage using reverse and progressive motion while overcoming the static friction force (Khoroshylov, 2013, p. 22): 1,2 –the dependence of the change in the value of the parameter of damage to the billet on the frequency of its movement in the mold during the progressive and reverse motion of the billet during overcoming the FFR; 3,4 - Dependences of the power limits while stretching the bronze billets of the BrT5Z5L5 on the damage parameter.

The dependencies shown in Fig. 5 allow us to make a comparative assessment of the change in the damage parameter for cyclograms created in the second and third stages of improving the process of continuous casting. So, according to the cyclogram created at the second stage (dependence 1), the billet in the cycle moves only progressively. With an increase in the frequency of movement of the billet from 2.5 to 7.5 min^{-1}, the parameter of damageability of the billet increases (dependence 1), and its mechanical properties decrease (dependence 3). Dependence 2 shows the change in the parameter of damage to the billet, provided that during the overcoming of the FFR it makes a reverse movement. Dependencies 2 and 4 indicate that increasing frequency of movement of the billet leads to the following processes:

– increase the parameter of damage to the billet from 0.224 to 0.3, while reducing the tensile strength of the billet under tension from 234 to 219 MPa;

– reduction of the damage parameter from 0.175 to 0.1, with an increase in the tensile strength of the billet under tension from 242 to 255 MPa;

Thus, the use of the element "swing" of the mold in the form of a reverse movement of the billet during overcoming the FFR while simultaneously increasing the frequency of movement of the billet from 2.5 to 7.5 min^{-1} allows increasing the tensile strength of the billet under tension from 242 to 255 MPa.

Advantages:

1. As it follows from (Khoroshylov, 2013, p. 22), this improved continuous casting process allowed to increase the machine productivity by 25.5...56.3%, to increase the mechanical properties of the billet: temporary tensile strength by 12.4...15.8%.

2. LLC «Energoprom» is the enterprise where the patent of Ukraine No. 79415 was introduced in 2007, as well as the process of continuous casting in 2011.

Disadvantages:

1. There is no availability to conduct experimental studies on the manufacture of copper alloys billets with a frequency of movement of the billet from 60...120 min^{-1} due to the lack of appropriate equipment (drive and non-friable crystallizer);

2. Low rates of increase in productivity HCCM and increase the mechanical properties of the billet.

Thus, during the work of the third stage we can draw the following conclusions:

1. The second stage began in 1995 with information about the possibility of increasing the frequency of movement of the billet in a horizontal mold. The stage ended with the improvement of the technological process of continuous casting of copper alloy billets, the implementation of the results of work in Energoprom LLC in Kharkiv in 2011, and the patent of Ukraine No. 79415 in 2007, in 2002 also in the Tsiboropteks enterprise in Dubai, UAE.

2. The reverse motion of the billet during the overcoming of the FFR eliminates the formation of micro-cracks at the initial moment of movement and further

development (microcracks) during the overcoming of the sliding friction force. This causes a decrease in the damage parameter, and the higher the frequency of movement of the billet, the more significantly the damage parameter decreases. So, at a frequency of 7.5 min^{-1}, the damage parameter (ω) with the reverse movement of the billet (technology of the second stage) was 0.1, and ω for the billet without reverse movement (technology of the first stage) was 0.3.

3. The development of new metal or metal-ceramic coating can contribute to the replacement of the graphite sleeve of the mold when casting copper alloy billets, in turn, this will increase the frequency of movement of the billet in the mold above 7.5 min^{-1}, which will significantly increase the mechanical properties of the copper alloys billets.

The fourth stage began with the creation of a project to improve the process of continuous casting of steel with a frequency of alternating movement of the billet to 150 min^{-1}, we will conditionally assume that this happened in 1995...2000 and is happening now. The fourth stage is not limited only by increasing the frequency of movement of the billet in the mold and monitoring the damage parameter of continuously cast billet.

The objectives of the fourth stage are the integration of all scientific, technical and technological solutions and regulation of the productivity of the continuous casting machine and the quality (mechanical properties) of blanks with high stability (reliability) of the machine.

By the fourth stage of improvement, the continuous casting process can be classified according to the following criteria.

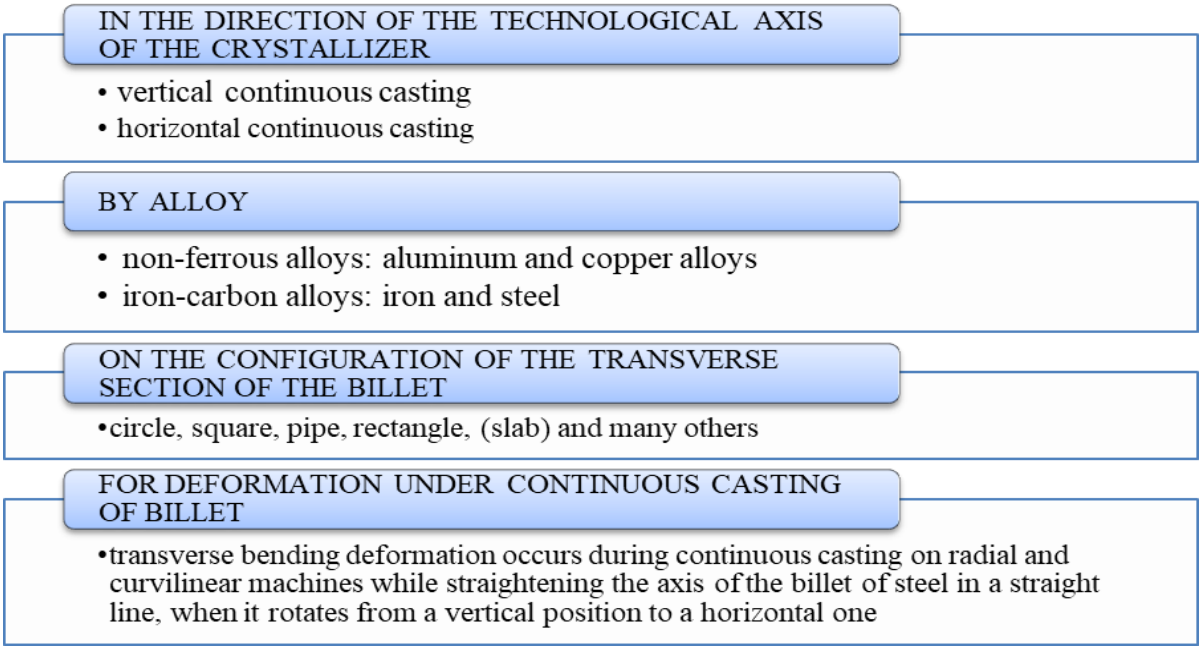

Figure: 7. Classification in the direction of the axis of the billet, by alloys, cross-section of the billet and the deformation to which the billet are subjected on radial and curvilinear machines.

For the further development of the fourth stage, specialists involved in continuous casting are working in various directions. For example, the author of (Verzilov, 2018, p. 20) investigated the stabilization of hydraulic processes in a vertical crystallizer, (Meshhaninova, 2000, p. 15) improved the technological process for the production of high-quality billets, (Andrianov et al., 2010; Gunenkov, Andrianov, & Prokhorenko, 2005) are working on the modernization of the steelmaking industry. Work (Mazumdar & Ray, 2001) is aimed at controlling the solidification of billets during continuous casting of steel. Much attention is paid to the control of the structure of the workpieces depending on the processing of melts (Narivskij, 2006, p. 24; Ukhin, 2012), as well as the change in technological parameters (Neklyudov, Sokolenko, & Netyosov, 2008). Significant results will be used to improve continuous casting productivity and improve quality.

The fourth stage is currently used for the continuous casting of iron-carbon alloys. The main objective of the fourth stage is reducing the damage parameter by increasing the frequency of the billet movement to the interval of 120...150 min^{-1}, as well as using inertial forces during alternating movement of the billet to mechanically affect the damaged parts of the forming billet, which leads to an increase in the linear productivity of the continuous casting machine with given mechanical properties of the billets.

An advertising article that appeared on the Internet resources from Spetsmash LLC reports the following: “We develop and manufacture continuous steel casting plants, which are new generation machines for domestic metallurgy. Our specialists have manufactured a drive that allows developing the frequency of cycles up to 120...150 per minute, according to the progressive “jerk – reverse stroke – pause” scheme that is used on almost all foreign machines, which made it possible to pour only high-quality carbon and low-alloy steels (Fig. 8).

Figure 8. Horizontal continuous casting machine for steel billets with a diameter of 0.08 m designed by LLC «SPETSMASH», commissioned in 2002–2003 (press release «SPETSMASH» LLC, 2005)

The advertising information from also reports on the performance of the HCCM, developed by them (press release «SPETSMASH» LLC, 2005). So, round and square billets with a diameter of 0.08...0.1 m have a linear capacity (V, m/min) – 2.5...4.0 m/min, billets with a diameter of 0.1...0.125 m are poured at a speed of 1.8...2.5 m/min, and billets with a diameter of 0.11...0.145 m – at a speed of 1.5...2.0 m/min. In recent years, we have seen that the world community has made clear progress in terms of the spread of the continuous casting process. There were publications from India, that in this country both non-ferrous and iron-carbon alloys are produced by continuous casting. This indicates the trend of moving the construction of new metallurgical complexes in the rapidly developing countries (Kumar, Suresh, & Van Swygenhoven, 2003, p. 5751; Yamaguchi, Sawai, & Nakashima, 2013, p. 17).

Each enterprise chooses the quality level of the billet, or the productivity of continuous casting machines. In 2010, for the future, the process of continuous casting of steel was being developed, which will allow us to have a continuous casting speed in the range of 0.5...0.8 m/min. In fact, this only indicates that these developers have a goal to significantly improve the quality of billets (Smirnov, 2010). A six-roll production line of square billets of 0.15×0.15 m made of steel was also launched at public company Arcelor Mittal Kryvyi Rih, and in 2019 another line of producing a 0.13×0.13 m square is expected. The average linear productivity of the machine when casting billets 0.15×0.15 m is 2.2 m/min, and the weight is 100 thousand tons per month (Press –release: «Arselormittal Kryvyi Rih», 2011).

In 1984 the thesis “Development of parameters of blues non-continuous casting machines with electromagnetic stirring for the production of billets of high-quality steel” was defended (Shifrin, 1984, p. 12).

And despite the fact that this dissertation work was defended before 2000, its theme is very consonant with modern tasks that metallurgical enterprises face: building bloom machines, using electromagnetic stirring with reversing the direction of the magnetic field. This work is aimed at the development of technological parameters of the bloom machines of the radial or curvilinear type. The development of technological parameters is complicated by the fact that the technological parameters must take into account the deformation processes that occur in curved sections of the trajectory of the billet (bloom). There are also dissertations made in the XXI century aimed at solving problems of improving the quality of continuously cast slabs during their casting from steel of wide grade composition (Shpak et al., 2008).

At the beginning of 2000, the production of steel billets began to develop rapidly, the essence of which was that this technological process by increasing the frequency of movement of billet from 60...90 to 150 min^{-1} and cyclic reverse movement in the mold according to the scheme: "jerk-reverse -pause". This allowed increasing the linear productivity of HCCM from 1.0 to 4.0 m/min on a wide range of sizes. The speed of continuous casting of billets (slabs) is currently reaching 5.0...7.0 m/min. (Press – release: «SPETSMASH» LLC, 2005). It should be noted that the specificity of the thermal operation of the mold of a continuous casting machine is such that the smaller

the cross-section of the billet, the higher the casting speed and vice versa. Therefore, for billets of a size range, for example, of a circular section from 0.04 to 0.2 m, it can be in this range (5.0...7.0 m/min) of the linear productivity of the machine (Press – release: «Arselormittal Kryvyi Rih», 2011) Fig. 9. It should be noted that in the converter shop of Public company Arcelor Mittal Kryvyi Rih, the first continuous casting machine for steel square billets 0.15×0.15 m in size with a design capacity of 1.2 million tons per year was put into operation in the year (Press –release: «Arselormittal Kryvyi Rih», 2011). Figure 9 shows the machine.

Figure 9. A six-roll continuous casting machine for billets of steel 0.15x0.15 m in size at the converter shop of Public Company «Arselormittal Kryvyi Rih» (Press –release: «Arselormittal Kryvyi Rih», 2011)

Currently, two more continuous casting machines for steel billets with a section of 0.15×0.5 m and 0.13×0.13 m are being built. Supplier of basic equipment SMS Group (Germany). The design capacity of the second and third machines will be 1.2 and 1.4 million tons per year. Thus, we conditionally identified four stages of improving the process of continuous casting of billets from 1826 to the first quarter of the twenty-first century (Table 5.)

From table 5 it follows that data on the damage parameter are available only in those cases where they were determined. At the moment, these data are available only for billets from copper alloys obtained at the «Leninskaya Kuznitsa» plant and at «Energoprom» LLC. Such an effective damageability (ω=0.6...0.7) of the billet, shown in Fig. 4, was obtained in conditions of non-stop traffic (Shatagin, Sladkoshteev, & Vartazarov, 1974, p. 76). An expert assessment of the damageability parameter was obtained 30 years after the experiment by O. A. Shatagin.

The table includes experimental data obtained on samples of copper alloys tested in the crystallization temperature range in the range (0.9...0.95) T_L for continuous casting processes related to the second and third stages, on the basis of which dependences 1 and 2 were constructed (Fig. 6).

Table 5. Indicators of linear productivity causing different values of the parameter of damageability of the billet and the stability of the continuous casting process

Years	Stages	Linear productivity (m/min) of billets copper alloys with a diameter 0,08 m, V, m/min, or for a square of steel 0.15×0.15 m		Parameter of damaging the produced billets, ω (According to fig. 6)	Stability of the continuous casting process
1826…1960	First stage	Steel:	No data	No data	The process is not stable
		Copper alloys:	No data	(Expert review: 0.6…0.7) (Shatagin, Sladkoshteev, & Vartazarov 1974, p. 76), (fig. 4)	Cast from 0.2 to 9.2 m per casting
1960…1995	Second stage	Steel:	0.7…1.0 Karaganda Metallurgical Plant.	No data	The process is stable
		Copper alloys:	0.25…0.35 “Leninskaya Kuznitsa”, Kiev, (fig. 1)	0.225…0.31	The process is stable
1995…	Third stage	Steel:	No data	No data	No data
		Copper alloys:	0.3…0.5 «Energoprom», Kharkiv, (fig. 2) (Khoroshylov, 2013, p. 21)	0.1…0.175	The process is stable
1995…	Fourth stage	Steel:	2.5…4.0 4.0…6.0	No data	The process is stable

Despite the fact that damage data is available only for copper alloys for the second and third stages, we conduct an indirect assessment of the reduction of the damage parameter from stage to stage in terms of linear performance. So, if at the second stage of improving the continuous casting process, the average speed of continuous casting of steel billets with dimensions of 0.15×0.15 m was 0.8...1.0 m/min, then at the fourth stage, billets of the same size are cast in some cases at a speed of 2.5...4.0 m/min, and in other cases – 5.0...7.0 m/min. Also from the data presented in table 4, it follows that the fourth stage of improving the process of continuous casting causes a significant increase in linear performance.

Based on the foregoing, the rate of change in the process of continuous casting will increase. The following changes that improve the quality of the billets can be expected within 10–15 years. However, major changes in the design of the continuous casting machine will probably not be possible, since efforts can be directed at changing the specific qualities of the billet, which can only affect minor changes in the design.

Conclusions.

Based on the analysis of the stages of improvement of the billets, the stages of technological improvement of the process of continuous casting of iron-carbon and copper billets, we can draw the following conclusions:

1. It is shown that, indeed, each stage of the improvement of the continuous casting process is associated with a decrease in the damage parameter, which in turn led to an increase in the mechanical properties of the billets, which in turn increased the linear productivity.

2. It was determined that in addition to the non-stop (continuous) movement of the billets from 1826 to 2018, there were applied the following types of cyclic movement of continuously cast billets:

– alternating movement ("swing") of the mold on vertical continuous and semi-continuous casting machines; on radial and curvilinear machines with a frequency of alternating movement of the mold up to 100...250 min^{-1};

– the cyclic movement with the release of time for pauses according to the schemes: "translational movement – pause" and "reverse - translational movement - pause"; during the pause time, damaged parts of the billets (microcracks) are partially restored depending on the pause duration;

– cyclic alternating movement of the billet with a frequency of up to 150 min^{-1} using the inertial component of the movement.

3. It was determined that the mechanical properties of the billet increased on the one hand while reducing the frequency of the movement of the billet, i.e. according to the cyclogram developed at the second stage of the continuous casting process improvement. On the other hand, the mechanical properties of the billet increase:

– when increasing the frequency of movement of the billet in the range of 2.5...7.5 min^{-1} and the reverse movement of the billet during the overcoming of the FFR (third stage);

– when increasing the frequency of movement of the billet in the range of 90...150 min^{-1} and the translational movement of the billet during the overcoming of the FFR (fourth stage).

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Етапи технологічного вдосконалення процесу безперервного лиття залізовуглецевих і мідних заготовок

Анотація. *У статті представлені етапи вдосконалення процесу безперервного лиття. Виявлено, що на кожному етапі технологічного вдосконалення процесу безперервного лиття відбувалося зниження параметра пошкоджуваності заготовки. Удосконалення процесу безперервного лиття дозволило на кожному етапі підвищити механічні властивості заготовки і продуктивність машин безперервного лиття. Перший етап, показаний як процес переходу кількості експериментальних напрацювань в якість, при якому лиття заготовок перейшло з нестабільного процесу в стабільний. Другий етап*

охарактеризований створенням нових удосконалених процесів безперервного лиття. Так, крім існуючих машин вертикального типу були винайдені машини радіального, криволінійного та горизонтального лиття. До кінця XX століття цей варіант технологічного процесу вийшов на межу можливостей зростання якості заготовок і продуктивності машин безперервного лиття. Показано, що третій етап, призначений для безперервного лиття мідних сплавів і, був заснований на впливі частоти руху заготовки та реверсивного руху заготовки під час подолання сили тертя спокою. Визначено, що для частоти руху заготовок з мідних сплавів, що знаходиться в інтервалі 2,5...7,5 хв$^{-1}$ на механічні властивості заготовки впливає напрямок її руху під час подолання сили тертя спокою. Четвертий етап – обумовлює підвищення механічних властивостей заготовки за рахунок використання сил інерції при знакозмінному русі заготовки. Виявлено, що на четвертому етапі найбільш ефективно зросли механічні властивості заготовок, а лінійна продуктивність підвищилася від 0,4...0,8 м/хв до 2,5...4,0 м/хв, а в деяких випадках до 5,0...7,0 м/хв.

Ключові слова: *безперервне лиття заготовок; реверсивний і поступальний рух; мідні сплави; параметр пошкодження*

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Этапы технологического совершенствования процесса непрерывного литья железоуглеродистых и медных заготовок

Аннотация. *В статье представлены этапы совершенствования процесса непрерывного литья. Выявлено, что на каждом этапе технологического совершенствования процесса непрерывного литья происходило снижение параметра повреждаемости заготовки. Усовершенствование процесса непрерывного литья позволило на каждом этапе повысить механические свойства заготовки и производительность машин непрерывного литья. Первый этап показан как процесс перехода количества экспериментальных наработок в качество, при котором литье заготовок перешло из нестабильного процесса в стабильный. Второй этап охарактеризован созданием новых усовершенствованных процессов непрерывного литья. Так, кроме существующих машин вертикального типа были изобретены машины радиального, криволинейного и горизонтального литья. К концу XX столетия*

данный вариант технологического процесса вышел на предел возможностей роста качества заготовок и производительности машин непрерывного литья. Показано, что третий этап, предназначенный для непрерывного литья медных сплавов, был основан на влиянии частоты движения заготовки и реверсивного движения заготовки во время преодоления силы трения покоя. Определено, что для частоты движения заготовок из медных сплавов, находящейся в интервале 2,5…7,5 мин$^{-1}$ на механические свойства заготовки влияет направление ее движения во время преодоления силы трения покоя. Четвертый этап – обуславливает повышение механических свойств заготовки за счет использования сил инерции при знакопеременном движении заготовки. Выявлено, что на четвертом этапе наиболее эффективно возросли механические свойства заготовок, а линейная производительность повысилась от 0,4…0,8 м/мин до 2,5…4,0 м/мин, а в некоторых случаях до 5,0…7,0 м/мин.

Ключевые слова: *непрерывное литье заготовок; реверсивное и поступательное движение; медные сплавы; параметр поврежденности*

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Motorcycle MT10-36 as a landmark of science and technology

Abstract. *Based on the source and comparative analysis of the history of creation, design, and production of the Kyiv Motorcycle Works' motorcycles, the value of the MT10-36 motorcycle as the landmark of science and technology has been determined. It has been shown that the development of a new engine and MT10-36 motorcycle was, first of all, the initiative of the plant's engineers. Ovcharenko M. completed the development of a 650 cubic capacity boxer engine. The design of new units and a vehicle outpaced the technological capabilities of the plant. This led to a delay in introducing new technology into production. The involvement of the Foundry Department of the Kyiv Polytechnic Institute under the leadership of K. Vashchenko made it possible to improve the production technology of the motorcycle engine. The reliability of the engine has increased. The design of the engine of the Kyiv Motorcycle Works was in line with the tendencies of the world motorcycle industry. On the basis of a comparative analysis of the MT10-36 motorcycle design and the Ural motorcycle of the Irbit plant (Russian Federation), the strengths and weaknesses of the vehicle design have been determined. Selected episodes of sales of the Kyiv Motorcycle Plant's motorcycles within the country and abroad have been highlighted. It has been highlighted that the motorcycle was operated in conditions that did not reveal its speed and transport capabilities. The motorcycle's design outpaced the pace of development of transport infrastructure (highways). The basic principles of museification of motor vehicles have been considered. It has been noted that one of the valuable qualities of the landmark of technology is the reflection of the peculiarities of the use of the object and its change after leaving the plants' shop. Some aspects of the principles of technique restoration as a material historical source with the optimal preservation of the landmark and the information reflected in it have been considered. It has been concluded that the MT10-36 motorcycle meets the criteria of the landmark of science and technology in the broad sense of this concept. The motorcycle embodies the original technical solutions of native engineers, reflects the level of development of domestic technology and illustrates the practice of operating motorcycle technology.*

Keywords: *Kyiv motorcycle works; engine; Polytechnic museum; exhibit*

Introduction.

Motorcycle is the most popular vehicle in countries with warm climate, where machine-building is developed, but the standard of living is quite low. In Ukraine, the greatest popularity of the motorcycle as a vehicle dates back to the second half of the twentieth century, when the Kyiv and Lviv motor plants were in operation. At that time, the motorcycle from a cheap, simple vehicle turned into a kind of subculture.

Today, along with the fact that the motorcycle remains a means of transport, it has become more of a hobby, a hobby, and an interesting recreation. Illustrating the history of technology, the history of transport development, the activities of outstanding engineers as well as the level of technology development, technical museums also exhibit motor vehicles. The world's leading polytechnic museums such as the Museum of Science (London), the Museum of Science and Industry (Chicago), the National Technical Museum (Prague), the State Polytechnic Museum (Moscow), the German Museum (Munich), and the German Museum of Technology (Berlin) exhibit motorcycle collections. Abroad, some of the best collections of motor vehicles are exhibited in the factory museums that made such products. In such institutions, along with the subject, the history of its creation, use, and modernization is revealed. Enterprises are interested in replenishing such collections and popularizing them. Collections are a means of advertising a new motorcycle.

Analysis on recent researches and publications.

Considering the motorcycle as a materialized embodiment of technical ideas of a certain time, researchers publish a significant number of works not only of a technical, historical, but also cultural nature. Researchers on the history of motor vehicles reveal the subject not only as a vehicle, the embodiment of technology, but as a unique cultural phenomenon in all interconnections in mass culture: cinema, television, museums, sports, etc. (Krens & Drutt, 1998; Cole, 2020; Dewey, 2018). Encyclopedic and reference publications combine various aspects of motorcycle design, operation, and museum presentation (Broun, 2003). The number of such works abroad is enormous. Domestic researchers still have to go through such a difficult path to the deep highlighting of motorcycle history. Moreover, both the largest manufacturers of motor vehicles Kyiv and Lviv Motor Plants do not exist today. The main sources of the enterprises' activity are periodicals, including electronic ones, and narratives - interviews of engineers, employees of the Kyiv and Lviv Motorcycle Works.

General issues of reflecting the history of the technology development by museum means are well highlighted. A number of issues related to the identification, research and preservation of science and technology landmarks were raised in the works of the employees of the Center for Monument Studies of the National Academy of Sciences and USPHCM (Ukrainian Society for the Preservation of Historical and Cultural Monuments). (Griffen & Konstantinov, 2008). The issues on research, preservation of

technique in museums were studied in the works of L. A. Griffen, V. O. Konstantinov, V. V. Kobzar, V. P. Iievliieva, S. V. Romadin., etc. (Griffen et al., 2014). Few works deal with the issues of preservation and presentation of vehicles and technical facilities in the form of monuments and their components. Exhibits of motor vehicles in museums are occasionally mentioned (Gurnak & Ananchenko, 2012). The equipping of museums with motor vehicles and restoration issues are briefly covered in separate works (Yermolaieva, 2015). However, issues of the history of research, preservation and museumification of motor vehicles do not reach the required depth. Most of the works are of general applied value and are published in the electronic media. A significant part covers the history of a separate subject, its modernization and use. For example: changes in the design of carburetors of motorcycles "Dnipro" (Nikonchuk, 2018).

The interest in the history of the motorcycle has caused the appearance of works in which the formation of the definition of the motorcycle concept and its classification in various fields of use has been investigated. An attempt has been made to study the motorcycle as a landmark of science and technology through the prism of the formation of the domestic term "motorcycle" (Nikonchuk, 2019).

Today, in this direction, practice is significantly ahead of theory. The motorcycle is a popular collector's piece; it is displayed both in private and public museums. Therefore, the issue of improving the selection criteria, the value of a motorcycle as the landmark of science and technology is relevant. The purpose of the research is to determine and highlight the value of the MT10-36 motorcycle as the landmark of the history of technology, the embodiment of technological progress and the materialized contribution of outstanding domestic engineers to technical progress. In the article, based on a source study and a comparative analysis on the history of creation, design and production of the Kyiv Motorcycle Works motorcycles, the value of the MT10-36 motorcycle as a monument of science and technology has been determined. It has been shown that the development of a new engine and motorcycle MT10-36 was, first of all, an initiative of the works' engineers.

Research methods.

The general methodological basis is the method of historicism, which has been used to study the place of the research object in the system of the national history of technology. According to the formulated goal and available sources, research methods have been selected. A system-structural approach has been applied in studying the relationship between engineering and design developments with their implementation and the expected result of implementation. Critical analysis and comparison of narrative information with other available sources will avoid subjective interpretation of facts. Analysis of the main technical parameters against the background of a critical assessment of the motorcycle design by users, and implemented technical solutions to improve technology will allow evaluating objectively the design of the motorcycle, compare it with analogues, and vehicles close in class. Retrospective analysis as a

method to reproduce the technology of production and marketing of motor vehicles in the 70–80s of the XXth century has been applied. Experimental methods have been used to test conservation and partial restoration methods that are economical to preserve the historical value of the subject.

Results and discussions.

The work is based on information published in various reference publications, catalogs, manuals for the operation of motor vehicles, specialized journals for users, for example, the journal "Behind the wheel". As P. Nora noted: "Today the historian is by no means a lonely producer of the past. He shares this role with the judge, the witness, the media and the legislator" (Bondar, 2014, p. 103). This necessitated the widespread involvement of narrative sources, interviews, news resources, primarily electronic media - due to their efficiency and quick response to users' requests. The request for information on domestic motorcycle production prompted the emergence of short but informative interviews with engineers, technologists, heads of institutions that were involved in the production, sales and service of Mototechnics (Auto consulting, 2020). These interviews bring in unique facts that need verification. The subject (researcher, engineer) is "endowed with living feelings, emotions, passions, and is considered as an individual" (Pylypchuk & Strelko, 2018, p. 354). This is due to the use of certain biographical research methods.

An indispensable source of information was a visual inspection, experience of operating and studying motor vehicles in the expositions of domestic museums and during the conservation of museum exhibits. One of the world's first motorcycles was created in 1885 by Gottlieb Daimler and Wilhelm Maybach as "a horse-riding machine with a kerosene engine". Structurally, the motorcycle resembled a bicycle of a "safe" design with two wheels of the same size, an engine between them, a drive to the rear wheel, and a driver's seat above the engine with two smaller supporting wheels (Firsov, 2012, p. 29). Motorcycles have been widespread due to the affordable price compared to the car and the simple design, high power density. These vehicles were especially delighted in Europe and the USA in the first half of the 20th century. This is the time of real passion for vehicles with internal combustion engines, their conquest of high speeds and continents. The first domestic serial motorcycle was manufactured in Kharkiv in 1931 by the Kharkiv car assembly works. 10 motorcycles designed by P. Labura were made. Later, after testing the cars and making changes to the design, the plant had produced motorcycles called HMZ-1M in small series until 1933. Kharkiv residents went further and developed several models with different types of frames, different engines, with a chain final drive and cardan. However, the top leadership of the USSR decided not to produce motorcycles in Kharkiv. Since 1941, the "Serp and Molot" plant was to begin production of heavy M-72 motorcycles – a Soviet copy of the BMW R71. But this was prevented by the war (Pevzner, 1994; Auto24, 2019).

In September 1945, the Kyiv Motorcycle Works was created on the basis of the Armored Repair Plant No. 8 in Kyiv. The first specialized product was the 2.3 – strong motorcycle K-1B "Kievlyanin", a copy of the German motorcycle "Wanderer-1Sp", which was manufactured on equipment exported from Germany. Since 1949, the production of the M-72 motorcycle has begun on the basis of documents transported from the town Gorkyi, machine tools and motorcycles' spare parts. In 1956 a new, completely own model K-750 was launched into serial production (Sukhovskii, 2004). Since 1968, the works has begun mass production of the K-650 motorcycle, after the introduction of a new principle of motorcycle indexing; it was named MT-8 "Dnepr" (MT-heavy motorcycle). Since then, almost all KMZ motorcycles have been called "Dnepr" with the model number indication, despite the official indexes of the manufacturer. The motorcycle had a new top-valve engine of its own design. Since 1972, a new model MT-10 with a new gearbox with a reverse gear has been launched. The production of the MT10-36 model has begun since 1977 (Sukhovskii, 2004). The number 36 indicates the engine power. According to other data the works has begun the production of the 36 hp engine since January 1976 (Ovcharenko & Shypota, 1976). This model summarized all the experience of development and operation of Kyiv production motorcycles. It embodied interesting solutions tested by the operation of sports and escort heavy motorcycles. MT10-36 (Fig. 1) in contrast to the previous model (MT-9) had 12-volt electrical equipment, a more powerful generator – which improved lighting, performance indicators of various systems and light alarms.

Figure 1. MT10-36 motorcycle in the exposition of the Polytechnic Museum (Kyiv) (Author's photo).

A double drivers and passenger's seat was installed, which improved driving conditions at low temperatures. The side trailer remained without brake. The motorcycle could be operated without a side trailer, the front fork shock absorber covers had a hole for installing the right turn indicator (Avtoeksport, 1979, pp. 2–7). The main directions of modernization were caused by the adoption of new state standards to improve safety and reduce noise. These works were reduced to the improvement of the brake system – the introduction of a two-cam system with two active brake pads. The front brake had the ability to adjust as the pads wear out, first by connecting the union and then repositioning the cam. "Such a device has been used for the first time on domestic heavy motorcycles" (Yarmak, 1977). Metal clamps were introduced on the fuel flow line under the tank. The parking brake lock has been installed on the front brake lever. A steering wheel lock to prevent motorcycle theft has been installed. The front end of the wing has been flared. The muffler has been modernized, its fastening with cap nuts has been introduced (Yarmak, 1977). But the biggest differences between the MT10-36 models were in the design of the increased power engine. These improvements were not regulated by the new safety standard. They were a natural continuation of the long-term work of KMZ engineers to improve the characteristics of the engine of their own development. The engine of its own design was put into mass production in 1968, unlike its predecessor – it was not a lower-valve, but an overhead valve. The scheme of upper-valve engines has been known since the 30s. In particular, BMW had been producing motorcycles with both upper and lower opposed valves since 1929. The motorcycle with the lower-valve opposite engine became widely used in armies. Unlike the upper valve motorcycles, it had smaller dimensions in width, fewer parts, higher reliability and simplicity. In the early 50s, a heavy motorcycle was no longer perceived as a purely military vehicle. The troops were increasingly using high-powered vehicles, armored personnel carriers, which better performed the role of motorization means of the army.

This upper-valve scheme allowed optimizing working processes in the cylinder, to increase power and to improve efficiency. Focusing on the civil market the motorcycle works begins mass production of motorcycles with upper-valve engines. Confirmation of this is the fact that for a long time MV-750 with a lower valve engine was made for the military after the mass production organization of the upper valve engine. Thus the trend is typical for the evolution of opposing motorcycles abroad. The trend has not spared our country either.

The new engine has absorbed the experience of production and operation of both motorcycle engines, as well as tested design solutions and technological developments of the automotive industry. The engine was developed in 1966 (according to other sources in 1960 (Zapisnaya knizhka mototsiklista, 2015) as KMZ-801 had an aluminum alloy crankcase (silumin), bimetallic cast-iron liners with aluminum alloy fins. All cast crankshafts was with split crank heads and sleeve bearings (from the car Moskvych 407). Lubrication system was with a fashionable at the time cleaning centrifuge, although a few years earlier a project with a paper filter was created

(Ocherki po istorii KMZ, 2019). Nowadays, the system of cleaning with a paper filter is more common; at that time it could not be implemented due to the inability of the industry to produce filter elements in the required quantity.

Gradually, this engine displaces the previous model of the low-valve engine from production, which was in production until the early 80s. Improving the engine, increasing its power and, in general, the characteristics of the motorcycle are reflected in the name – MT10-36. The lack of detailed information on the MT10 motorcycle led to the fact that there is sometimes information that the MT10 engine also had a power of 36 hp. (Nikonchuk, 2018, p. 42). However, this is not true. The engine was equipped with a new K-301D carburetor of higher throughput (larger diffuser and throughput of the main discharge jet). The engine had an increased intake valve head from 38 to 40 mm. The profile of the camshaft cams was changed to optimize operation at high speeds. The shape of the depression at the bottom of the piston was changed (Ovcharenko, & Shypota, 1976). The gas distribution shaft in this motor allowed filling quickly the combustion chambers with a working mixture. The compression ratio of the engine was increased due to the use of a hemispherical piston and a short sleeve (Shypota, 1986). The maximum number of revolutions of the crankshaft was 5900 rpm. The torque was 4.8 kg-cm. The engine reached its maximum power at almost maximum speed. This means that it was adapted primarily to improved paved roads. This mode of operation required the improvement of the lubrication system. In general, the engine, which development began in 1960 under the leadership of M. Ovcharenko, did not exhaust the possibilities of modernization and was gradually improved (Zapisnaya knizhka mototsiklista, 2015).

The Kyiv Polytechnic Institute also made its contribution to the improvement of KMZ motorcycles. For a long time, the most short-lived part of a motorcycle engine was the assembled crankshaft, the service life of which was 20–25 thousand km of run. Together with the department of foundry of KPI in 1963-1966, the design of the crankshaft was worked out. It was cast into shell molds of high-strength cast iron. The test showed that after 40 thousand km. mileage wear on the crankshaft journals is minimal. The department of foundry of KPI under the leadership of K. Vaschenko developed the technology of casting and processing of prefabricated steel piston cylinders with aluminum radiators (Bashtova, 2020, p. 34) and improved the technology of the engine's block casting. The mass of the engine block decreased and the casting accuracy increased. Therefore the time consumption for post-casting processing decreased (Luparenko, 2020, pp. 169–170). The MT10-36 motorcycle was one of the most powerful in the USSR. At the same time, the Irbit plant began production of motorcycles with a 36 hp engine. However, "Dnipro" had a significant advantage in performance. Users noted the softness and precision of gear shifting of the "Dnipro" gearbox, the impossibility of jumping over the gear, sometimes it happened on Irbit motorcycles. And most importantly is the reverse gear, which was switched on with a separate lever. On the "Ural" motorcycle, a gearbox with reverse gear appeared in 1986. For a motorcycle, this seems superfluous. But you have to take

into account that a motorcycle of this class is a small truck. Therefore, it is not easy to roll over, manually deploy a 300-kilogram car, and even more so a loaded one. Therefore, having a reverse gear is a necessity and does not seem like a bonus. In addition, the "Dnipro" gearbox had a semi-automatic clutch. When you press the gearshift lever, a special protrusion of the gearshift lever through the pull rod pressed on the lower part of the gear box release lever (Avtoeksport, 1979, p. 44). In addition, in this way, the possibility of turning on the speed with the gear box not disengaged was eliminated, and therefore the cause of frequent transmission breakdowns was eliminated. Additionally, in the event of a break in the gear box cable, it was possible to start driving and a full, trouble-free ride without engaging the lever and gear box cable, usually with minimal driver training. All of this has improved the reliability and performance of the gear box. The extraordinary popularity of the motorcycle was due to its availability and free sale. The price of MT10-36 was 1640 rubles (1984). For comparison, ZAZ 968 cost 4500 rubles (1979) while the power of the ZAZ engine was 40 hp at its own weight of 840 kg and the "Dniro" 36 hp at 325 kg. The motorcycle was a cheaper, more affordable vehicle. It was bought mainly by villagers (Shypota, 1986). This means that it was used mainly in the conditions of unpaved, crushed stone, gravel, and less often paved and asphalt roads. The operation of a vehicle in the countryside implied its more frequent use for transporting not passengers but goods for the needs of peasant farms. Moreover, users often retrofitted the motorcycle with a cargo platform above the spare wheel. For use with a motorcycle, a single-axle trailer was made. It was attached to a hitch mounted between the motorcycle and the tube (to the frame of the side trailer). Thus, the volume and weight of the transported cargo was increased. The Kyiv Motorcycle Works manufactured motorcycles with a cargo side trailer in a small series. In the late 80s of the twentieth century some enterprises, for example the Odessa car assembly plant, mastered the production of a limited series of trailers for heavy motorcycles. This confirms the specific perception of a heavy motorcycle as a truck. That is, the MT10-36 motorcycle was used as a cargo vehicle: simple, cheap, reliable, powerful. MT10-36 speed parameters could be realized only with improved road surfaces. Operation of the motorcycle did not reveal its best characteristics - maximum power at high speeds. "The basic parameters of its engine are not quite satisfactory for motorcyclists who live in rural areas. When driving on unpaved, stone, rubble roads, they almost never use their maximum power (36 hp)" (Shypota, 1986). The operation of the motorcycle on roads with poor quality surfaces meant that the motorcycle did not develop its maximum power, overextending the fuel. Moreover, at medium crankshaft speeds, the power of the MT10-36 engine was less than the MT10 with a 32 hp engine. Users noticed this feature. The Kyiv Motorcycle Works management was forced to respond to the wishes of users. The next model MT11 had a lower power of 32 hp. but with the ability to develop high power already at medium engine speeds (Shypota, 1986). Therefore, the MT10-36 remained the most powerful serial domestic motorcycle, embodying the latest technical ideas and

domestic technologies of the 60–70 of the XX-th century. However, for objective reasons, it could not use the design and operational advantages.

For a long time, the “Dnipro” motorcycle was used for filming various feature films. Most often it was used as a BMW R71 by Wehrmacht motorcyclists in almost all domestic films of the early – mid-80s of the XXth century. The uninitiated viewer did not pay attention to the clear rectangular outlines of the “Dnipro” cylinder heads, which markedly distinguished it from the BMW during the Second World War. As a common vehicle in the early 80s the MT10-36 motorcycle was also recorded in Western European cinema. It was the MT10-36 motorcycle that starred in the films “Ace” and “Let’s argue?” on which Adriano Celentano rode. By the way, it was filmed the actor’s motorcycle (Fig. 2) (As, 2017). Motorcycles of the Kyiv plant were exported abroad, in particular in Germany, the Netherlands, Switzerland, Cuba, Argentina and a number of other countries. The motorcycles of the Kyiv Motorcycle Works were sold in 50 countries of the world (Auto consulting, 2020).

Figure 2. Frame from the feature film "Ace" in 1981 (As, 2017).

Advertising Soviet cars and motor vehicles, the Italian campaign Martorelli made a run across the Sahara Desert. 4 UAZ vehicles and one MT-9 motorcycle participated in the race. (Fig. 3.), (As, 2017).

In 2017, a group of craftsmen who were not indifferent to the fate of KMW decided to assemble new motorcycles. The Vintage series was released – until now it has been the last series of the Dnipro motorcycles. This series is only indirectly related to KMW since the motorcycles were assembled from new factory-made components that were found. The series was made in a two-tone color. Additionally, they installed something that was not in the works models: additional lighting, LED illumination of a license plate, a lubrication indicator, a voltmeter and a taillight. Installed: winch, protective arches, audio system with Mp3-player and alarm (Auto consulting, 2020).

The winch, safety arches, audio system with Mp3 player, and alarm were installed in it (Auto consulting, 2020). A certain similarity between the MT10-36 and BMW motorcycles contributed to the insignificant sales of relatively cheap domestic motorcycles abroad as "vintage" vehicles that were restored and repaired abroad (Auto consulting, 2019). But in this regard, the K-750 motorcycle is much more popular, which is more similar to the legendary BMW R71.

Figure 3. MT9 motorcycle in Africa (from the advertising article "Martorelli") (As, 2017).

Today the MT10-36 motorcycle can be seen less and less on city streets. A significant number of them are not used for technical and economic reasons. However, people's interest in such means, their reflection of important events and phenomena in the history of technology, causes the need for their preservation and exhibiting in museums. Motorcycles of the Kyiv Works are exhibited by: the Museum of Retromotors in Lviv, the private collection of Oleksandr Frolov (Kam'ianske), the Museum of Technology of Buslaev (Zaporizhzhia), the Museum of Motorcycles (Uman). Herewith the motorcycles K-1, M-72, K-650, MV-650, MT-11, MT-14, MT-16 are exhibited. But it was the MT10-36 motorcycle that was not recorded. However, a significant number of private collections in Ukraine are not covered in the mass media, so we can cautiously say that the MT10-36 motorcycle in the State Polytechnic Museum is still the only one in the museum collection in Ukraine.

MT10-36 from the exposition of the State Polytechnic Museum was made in January 1979. On January 26, the millionth motorcycle rolled off the assembly line of KMW. The motorcycle is in working order; its completeness according to the model is more than 90% (Fig. 1). Very rare units and parts, such as a side trailer wheel cover, a

parking brake, metal air ducts, and a double seat lock have survived. It should be noted that up to now the domestic practice of restoration of vehicles involved, in fact, a major overhaul. The vehicles are disassembled to units and parts, defective, worn parts are replaced, cleaned of dirt and old paint, polished, covered with anti-corrosion coatings, modern paints and varnishes. That is why the items look completely new, "shine" unusually. Such works inevitably lead to a wrong perception of the subject and generally distort the truth of the perception of historical facts and phenomena. For example, the painted parts of the KMZ were not varnished, and in some periods the soil was not used. The reason for this attitude is the methodologically incorrect perception of the historical information content of technology. This principle of restoration has long been abandoned in domestic historical museums. In some cases, a motorcycle is restored with similar original paints and varnishes, which are ordered from manufacturers who specializing in this (Yermolaieva, 2015). Abroad, in general, the maximum safety with minimal restoration intervention or repair is appreciated (Gantriis, 2013, pp. 60–65).

After leaving the shop gate the vehicle certainly changes in the process of operation and use. These changes take place not only in the direction of wear of parts and items. The owner is already involved in the improvement of the vehicle. He equips it additionally, modernizes, and improves in accordance with his own needs. Often the vehicle is mounted with units, which are made in other companies and are not included in the basic package. Unfortunately, until recently, in modern domestic restoration practice, due attention to such changes has not been paid. Today, such additions are differently evaluated, researched and stored as evidence of the degree of conformity of the model to the user's needs and the embodiment of technical thought, ideas of the time.

Conservation involves the maximum preservation of the authenticity of the transferred item. The motorcycle transferred to the museum has some cases of modernization of components and parts. Taking into account the principle of the return of restoration works, these changes were preserved whenever possible. Motorcycle parts were cleaned from excrescences and corrosion and painted. The paint coating of assemblies and parts, which was in good condition, has been preserved. However, for the safety of visitors, hazardous sharp parts of welding flux and metal droplets have been removed. Thus, the motorcycle has retained evidence of production history, operation and further development.

Conclusions.

Thus, MT10-36 "Dnipro" illustrates a separate branch of the domestic transport engineering, is the creation of domestic engineers, an extremely popular vehicle at the time, embodies domestic technologies in transport engineering. The ideas introduced into the design were somewhat ahead of the readiness of the operation infrastructure; they were given as signs on the further development of the implemented ideas. The involvement of the department headed by the famous scientist K. Vaschenko to

improve the motorcycle adds value to the exhibit. Strengthening the information content of the exhibit is possible if the history of the object creation is illustrated with additional information from documentary sources, which determines the direction of further scientific research. The high degree of safety of the motorcycle, provided that it is economically restored, will certainly contribute to the effective presentation of the vehicle in the exhibition and will interest the visitors of the Polytechnic Museum.

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Мотоцикл МТ10-36 як пам'ятка науки і техніки

Анотація. *В статті на основі джерелознавчого та порівняльного аналізу історії створення, конструкції та виробництва мотоциклів Київського мотоциклетного заводу визначено цінність мотоцикла МТ10-36 як пам'ятки науки і техніки. Показано, що розробка нового двигуна та мотоцикла МТ10-36 була, в першу чергу, ініціативою інженерів заводу. Завершив розробку опозитного двигуна об'ємом 650 см³ Овчаренко М. Конструкція нових вузлів та транспортного засобу випереджала технологічні можливості виробництва заводу. Це спричинило затримання у впроваджені нової техніки у виробництво. Залучення кафедри ливарного виробництва Київського політехнічного інституту під керівництвом К. Ващенко, дозволило покращити технологію виробництва двигуна мотоцикла. Підвищилась надійність роботи двигуна. Конструкція двигуна Київського мотоциклетного заводу відповідала тенденції світового мотобудування. На основі порівняльного аналізу конструкції мотоцикла МТ10-36 та мотоцикла «Урал» Ірбітського заводу (Російська Федерація) визначаються слабкі та сильні сторони конструкції транспортного засобу. Висвітлено окремі епізоди збуту мотоциклів Київського мотозаводу в середині країни та за кордоном. Висвітлено, що мотоцикл експлуатувався в умовах, що не розкривали його швидкісних та транспортних можливостей. Конструкція мотоцикла випереджала темпи розвитку транспортної інфраструктури (шосейних доріг). Розглянуто основні принципи музеєфікації мототехніки. Відзначено, що однією із цінних якостей пам'яток техніки є відображення особливостей використання предмету та його зміни після виходу з цеху заводу. Розглянуто окремі аспекти принципів реставрації техніки як матеріального історичного джерела із оптимальним збереженням пам'ятки та відображеної в ній інформації. Зроблено висновок про відповідність мотоцикла МТ10-36 критеріям пам'ятки науки і техніки в широкому розумінні цього поняття. Мотоцикл втілює оригінальні технічні рішення вітчизняних інженерів, відображає рівень розвитку вітчизняної техніки та ілюструє практику експлуатації мотоциклетної техніки.*

Ключові слова: *Київський мотоциклетний завод; двигун; політехнічний музей; експонат*

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Мотоцикл МТ10-36 как памятник науки и техники

Аннотация. *В статье на основе источниковедческого и сравнительного анализа истории создания, конструкции и производства мотоциклов Киевского мотоциклетного завода определена ценность мотоцикла МТ10-36 как памятники науки и техники. Показано, что разработка нового двигателя и*

мотоцикла МТ10-36 была, в первую очередь, инициативой инженеров завода. Завершил разработку оппозитного двигателя объемом 650 см³ Овчаренко М. Конструкция новых узлов и транспортного средства опережала технологические возможности производства завода. Это привело к задержанию во внедрении новой техники в производство. Привлечение кафедры литейного производства Киевского политехнического института под руководством К. Ващенко, позволило улучшить технологию производства двигателя мотоцикла. Повысилась надежность работы двигателя. Конструкция двигателя Киевского мотоциклетного завода отвечала тенденции мирового мотостроения. На основе сравнительного анализа конструкции мотоцикла МТ10-36 и мотоцикла «Урал» Ирбитского завода (Российская Федерация) определяются слабые и сильные стороны конструкции транспортного средства. Освещены отдельные эпизоды сбыта мотоциклов Киевского мотозавода внутри страны и за рубежом. Показано, что мотоцикл эксплуатировался в условиях, которые не раскрывали его скоростных и транспортных возможностей. Конструкция мотоцикла опережала темпы развития транспортной инфраструктуры (шоссейных дорог). Рассмотрены основные принципы музеефикации мототехники. Отмечено, что одной из ценных качеств памятников техники является отражение особенностей использования предмета и его изменения после выхода из цеха завода. Рассмотрены отдельные аспекты принципов реставрации техники как материального исторического источника с оптимальным сохранением памятника и отраженной в ней информации. Сделан вывод о соответствии мотоцикла МТ10-36 критериям памятники науки и техники в широком смысле этого понятия. Мотоцикл воплощает оригинальные технические решения отечественных инженеров, отражает уровень развития отечественной техники и иллюстрирует практику эксплуатации мотоциклетной техники.

***Ключевые слова**: Киевский мотоциклетный завод; двигатель; политехнический музей; экспонат*

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The establishment of the Kharkiv Practical Technological Institute in the context of modernization

Abstract. *The article examines the history of establishment of the Kharkiv Practical Technological Institute in the broad context of modernization processes. The history of the Practical Technological Institute in Kharkiv is considered in the context of socio-economic changes in the South of the Russian Empire, primarily in the "Ukrainian provinces", in the last third of XIX – early XX centuries. The methodological basis of the article is the modernization approach. Changes that took place in the Russian Empire in the last third of the XIX – early XX century are considered as a modernization movement. Modernization is understood as a complex number of transformations that society is undergoing on the path of development from traditional agricultural to urban and industrial. We proceed from the fact that modern society of that time was aware of the speed of industrial production, the need for qualified engineering personnel. The training of such personnel required the opening of local higher education institutions. The processes of industrialization, migration and*

urbanization, due to the modernization theory, were the main components of social development in the XIX century. The approach chosen by the authors allowed to analyze the formation of higher technical institutions in the Russian Empire, on the example of the Kharkiv Practical Institute of Technology, within these changes. The approach within the new imperial history enabled us to take into account the socio-political subtext of the situation and the decisions that contributed to the establishment of technical universities in the south of the empire. An important aspect of our article is the European context. We investigated the general tendencies of opening similar to Kharkiv educational institutions. We can see certain commonalities, which allows us to explore the problem more deeply. We came to the conclusion that, the emergence of a higher technical educational institution – Kharkiv Practical Technological Institute, in Kharkiv was due to the demand of local elites, which was met by the highest bureaucracy of St. Petersburg, as well as the situation in the city itself. This compromise did not cancel the rivalry, both at the highest bureaucratic level – the Ministry of Finance and the Ministry of National Education, and at the regional level, in particular Kharkiv university elite and the inspirers of the idea of a separate technical institution.

Keywords: *Kharkiv Practical Technological Institute; Russian Empire modernization; Polytechnics; education in Europe; higher technical educational institution*

Introduction.

The last third of the XIX century in the history of the Russian Empire was marked by radical changes in the socio-economic situation. The period was characterized by mechanization processes, the emergence of large enterprises, the development of powerful mineral deposits, the rapid development of the transport network. Technological changes were combined with social shifts. The urban space had undergone significant transformations. Cities such as Odessa, Kyiv, and Kharkiv morphed into densely populated modern centers, with inherent lifestyles, economies, and social structures. They became magnets for migrants, providing opportunities for them. We believe that the opening of the Kharkiv Practical Technological Institute (KhPTI) during this period was due to the processes that took place in the Ukrainian lands of the Russian Empire.

We argue that the study of the history of the opening of a technological educational institution in Kharkiv should also be considered in the context of the processes taking place in European countries during the "long nineteenth century".

The theoretical basis of the study was the theory of modernization, which gained popularity in the academic environment in the 1950-1960s. Attention to the transformations in the Russian Empire through this focus was a later scientific achievement. Historiography of the period of the Russian Empire gave its own assessment of the changes that had taken place. Thus, a historian and public figure Dmytro Bahaliy assessed the impact of the emergence of a technical institution of

higher education in Kharkiv on the cultural space of the city (Bahaliy, 1993). Soviet historiography, and later Ukrainian historiography, in the first decades of independence, increasingly focused on the importance of the reforms of the 1860s and 1870s, which, according to many, created a whole new context, particularly in the field of higher education. For some time, this idea was supported by Western scholars who were involved in Russian Studies, making the paradigm of the Great Reforms almost inviolable (Payps, 1993).

But as early as in the 1990s, researchers were looking for alternatives to the old theoretical baggage. Daniel R. Brower studied the history of cities, emphasizing the transformation of urban life in the late Imperial period. In the changes that took place in the Russian Empire between the reforms of Alexander II and the revolution of 1905, he granted a privileged place to the role of urban society. Standards of change were spread among educated citizens, which prompted them to certain intentions, formed requests for educational projects (Brower, 1990). The American scientist Elise Wirtschafter, a researcher of social processes in the Russian Empire, focused on "raznochintsy"; who were considered to be outsiders and whose role in the social hierarchy was marginalized. Wirtschafter demonstrated the importance of this social category in imperial society, outlined its impact on society (Wirtschafter, 1994).

In the Ukrainian historiography of the 2010s, the authors pay attention to the history of the city from the standpoint of economic, social and cultural development, especially in the era of modernization, when the city was a space that attracted the latest trends and was a certain civilizational measure (Portnova, 2012). Researcher Victoria Konstantinova, describing the role of urban settlements in the development of educational and health care facilities, emphasizes that cities in the south of the empire maintained a monopoly position as the location of higher and the vast majority of secondary schools (Konstantinova, 2010, p. 23). In some works, attention is paid to technical education and its role in the formation of the cultural layer (Koshman, 2008).

Of particular interest for the study is the paradigm of the "new imperial history" which was actively formed in relation to the research of the Russian Empire in 2000-2010. It defines the "imperial situation", which was an important factor in the decision-making process. The universal order from the capital was reflected in the mirror of such a situation and was implemented with unpredictable consequences (Glebov, Mogil'ner, & Semenov, 2015). In such important regions as the "Ukrainian provinces", the control of the empire depended on the imperial authorities taking into account local trends and finding a form to support the interests of influential groups (Imperskaya, 2015). The emergence of a higher technical institution in Kharkiv can be considered to be an episode of such an "imperial situation". The conservative education system required the interaction of imperial power and local elites. In the formation of a new technical elite for the empire, it is important to mention social engineering as the foundation of imperial public policy (Glebov, Mogil'ner, & Semenov, 2015). The very principle of reformism in the Russian Empire was the foundation of state policy and the justification of its legitimacy (Imperskaya, 2015). The meaning of the general

program was "Europeanization", which in the empire became a framework phenomenon. The creation of a new industry and a new technical elite fully corresponded to this framework.

Thus, the current historiographical situation provides an opportunity to consider the formation of a system of higher technical education in the Russian Empire through the prism of modernization processes, taking into account the imperial situation inherent in the period.

The purpose of this publication is a case study of the opening of the Kharkiv Practical Institute through the prism of modernization processes in the south of the Russian Empire, primarily in the "Ukrainian provinces", in the last third of XIX – early XX centuries. The concept of modernization is the main focus of this publication, and the history of the Institute of Technology in Kharkiv is considered in the context of socio-economic changes in the region.

The methodological basis of the article is the modernization approach. Changes that took place in the Russian Empire in the last third of the XIX – first decades of XX century are considered as a modernization movement. Under modernization we understand a complex number of transformations that society is undergoing on the path of development from traditional agricultural to urban and industrial (Davies, 1997, p. 764). Proponents of the modernization approach explained the problem of the development of the society with the help of analyzing components of modernization, studied the transition between traditional and modern society. Ukrainian historian Tetyana Portnova notes that the foundations of the theory of modernization are the understanding of development as an evolutionary, stage, one-sided process of social change, the result of which is modern society (Portnova, 2012). Such a modern society is aware of the speed of industrial production, the need for qualified engineering personnel. The training of such personnel requires the opening of local higher education institutions.

Social changes in the Ukrainian society of the specified period were traced through the modernization perspective. The processes of industrialization, migration and urbanization since the advent of modernization theory were the main components of social development in the XIX century. The approach chosen by the authors allowed to analyze the formation of higher technical institutions in the Russian Empire, on the example of the Kharkiv Practical Institute of Technology, within these changes. The approach within the new imperial history enabled us to take into account the socio-political subtext of the situation and the decisions that contributed to the establishment of technical universities in the south of the empire.

Results and Discussions.

The establishment of technical higher education institutions. According to researchers of higher education, the institutions of "the Long nineteenth century" were

influenced by the following factors: the Industrial Revolution, the French revolution, the new Imperialism and so on. All these aspects had an impact on higher education at the time. Obviously, this also affected technical education. The needs of industrial society made it necessary to open technical schools, many of which eventually became universities, and mechanical engineering became a standard part of higher education (Moore, 2019, p. 61). Modernization and industrialization required more engineers and technicians to work in the public sector. They were needed for the construction of railways, canals, roads, urban development and more. Such engineers and technicians were needed to manage the industry, to guide skilled workers. In turn, new modern methods of production required highly skilled workers who were educated in technical schools (Pombo Vejarano & Ramírez, 2002, p. 20).

Understanding the importance of science for industry significantly increased during the XIX-th century. The combination of science with practical experience in technology became increasingly important. At the same time, technical education in England, the leading industrialization country, was based on the principle of "learning by doing" with the domination of empirismus. With the growing role of science, this approach no longer met the requirements of the time (Ahlström, 1978).

Traditionally, there are two models of university education that emerged at this time. The first of them arose in France after revolution. Higher education here was under strict state control. Under the influence of the revolution, higher education was perceived as one that should work for the public utility (Capecchi & Ruta, 2014). The second, Berlin (German or Prussian) model was also the creation of the state, but in contrast to French one, this model was not controlled by the state and was to emphasize the free pursuit of knowledge (Moore, 2019, p. 67). Both models significantly influenced higher education in other European countries in the nineteen century. This also applied to technical education at that time. If we take the "polytechnic" model, researchers traditionally pay attention to the first such institutions in France and Germany (École Polytechnique (The Polytechnic school) in Paris and the technical universities of Karlsruhe and Berlin in Germany).

Thus, in the XIX century in France, higher education was treated as public. In fact, since the French Revolution, the central government promoted and supported technical institutions. The state was interested in training engineers and technicians not only for the civil service, but also for private industry. In Germany, local governments played a leading role in the opening of educational institutions due to disunity. Each region had its own technical education. Local entrepreneurs also understood their need due to the rapid industrial development. (Pombo Vejarano & Ramírez, 2002, p.19). In the second half of the 19th century, the reorganization of higher technical educational institutions took place in Germany. Previously established technical schools were transformed into technical universities, which had the same academic autonomy as universities. They were transferred from the Ministry of Commerce to the Ministry of Education. During this process, workshop training lost its original significance. More attention was paid to the study of scientific disciplines

as in universities. Qualified teachers who had the opportunity to teach original courses were invited (Rüegg (Ed.), 2004, p. 611).

The formation of higher technical education in Italy took place in the first half of the nineteenth century. In the largest cities, such as Naples, Rome, Turin and Milan, where there was a need for engineers, such educational institutions were established. For example, in Naples, a similar school was built on the French model. After the unification of Italy, the understanding of the need for higher technical institutions grew even more. Engineering schools and courses for engineers were separated from the faculties of mathematics in universities (Capecchi & Ruta, 2014)

As in Europe, polytechnic education developed during the nineteenth century in the United States. The oldest technological university in the USA was Rensselaer Polytechnic Institute (founded as a technical school in 1824). Education at the Polytechnic Institute was primarily aimed at science and civil engineering for national and international needs. Rose Polytechnic Institute was founded in 1874. According to the charter, this Institute focused on the "mechanical arts and sciences" as well as "useful and practical knowledge of some art trade or occupation" that would enable its students "to earn a competent living" (Mercer & Ponticell, 2012).

Thus, the industrial revolution and modernization prompted the world's leading countries to organize higher technical education. It happened in different ways. The role of the state, central and local government, and industrial owners was different. At the same time, the understanding of the development of technical education was common in the leading countries. Let us turn to the processes that took place in the Russian Empire's Ukrainian lands and Kharkiv firstly.

The Russian Empire context.

The last third of the XIX century was a period of a new wave of industrial revolution in the Russian Empire. The south of the empire, in particular the "Ukrainian provinces", became the epicenter of the technological revolution. New industrial enterprises were established, associated with the intensive development of the iron ore industry, coal mining, metallurgy, and mechanical engineering. The new enterprises actively used the achievements of science and technology, which were to increase productivity (Dovzhuk, 2009, p. 3). The arrival of the railway significantly intensified the processes of industrial development. The implementation of these processes required a significant increase in the number of professional engineers.

Socio-economic conditions prevailing in the south of the Russian Empire (we are primarily interested in Kharkiv, Ekaterinoslav, Kherson, Tavriya, Kyiv) contributed to the expansion of the network of higher technical institutions. Their establishment was a demand of industrial circles, which needed a large number of cheaper personnel, especially since this need only intensified in the following decades. The analysis of the functioning of such a network broadens the view of the general situation in the empire, through the active collaboration of the southern technical institutions with the northern ones, both at the level of ideas and through the exchange of teaching and student staff.

Powerful industrialization created a large number of new jobs and affected changes in the social structure of the population. As a result, the number of industrial entrepreneurs and employees, both men and women, increased in number. The growing sphere encouraged foreign entrepreneurs to both invest and do business in the field. The Donbass adjacent to Kharkiv province developed most intensively. The influx of foreign workers and engineers and capital was so intense that the region was called the "tenth province of Belgium"; The arrival of foreign entrepreneurs and financiers, their investments and direct participation in the development of industry took place under the protection of the imperial government (Kulikov, 2014, p. 154). Intensive industrial development also encouraged internal migration. The migration wave of the last quarter of the XIX century is associated with the active spread of market relations (Nikitin, 2018). In the region called "Ukrainian America", the role of Kharkiv was crucial, playing the role of a transit center between the "inner provinces"; of Russia and the capital cities and the south of the empire, primarily Odessa and Ekaterinoslav. The role of Kharkiv as the financial and intellectual center of the region gradually increased.

In the last third of the XIX century the urban environment was changing significantly. Housing construction was launched, post and telegraph offices, telegraph stations were opened, and banks were established. An intra-city transport network was created - horse and electric tram lines, etc. (Vodotyka, 2018). Kharkiv became one of the main platforms for these changes. After the opening of the railway in 1869, the industrial development of the city intensified. Kharkiv received fast communication with many regions. In the 1870s and 1890s, such industrial enterprises as the Melgoze and Gelferich-Sade agricultural machinery plants, the N. F. von Dietmar locksmith and mechanical workshop (machine-building plant), the rope and machine-building plants, and the confectionery factory appeared here. There were several sugar and porcelain and earthenware factories near the city (Gutnyk, 2016, p. 3). These changes required increasing involvement of qualified personnel.

The polytechnic establishment – the case of Kharkiv

The emergence of a higher technical educational institution – Kharkiv Practical Technological Institute, in Kharkiv was due to the demand of local elites, which was met by the highest bureaucracy of St. Petersburg, as well as the situation in the city itself. Another secondary school reform prepared generations of those who were ready to enter a new technical college. The 1870s were the boundary between the ignorance of society and the explosion in primary education that changed society (Wirtschafter, 1994, p. 143). The long period of the 1820s and 1860s laid the foundations for change and created a generation of their inspirers (Lincoln, 1982, p. 41). Indeed, it was precisely the flexibility and inconsistency of these formulas that permitted their voluntaristic interpretation by both officialdom and society. Finally, the new technical "intelligentsia" appeared at a time when the staticity of formal definitions of laws relevant to administrative and social provisions resonated with complex socio-cultural

identities, when new cultural concepts were formed - society, "intelligentsia" (Wirtschafter, 1994, p. 118).

The first wave of opening of technical institutions in the Russian Empire fell on in the 1860s. At that time, the Riga Polytechnic School and the Commissar Technical School in Moscow began to function. At first glance, purely economic reasons for the creation of technical institutions had hidden motives outside the "inner Russian provinces". Thus, Russian was the language of instruction at the University of Riga, which led to the loss of part of the teaching staff (RHYA, f. 1293, op. 97, spr. 155, ark. 9.). On the other hand, graduates were not subject to conscription and received the rights of honorary citizenship.

In the 1880s, at a new stage in the formation of the system of higher polytechnic institutions in the empire, Kharkiv became one of the main contenders. As well as Kyiv and Odessa, the city had a department at the university that produced technological engineers. The idea of establishing a separate higher technical institution was actively discussed by local elites in these cities. In Kyiv, in 1880, large entrepreneurs collected more than 1 million rubles "to establish a technical institution" (RHYA, f. 1276, op. 20, spr. 85, ark. 45).

But, organizationally, Kharkiv elite took the lead in this competition. Back in January-May 1871, local authorities of Kharkiv allocated 50 thousand rubles from the profits of the "public bank", part of which went to buy land for the future institution. Dmytro Bahaliy noted that the agreement was extremely successful, and a well-located large plot of land was purchased at the lowest price (Bahaliy, 1993, p. 606). The project received support from the Ministry of Finance and the Minister himself - Michael Reiter, which gave the opportunity to immediately begin construction of buildings, designed by architect Roman Heinrichsen. Decision-making was accompanied by appeals to the Ministry of Finance and the Ministry of National Education, which took care of this issue. The arguments in the appeals reflected the general position of the regional elite, which insisted on the opening of a technological institute, arguing for the importance of Kharkiv as the center of "southern Russia", the request of the local mining industry, the need to educate its own technical elite (DAKhO, f. 45, op. 1, t. 2, spr. 18). In this situation, the interests of the central bureaucracies and the regional elite coincided. The view of the special role of Kharkiv was characteristic of imperial officials as early as in the middle of XIX century, when in his economic report Ivan Aksakov predicted the city's great future of an important transit center (Aksakov, 1858, p. 57).

In 1881, a new stage of discussion began around the creation of the KPTI, which was quickly transferred from the capital's State Council to the regional level, with the involvement of the public - the Kharkiv branch of the Technical Society. The project of the future institute was modelled on Riga Polytechnic.

In 1882 a two-year technical high school was opened in Kharkiv. The congress of miners, which took place in the city of the same year, once again stressed the need for training for regional enterprises (DAKhO, f. 45, op. 1, t. 2, spr. 18). In April 1885, with

the assistance of the Minister of Public Education Ivan Delyanov, the charter of the Kharkiv Practical Technological Institute was approved. Financing of the institution was approved for the first five years of operation, with an average allocation of 145 thousand rubles, the sources of subsequent revenues are provided and a state loan of 3 million rubles was opened for "extraordinary needs". The support of the regional elite continued in providing additional scholarships to successful students of the institute, replenishment of the institute library, donations for the activities of the institution.

In September 1885, Kharkiv Practical Technological Institute was officially opened, which was accompanied by the consecration of the premises and a prayer service. The speech from the trustee of the educational district, the formal head of the institution, Nikolai Velyaminov-Vorontsov, once again outlined the hopes of the regional elite: "… realization of all hopes… for the revival, rise, development of industrial forces… so that the sons of the homeland and our land, and not people alien to it, can use its gifts… turned cosmopolitan science… into our property" (Bagaley, & Miller, 1993, p. 605). Bagaley noted that the existence of the Institute of Technology in Kharkiv undoubtedly "spread its influence as the cultural center of southeastern Russia" but his regional patriotism did not hide the motive for KhTI's rivalry with the historian's alma mater. In a short historical essay, two pages of a rough volume of a monograph on the technical institute, Bahaliy did not forget to point out the lower qualifications of the teaching staff, compared to the university, adding that the institute did not assign such tasks (Bagaley & Miller, 1993, p. 605).

As in the case of the Riga Technical Institution, the KPTI acted as an instrument of Russification and integration for the imperial bureaucracy - it had Russian as the language of instruction and granted honorary citizenship to university graduates. In 1898 the institution received a new name - Kharkiv Technological Institute of Emperor Alexander III. The autonomy of the institute gave it the right not to censor its own publications and imported literature. Choosing a job by profession promised the engineer for ten years the heredity of this privilege. KPTI was not without problems of its time. Thus, as early as 1886, a discriminatory percentage rate was established for Jewish students (Pozner, 1914, p. 781). Only in the XX century the issue of admission of women to the institution was considered (DAKhO, f. R 1682, t. 2, op. 1, spr. 10).

At the turn of the XIX-XX centuries, technological institutes were opened in Kyiv, St. Petersburg, and Warsaw. Their opening was supported by the Minister of Finance and later the Prime Minister of the Russian Empire Sergei Witte. At this time, the Russian Empire received a network of higher technical schools. As indicated, the links between institutions affected the level of ideas, in particular KhTI initially chose a rehearsal system for students, first introduced at the St. Petersburg Technical Institution by Ivan Vyshnegradsky, as well as at the staff level - the first director of KPTI Viktor Kirpichov continued his work as the rector of the Kyiv Polytechnic University, and another director of the Kyiv Polytechnic University Dmytro Zernov, and another director of the KhTI, later headed the institution in St. Petersburg (K 25-letiyu KhTI imperatora Aleksandra III, 1885–1910).

Conclusions.

The opening of higher education institutions in Europe and the United States in the "long nineteenth century" was due to the reality dictated by the era. The industrial revolution and industrial movements led to the evolution of technical education, which in every corner of the world had its own characteristics, conventions and trends. The appearance of a technical educational institution in Kharkiv shows that we have not lagged behind world trends and movements, while having its own characteristics and conditions. Thus, the modernization of the empire prepared the socio-economic background for the implementation of this idea.The modernization of the empire prepared the socio-economic background for the realization of the idea. In the last third of the XIX century, the industrial explosion constantly revived the personnel hunger for technical "intelligentsia". The generation of young people who graduated from local schools and gymnasiums fulfilled the desire of business circles to receive domestic staff.

The emergence of the Kharkiv Practical Institute of Technology was affected by the "imperial situation", in which the capital's center probed regional sentiment and adjusted its policy to the demands of local elites. This compromise did not cancel the rivalry, both at the highest bureaucratic level – the Ministry of Finance and the Ministry of National Education, and at the regional level, in particular Kharkiv university elite and the inspirers of the idea of a separate technical institution.

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Заснування Харківського практичного технологічного інституту в контексті модернізації

Анотація. *У статті розглядається історія створення Харківського практичного технологічного інституту в широкому контексті процесів модернізації. Історія відкриття технологічного інституту у Харкові розглядається в контексті соціально-економічних змін на Півдні Російської імперії, насамперед в «українських губерніях», в останній третині XIX – на початку XX століть. Методологічною основою статті є модернізаційний підхід. Зміни, що відбулися в Російській імперії в останній третині XIX – на початку XX століття, розглядаються як модернізаційний рух. Під модернізацією ми розуміємо перетворення, що суспільство переживає на шляху розвитку від традиційного сільського господарства до урбанізованого та індустріального. Ми виходимо з того, що модерне суспільство того часу усвідомлювало швидкість промислового виробництва, потребу в кваліфікованих інженерних кадрах. Навчання таких кадрів вимагало відкриття вищих навчальних закладів на місцях. Процеси індустріалізації, міграції та урбанізації, відповідно до теорії модернізації, були головними складовими соціального розвитку в XIX столітті. Обраний авторами підхід дозволив проаналізувати формування вищих технічних закладів Російської імперії на прикладі Харківського практичного технологічного інституту в рамках модернізаційних змін. Підхід в рамках нової імперської історії дозволив врахувати соціально-політичний підтекст ситуації та рішення, які сприяли створенню технічних університетів на півдні імперії. Ми дійшли висновку, що поява у Харкові вищого технічного навчального закладу – Харківського практичного технологічного інституту, була обумовлена попитом місцевих еліт, якому відповідала найвища бюрократія Санкт-Петербурга, а також ситуацією в самому місті. Цей компроміс не відміняв певного суперництва як на найвищому бюрократичному рівні – Міністерства фінансів та Міністерства народної освіти, так і на регіональному рівні, зокрема між харківською університетською елітою та натхненниками ідеї окремого технічного закладу .*

Ключові слова: *Харківський практичний технологічний інститут; модернізація Російської імперії; Політехніка; освіта в Європі; вищий технічний навчальний заклад*

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Основание Харьковского практического технологического института в контексте модернизации

Аннотация. *В статье рассматривается история создания Харьковского практического технологического института в широком контексте процессов модернизации. История открытия технологического института в Харькове рассматривается в контексте социально-экономических изменений на Юге Российской империи, прежде всего в «украинской губерниях», в последней трети XIX – начале XX веков. Методологической основой статьи является модернизационный подход. Изменения, произошедшие в Российской империи в последней трети XIX – начале XX века, рассматриваются как модернизационный движение. Под модернизацией мы понимаем преобразования, которые общество переживает на пути развития от традиционного аграрного к урбанизированному и индустриальному. Мы исходим из того, что модерное общество того времени осознавало скорость промышленного производства, потребность в квалифицированных инженерных кадрах. Обучение таких кадров требовало открытия высших учебных заведений на местах. Процессы индустриализации, миграции и урбанизации, согласно теории модернизации, были главными составляющими социального развития в XIX веке. Выбранный авторами подход позволил проанализировать создание высших технических учебных заведений Российской империи на примере Харьковского практического технологического института в рамках модернизационных изменений. Подход в рамках новой имперской истории позволил учесть социально-политический подтекст ситуации и решения, которые способствовали созданию технических университетов на юге империи. Мы пришли к выводу, что появление в Харькове высшего технического учебного*

заведения – Харьковского практического технологического института, была обусловлена спросом местных элит, которому способствовала высшая бюрократия Санкт-Петербурга, а также ситуация в самом городе. Этот компромисс не отменял определенного соперничества как на высшем бюрократическом уровне – Министерства финансов и Министерства народного просвещения, так и на региональном уровне, в частности между харьковской университетской элитой и вдохновителями идеи отдельного технического заведения.

Ключевые слова: *Харьковский практический технологический институт; модернизация Российской империи; Политехника; образование в Европе; высшее техническое учебное заведение*

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The forgotten contribution of J. E. Purkyně to dentistry

Abstract. Objectives: *the name of Jan Evangelista Purkyně (Purkinje in German), born in Bohemia in 1787 and died in Prague in 1869, is mainly associated with discoveries in histology and specialist fields of Medicine like embriology, histological techniques, ophthalmology, cardiology and neurophysiology. This short article presents a brief account of his life, commemorates his achievements in biology and medicine but also in in the politics and literature of his Country (he was elected to the Diet of Bohemia but also he composed poems and important translations from German, French and Italian languages into Czech) and examines in depth his contribution to Dentistry.* ***Materials and Methods:*** *Purkyně's major contributions to Dentistry, which focused on embryology and dental histology, endodontics and periodontology, are traced to two dissertations in Latin which were discussed by his pupils (Meyer Fraenkel and Isaac Raschkow), at Breslau University in 1835: we present a brief summary of each, with the major innovative findings highlighted.* ***Results:*** *the two dissertations contain remarkable, though often overlooked, contributions to Dentistry. Among these we can indicate the individuation of: the dental cement (substantia ostoidea), the acquired dental pellicle, the nature of optical illusion of Hunter-*

Schreger lines, the "enamel pulp" from which the enamel would evolve, the sub-odontoblastic nervous plexus which is the cause of tooth sensitivity, the predentine, the organic nature of the process of enamel formation, the dentine and enamel formation in opposing directions, the presence of alveolus membrane (id est: the periodontium). ***Conclusions:*** *after reviewing the main innovations these two dissertations made to Dentistry, Purkyně's personal share in both is very clear. Both the two his pupils acknowledged their debt to Purkyně and also famous contemporary Purkinje scientists such as Alexander Nasmyth, Sir Richard Owen, Sir James Paget had no doubt he is had generated the ideas expressed in the two little treatises.*

Keywords: *History of dentistry; Raschkow; subodontoblastic plexus; teeth*

Introduction.

J. E. Purkyně (Fig. 1) was born into a catholic family in Libochovice (Bohemia in the Austrian-Hungarian Empire, today's Czech Republic) on 18th December 1787. His father died in 1793. J. E. was educated at his local, Czech language primary school (Anonymous, 1870; Henry, 1953) and then from 1797 until 1804 at the Piarist Fathers secondary school in southern Moravia. There he learned German, Latin, French and Italian and entered the Piarist Order as a novice (Henry, 1953; Posner, 1969; Sykora, 1988) but decided against taking his vows in 1807. He started working as a private tutor in Prague while studying at Prague University faculty of philosophy. He began his studies in medicine in 1812, graduating in 1818 from Prague University with a dissertation entitled «A contribution to knowledge about subjective sight» (Purkinje, 1819). He was appointed assistant professor of anatomy at the university, a post he held for five years before moving in 1823 to the Royal Prussian University of Breslau (now Wrocław, Poland) where he worked as professor of physiology and pathology until 1850.

Dr. Purkyně married Julia Rudolphy in 1827, daughter of a professor of physiology in Berlin. From 1829 to 1834 they had four children: Rosalia and Johanna who died of scarlet fever in 1832 (Henry, 1953), Emmanuel, who became a professor of botany and karel, who was destined to be one of the Czech Republic's most famous painters, dying in 1868. When Julia succumbed to meningitis in 1835 (Henry, 1953), J.E. was left a widower with two children under the age of four. Despite these family tragedies, which he bore with Job-like patience, the years he spent at Breslau were among his most prolific. He founded the physiology institute, acquired the highly advanced Plössl microscope and published many of his ideas in his pupils' dissertations. In 1850 he was appointed professor of physiology at Prague University, a post he held until his death in 1869.

He founded «Živa» (Life), a Czech scientific journal in 1853, was elected to the Diet of Bohemia for the 1861–1866 legislature and was awarded the austrian imperial order of Leopold in recognition of his scientific achievements in 1868 (Szpilczynski, 1971; Jay, 2000). After a short illness, he died in Prague in 1869, at the age of 82. He

received a state funeral and is buried in Prague's «Vyšehrad» monumental cemetery, which is reserved for the Czech Republic's most prominent citizens.

Figure 1. Jan Ev. Purkyně. Drawing by Jan Vilímek (Vilímek, 1887).

Purkyně's main innovations in biology and medicine.

Summarizing Purkyně's many discoveries is not easy, due to his wide range of interests and, according to one of his pupils, his habit of «passing from one discovery to the next, leaving the task of working out details to others» (Eiselt, 1859; Cavero, Guillon, & Holzgrefe, 2017). Vision was among his earliest and most constant interests, as shown by his graduation dissertation. According to Purkyně, diverse ocular properties and structures could be investigated psychologically and physiologically, the latter by means of careful analysis of microscopy findings (Anonymous, 1870). In 1820 he published a paper on vertigo (Purkinje, 1820) and one year later, a wide-ranging work on the psychology of dreams (Cavero, Guillon, & Holzgrefe, 2017). After moving to Breslau his inaugural lecture on the structure of the retina appeared in print in 1823 (Purkinje, 1823) and was followed by an innovative contribution to advancing knowledge of subjective vision in 1825 (Purkinje, 1825) as well as an original contribution to music acoustics (Cavero, Guillon, & Holzgrefe, 2017). Afterwards (1825–1833) he focused his attention on animal embryology and plant histology, identifying the germinal vesicle in a paper on embryology in bird's eggs (Purkinje, 1830a). His work on plant pollens (Purkinje, 1830b) won him the Montyon prize medal from the Institute of France (Anonymous, 1870). In 1836 Purkyně and G. G. Valentin, his assistant who would later become professor of physiology in Berne University, published a major paper on mammal, bird and amphibian genital and respiratory ciliated epithelia, correctly claiming they served to defend the organism from foreign substances (Purkynje & Valentin, 1836). This was followed, two years later in 1838 by a report that was co-authored with S. Pappenheim exploring in vitro tissue digestion by gastric juices (Purkinje & Pappenheim, 1838). In the meantime from 1824 until 1845, he had started publishing on a wide range of research topics in his pupils' dissertations, thus bestowing honours on them. These included: theory of vertigo after brain trauma, human skin histology, identification of sweat glands and their ducts, bone histology, embryology and tooth histology, cartilage histology, blood vessel histology, female genital embryology, heart muscle histology, uterus histology, granular nerve formation defining protoplasma, the nerve complex in spinal cord pia mater and cerebrospinal fluid histology. When Purkyně's wide range of publications were all collected in his 12 volumes of Opera Omnia (Purkinje, 1919–1985) so many great innovations emerged that contemporary scientists conferred his name on them. Hence in embryology there is *Purkyně's Vesicle* which is the germinal vesicle in the egg (Purkinje, 1830a). In ophthalmology one has *the Purkyně Effect* (how colour perception varies with environmental light), *Purkyně's Images* (projection of a light angled at 30°/50° generates four reflected images of different eye areas) and *Purkyně's Tree* (self visualization of retinal blood vessels under certain light conditions) (Wade & Brožek, 2001). In cardiology there are *Purkyně's Fibres* in the heart conduction system (Schweitzer, 1991; Davies & Hollman, 1996). In neurophysiology *Purkyně's cells* are found in the cerebellum (Haas, 1994). *Purkyně's compressorium* was used in histological techniques (Purkinje, 1834). However, many of his other

discoveries or major contributions such as new techniques for including and fixing cells in for histological analysis or the development of the first microtome were not named after him.

Purkyně and dentistry.

Purkyně's major contributions to dentistry, which focused on embryology and dental histology, endodontics and periodontology (Cox et al., 2017; Foster, 2017), are traced to two dissertations in Latin which were discussed at Breslau University in 1835. The first, by Meyer Fraenkel, was entitled «De penitiori dentium humanorum structura observations» (Fraenkel, 1835), while the second, by Isaac Raschkow, was «Meletemata circa mammalium dentium evolutionem» (Raschkow, 1835). Here's a brief summary of each, with major innovative findings highlighted in italics.

M. Fraenkel's dissertation «Observations on the structure of human teeth», consisted of 20 pages (plus 2 pages of explanations and 8 figures) containing 26 sections, and was histology based.

After a general presentation, he stated he would illustrate what was known and then his research (§1). He then described tooth anatomy, crown, the cemento-enamel junction and root/s (§2), the diverse functions of different teeth (incisors, canines etc) (§3), the differences between primary and permanent teeth (§4), dental pulp (§5), tooth sockets and gums (§6). He moved on to discuss dental substances in general (enamel – substantia adamantina and dentine- substantia dentalis propria), proving in 7 very clear steps that teeth could not be classified as bone (§7) and were not horns (§8). He then introduced the concept of *substantia ostoidea* which, as it covered the roots, can be identified as *dental cement* (§9). He refuted Hunter's statement that caries attacked the root more slowly than other tooth parts (§10). He described the general modality for the chemical preparation of teeth for dissection. Although he emphasized that after the mineral tooth surface had been dissolved in acid, «a very fine membrane-type substance» was observed at microscopy, he did not list its features. This might today be identified as an *acquired pellicle.* He also highlighted the importance of using the Plössl microscope (§11) and presented the materials and methods for observing dentine under the microscope (§12).

Sections 13-19 focused on dentine: its sinuous, tubular structure and the presence of a thin membrane *(odontoblasts layer?)* at the pulp border (§13); the tubule pattern in individual teeth (§14); longitudinal and cross sections of the tubule cavities (§15). Then he commented and expounded on Schreger lines in dentine (which are also found in animal tusks) (§16–17) and the reddish colour of dentine that Hunter had observed in animal teeth (§18). He reported the Hunter, Blake, Heusinger, Weber and Van Kaathoven descriptions of dentine (§19).

Sections 20-26 were dedicated to tooth enamel. Many scientists had described enamel as fibrous in nature. The Hunter, Blake and Schreger definitions of enamel were cited and Hunter's observation of fine striae on the enamel was confirmed. He insisted the fibres were mineralized (§20) and stated that a clear view of the enamel structure

could only be obtained by observing different sections on five planes following the fibre/prism patterns, which were illustrated in fine images. The planes included the longitudinal (*which led him to define the Hunter-Schreger lines as an optical illusion)*; oblique (§21–22); parallel to the surface (§23); parallel to the surface but closer to the dentine (§24) and the crown cross-section (§25). Finally, he summarized findings of his research into fibre/prism patterns and concluded by saying only excellent mathematicians could explain the reason for such complexity (§26). The reference list contained 48 citations.

Isaac Raschkow's dissertation, entitled «Essays on mammal tooth evolution», consisted of 20 pages (plus 2 pages of legends to the figures and 1 page of figures). Set out in 62 sections, it focused on embryology. Raschkow reported his own findings in the first part of his dissertation (§1-35) and compared them with previous publications in the second (§36-62).

After a general introduction, he stated that he would first present his own observations and then compare them with previous reports (§1); He described the dissection methods to obtain dental follicles in diverse animal species (§2–3) the dental follicle in general (§4-5); follicle contents and the tooth germ, in which he identified a globular nucleus. This he designated the «*adamantine organ*» from which the enamel would evolve (§6-8). He described the evolution of the enamel organ (§9) showing that it contained a *stellate reticulum* which he denominated *enamel pulp* (§10). Careful observation of the internal surface of the *adamantine membrane* (§11) showed it was composed of «*hexagonal cells»* (*ameloblasts?*) (§12). He claimed he had found small differences in the adamantine membrane in ruminants, swine and rodents (§13).

He continued with an in-depth description of the tooth germ (§14), stating it was connected to the nerve from its beginning and hypothesizing *it might originate from i*t (§15-16). In describing the dental pulp he identified the *sub-odontoblastic nervous plexus* which accounted for extreme tooth sensitivity (§17). He reported he had observed «*massae lapidosae»* (*pulp stones?)* in the dental pulp of hares, swine and deer (§18). He identified a basal membrane around the pulp which he named the «*maembrana praeformativa»* (§ 19). He described equal-sized globular grains (cells) as constituting the parenchyma that would form the dentine (§20), noting they were positioned in much greater order near the preformative membrane (*«odontoblastic layer»?)* (§21). He observed the dental germ was more evolved when the substantia dentalis (dentine) started to form, beginning at the coronal apex and passing through the tooth body to the roots. *Very early stage dentine was soft and easily detached* (*pre-dentine*?). Growth direction proceeded from the outside in, reducing pulp space (§22-24). At the end of tooth growth he observed root canals and apical foramen which serve for blood vessel and nerve entrance into the tooth. Since they may be *single or multiple* doubts were raised as to whether the *osteoid layer* covering the roots (denominated *cement* in equidae and ruminants) was generated from the pulp (§25). He then described *enamel formation* which he claimed was an *organic process* and not simply crystal precipitation, as had hitherto been believed (§26). He stated that enamel was

deposited in cross-section layers and reported he had observed the adamantine membrane secrete an *organic sap which, probably by means of organic chemistry processes, combined with the inorganic substance to form enamel* (§27). In accounting for prisms curvature he hypothesized that the adamantine membrane, which was present before prism development, must have been curved. He differentiated between teeth with a limited enamel growth (crown) and those with unlimited growth, such as found in rodents. He admitted further in-depth studies were needed as he had observed enamel layout varied with the type of teeth and animal species. After identifying two principal directions of tooth movement as they met for chewing he observed that since movement was perpendicular in carnivores, frugivore animals and insect-eaters and horizontal in ruminants, rodents and some pachyderms, enamel quantity was greatest in the occlusal zone in the former species and in the parietal area in the latter. This finding was valid for molars but less so for canines and incisors whose function was always the same in all species. Further studies would show if these differences were to be found in the enamel organ (§28). He noted that *dentine and enamel formed in opposing directions*. Dentine formed from the outside in i.e. *from the periphery towards the centre* while enamel formed from the inside out i.e. from the *centre towards the periphery. Dentine formation was more organic while enamel formation was more mineralized.* He refuted the argument that enamel formation was pure crystallization as that would prevent prisms curvature served an organic function (§29).

He then addresses the issue of cement formation (§30), hypothesizing that once the enamel had been formed, the enamel pulp changed its functions. In order to become the *cement forming organ,* it transformed into periosteu since the structures of bone and cement were similar (§31). He then discussed the *alveolus membrane (the periodontium), comparing it with cement* stating it was like lung parenchyma, defining it as elastic and flexible and hypothesizing that it served to provide the tooth with greater mobility (§32). He moved on to gum evolution (§33), stating immediately that gum was not cartilage as many believed. Histological findings showed it was composed of an epithelial layer which was covered by «polyedricis squamulis» *(keratinocytes?*) and by a mucous membrane. Underneath was a hard parenchyma with fibrous filaments and blood vessels (*lamina propria*?). He had observed the already identified Serres glands or pearls (§34). The epithelium was denser in the early stages of evolution and could easily be detached from the mucous membrane. Within the epithelium he observed there were globular cells which, when ruptured, were shown to contain lymph fluid which he speculated could become polyhedric squamules (§35).

In sections 36 to 61 he compared his findings with other reports, particularly by Cuvier, Dietrichs, Burdach, Blake, Hunter, Herissant and Arnold.

Conclusions.

After reviewing the main contributions these two dissertations made to dentistry, Purkyně's personal share in both remains to be established. His two pupils went on to have respectable careers in medicine but never published anything more (Grätzer,

1889). Both acknowledged their debt to Purkyně. Raschkow wrote in the Preface to his dissertation: (…) I would have given up if the illustrious professor Purkinje, such a supremely eminent man, had not guided and assisted me as my teacher with his heartfelt generosity and the power of his intellect. He showed me unknown regions under the microscope and although I was often doubtful and uncertain in these unexplored fields, he never ceased from helping me with facts and advice. He himself, in a generous gesture, drew the figures that illustrated my observations, which I then decided to engrave as prints (…). In his Preface Fraenkel wrote**:** «I don't deny I was terrified at the difficulties my task presented and I was afraid of being accused of being too audacious. The illustrious Prof. Purkinye encouraged me and promised to help me. He's a man who knows a lot, is highly intelligent and extremely precise in his research. He is admired for his kindness, generosity and humanity towards all, particularly his pupils. He helped me even more than he had promised. He not only got me everything I needed for this dissertation but also stopped me from making mistakes which is easy to do when making this type of observations, as he generously intervened in some of them» (...).

Above all, Purkinye's contemporaries had no doubt he had generated the ideas expressed in the two dissertations. Alexander Nasmyth wrote in 1839: «Researches on the structure of the teeth by Purkinje have lately been given to the world in a dissertation by one of his pupils (Fraenkel, 1835; Nasmyth, 1839). Sir Richard Owen wrote in 1840: «The results of the laborious investigations of this most original and indefatigable observer (Purkinje) were published, as is the custom in many German Universities, in two inaugural thesises, the one by Fraenkel (…); the other by Raschkow (…); both of which were defended in the University of Breslau in the month of October, 1835» (Owen, 1840). Sir James Paget wrote in 1842: «In no organs have the results of recent microscopic researches been so unexpected or so brilliant as in these. They have revealed structure before unknown in each of the three component parts of the tooth» and «the chief discoveries were made coincidently by Purkyně, of Breslau, and Retzius of Stockholm» ?. The former published his observation in 1835 in the dissertation of Fraenkel (…) and of Raschkow (…) (Paget, 1842).

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Забутий внесок Я. Є. Пуркинє в стоматологію

Анотація. Мета: *ім'я Яна Євангеліста Пуркинє (німецькою мовою Пуркіньє), який народився в Богемії в 1787 році і помер у Празі в 1869 році, в основному пов'язане з відкриттями в гістології та спеціалізованих областях медицини, таких як ембріологія, гістологічні методи, офтальмологія, кардіологія та нейрофізіологія. Ця коротка стаття представляє невеличкий звіт про його життя, згадує його досягнення в біології та медицині, а також у політиці та літературі своєї країни (він був обраний до Сейму Богемії, але*

також він складав вірші та важливі переклади з німецької, французької та італійської мови на чеську), і детально вивчає його внесок у стоматологію. ***Матеріали та методи:*** *основний внесок Пуркинє в стоматологію, який зосереджувався на ембріології та стоматологічній гістології, ендодонтії та пародонтології, простежується у двох дисертаціях латинською мовою, які захищали його учні (Мейер Фраенкель та Ісаак Рашков) в Університеті Бреслау в 1835 році: ми представляємо короткий огляд кожної з них з висвітленнням основних інноваційних висновків.* ***Результати:*** *дві дисертації містять неабиякі, але нажаль забуті внески у стоматологію. Серед цих внесків ми можемо вказати наступні дослідження: зубного цементу (substantia ostoidea), утворення зубного нальоту, характеру оптичних ілюзій смуг Гунтера–Шрегера, "емалевої пульпи", з якої емаль розвиватиметься, субодонтобластичного нервового сплетіння, яке є причиною чутливості зубів, предентину, органічної природи процесу утворення емалі, дентину і утворення емалі в протилежних напрямках, наявності мембрани альвеоли (наприклад, періодонт).* ***Висновки:*** *після розгляду основних нововведень, які ці дві дисертації внесли в стоматологію, рівень особистої участі Пуркинє в обох стає очевидним. Обидва його вихованці визнали свій борг перед Пуркинє, а також відомі сучасні вчені, такі як Олександр Насміт, Сер Річард Оуен, Сер Джеймс Педжет, які не сумнівалися, що він був авторм ідей, висловлених в цих двох маленьких трактатах.*

Ключові слова: *історія стоматології; Рашков; субодонтобластичне сплетення; зуби*

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Забытый вклад Я. Е. Пуркине в стоматологию

Аннотация. Цель: *имя Яна Евангелиста Пуркине (на немецком языке Пуркинье), который родился в Богемии в 1787 году и умер в Праге в 1869 году, в основном связано с открытиями в гистологии и специализированных областях медицины, таких как эмбриология, гистологические методы, офтальмология , кардиология и нейрофизиология. Эта короткая статья представляет небольшой отчет о его жизни, вспоминает его достижения в биологии и медицине, а также в политике и литературе своей страны (он был избран в Сейм Богемии, но также он сочинял стихи и выполнил важные переводы с*

немецкого, французского и итальянского языка на чешский), и детально изучает его вклад в стоматологию. ***Материалы и методы:*** *основной вклад Пуркине в стоматологию, который сосредоточен на эмбриологии и стоматологической гистологии, эндодонтии и пародонтологии, прослеживается в двух диссертациях на латинском языке, которые защищали его ученики (Мейер Фраенкель и Исаак Рашков) в Университете Бреслау в 1835 году: мы представляем короткий обзор каждого из них с приведением основных инновационных выводов.* ***Результаты:*** *две диссертации содержат значительные, но к сожалению забытые открытия в стоматологии. Среди них мы можем указать следующие исследования: зубного цемента (substantia ostoidea), образование зубного налета, характера оптических иллюзий полос Гунтера–Шрегера, "эмалевой пульпы", с которой эмаль развивается, субодонтобластичного нервного сплетения, которое является причиной чувствительности зубов, предентина, органической природы процесса образования эмали, дентина и образования эмали в противоположных направлениях, наличия мембраны альвеолы (например, периодонт).* ***Выводы:*** *после рассмотрения основных нововведений, которые эти две диссертации внесли в стоматологию, уровень личного участия Пуркине в обоих становится очевидным. Оба его воспитанника признали свой долг перед Пуркине, а также известные современные ученые, такие как Александр Несмит, сэр Ричард Оуэн, сэр Джеймс Пэджет, не сомневались, что он был авторм идей, высказанных в двух маленьких трактатах.*

Ключевые слова: *история стоматологии; Рашков; субодонтобластическое сплетение; зубы*

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The contribution of Kharkiv University scientists to the development of historical and legal science (first half of the XIX century)

Abstract. *In the article, the author, based on the methodological principles of historicism, objectivity, systematics, explored the specific achievements of Kharkiv University scientists, who worked in the first half of the XIX century, in the formation and development of science History of State and Law. Their scientific works, in accordance with the main trend in the genesis of this science at that time, were centered around the law of Kyiv Rus and, in particular, the content of the Rus'ka Pravda (Russian Truth). This area of their activity is studied insufficiently in the scientific literature, both domestic and foreign. This is due to the fact that the main contribution to the development of these issues was made in the second half of the XIX century – then a significant number of works on this topic was published, which provided an opportunity for their systematic analysis. The activity of scientists of this university in the first half of the XIX century concerns the period of formation of historical and legal science. Hence the main shortcomings of their work: a certain fragmentation in the coverage of problems, a narrow historiographical base, the hypothetical nature of some theses. Professor Uspenskyi was the first who started working on the history of law at Kharkiv University and considered the question of "the antiquity of Russian laws and their dignity". At that time, scholars of many universities in the empire had to prove the authenticity of the Rus'ka Pravda and those laws that was not yet generally accepted. O. Kunitsyn, a professor of Kharkiv University, also expressed some doubts in this, although he cannot be attributed entirely to the supporters of the "skeptical school" in Russian historiography. O. Paliumbetskyi made the most significant contribution to the development of historical and legal science at that time at Kharkiv University. He conducted one of the first comparative studies of Old German and Old Rus law, convincingly showed their differences, some influence of German law on Russian, which he considered insignificant. Quite thorough and one of the best was his study of treaties between Rus and Byzantium in the X century. Based on the provisions of these agreements, the scientist made a successful attempt to determine the essence of some of Old Rus laws, in particular on revenge, compensation to the victim and*

court evidence. Most of his arguments were tested over time and are not disputed by modern scientists. Scientists-lawyers of Kharkiv University in that period did not form a separate scientific school, as happened at the University of Kyiv due to the activities of M. Ivanishev, but they worked in line with the then prevailing paradigms in Russian historiography, and made a certain contribution to the formation of historical and legal science. Therefore, their scientific activity deserves further study.

Keywords: *Ukraine; Law; Old Rus law; Kyiv Rus; the Rus'ka Pravda*

Introduction.

The emergence of historical and legal science in the Ukrainian lands is linked inextricably with the opening and development of universities on these areas and the development of legal education in them. The formation of the science of History of Law in Ukrainian universities (we are talking, first of all, about the three universities opened in the XIX century: Kharkiv, Kyiv and Odesa) was provided by research of local professors. The first of these universities was in Kharkiv and it was its scholars who began to develop historical and legal science in the first half of the XIX century, as the other two universities were opened later. Already in the early XX century about the contribution of jurists of Kharkiv University to the development of jurisprudence, including to studying the law of Kyiv Rus, was written in the work "Law Faculty of Kharkiv University for the first hundred years of its existence (1805–1905)" (Chubinskyi & Bagaley, 1908, p. 311). General aspects of the development of legal education and science in universities in the Ukrainian lands are covered in the dissertation of O. Yegorova "Legal education in the universities of Ukraine XIX – early XX centuries (stages and features of development)" (Yehorova, 2004). Nothing was said about the works of historians of law of that period in the Great Legal Encyclopedia (Vol. 1 – History of State and Law, 2016) and in the 10-volume "Encyclopedia of the History of Ukraine" (2003–2019).

The activities of some professors of Kharkiv University in the field of historical and legal science are covered in several articles by the author of this scientific investigation (Grechenko, 2014; Bandurka & Grechenko, 2018). Thus, the scientific achievements of professors who were engaged in historical and legal research during that period at Kharkiv University have been studied insufficiently and very unevenly. Many more publications relating to the analysis of the works of scientists of the second half of the XIX century and early XX century. According to the degree of exploring they can be divided into three groups. The first group includes the more explored, who have made a significant contribution to the development of this science and about whom dissertations have been written. These are S. Pakhman and M. Maksimeiko. The second group includes less explored by scholars of later historians of law, about which there are separate articles or references (M. Kovalevskyi, A. Stanislavskyi, O. Paliumbetskyi, G. Uspenskyi, P. Tsytovych, O. Zagorovskyi, I. Sobestianskyi). The third group consisted of historians of law, whose scientific achievements for various reasons have not actually been studied (M. Klobutskyi, K. Mikhailovskyi, A. Fateyev

and some others. Only one article partially covers this problem, but it speaks only about the activities of G. Uspenskyi (Grechenko & Yarmysh, 2017).

Thus, the general assessment of the contribution of Kharkiv University professors in the first half of the XIX century and the personal contribution of most of them to the development of the History of Law of Kyiv Rus is an insufficiently developed scientific problem and needs further research. This insufficient study of the topic and its relevance led to the purpose of the article, which is to determine the value of scientific achievements of scientists of Kharkiv University in the study of the Rus'ka Pravda and the development of historical and legal science in the first half of the XIX century.

Research methods.

The methodological basis of the article were such principles of scientific knowledge as historicism, objectivity and systemacy. The author tried to adhere clearly to the principle of historicism, examining the processes, events and facts in chronological order, taking into account the current situation in education and science. The use of the principle of objectivity made it possible to analyze impartially the source base, works and views of legal scholars of the time. The task of system analysis was to give a holistic comprehensive picture of formation history and the History of Law development at Kharkiv University in the first half of the XIX century.

Results and discussion.

As it is known, on November 5 (17), 1804, the Emperor Alexander I approved the Charter of the Kharkiv Imperial University, which included the Department (Faculty) of Moral and Political Sciences. The main task of the faculty was to train lawyers for the civil service (Kharkiv University, 2004, p. 17). Professors from European countries, who during the first 15 years of the university's activity made up the majority of the scientific and pedagogical staff, had a significant influence on the formation of legal education at the department. This factor contributed to the spread of advanced educational ideas from Europe, where the theory of natural law dominated.

There was also an organizational institutionalization of scientific activity of the University professors. In 1812, the Society of Sciences at the University was founded the main task of which was to publish the scientific works of scientists. It must be noted that professors of the faculty in the first years of its existence prepared and published reports that had a historical and legal aspect. Thus, in 1811, Professor G. Uspenskyi published a study "The experience of the narrative of Russian antiquities" part one, and the following year – the second part (Faculty of Law, pp. 18–19). In the second part there were the divisions "On the antiquity of Russian laws and their dignity", "On proceedings, fines and punishment". Originally written and interesting for today's reader is the section "On the former ranks and present places in Malorosiya", which deals with the origin of the Cossack ranks (Colonel, Osaul, etc.) (Uspenskyi, 1818, pp.707–761). We can state that this was the first publication at Kharkiv University which had elements of historical and legal research.

In 1839, with the Law Faculty approval of Kharkiv University, M. Klobutskyi's work "Study of the main basic laws of the Russian Empire in their historical development" was published.

As we already mentioned, the pioneer in the field of historical and legal science at Kharkiv University was Gavrila Uspenskyi (1765–1820). He began working at Kharkiv University in 1807, after M. Karamzin refused to head the department of history. After that G. Uspenskyi was offered to work at this department. He immediately proved to be an active lecturer, and in 1807 he submitted to the department the first part of a detailed "Dictionary of Establishments and Observations", which he has been preparing for several years. Since October 1807 G. Uspenskyi was a lecturer at Kharkiv University in Russian history and statistics, since 1808 he was an associate professor, since 1811 he was an extraordinary professor, since 1813 he was an ordinary professor, and since 1814 he was the dean of the verbal department (Encyclopedic Dictionary, 1902, p. 19). In 1812, Uspenskyi became the editor of the scientific and art journal Ukrainskyi Visnyk (Ukrainian Herald), which was published in Kharkiv and distributed in Kharkiv province and Sevsk, Karachev, Briansk. In his work "The Experience of the Narrative of Russian Antiquities" (part II), G. Uspenskyi expressed the opinion that even in the pre-state period, the Eastern Slavs had their own laws. He believed that these laws were oral and passed on to subsequent generations through tradition (Uspenskyi, 1818, p. 452).

Regarding the existence and functioning of written laws and Rus'ka Pravda, the professor agreed with the opinion of V. Tatyshchev, considering their existence a proven fact (Uspenskyi, 1818, p. 453). Great importance among the evidence in favour of this thesis, he attached to the treaties concluded in the X century between Rus and Byzantium. G. Uspenskyi noted that these treaties have repeatedly contain references to Rus laws. The indisputable merit of the scientist is that he was one of the first to make a detailed analysis of these agreements and it was quite original and convincing. The novelty of the analysis was that, based on these agreements, the scientist tried to define the essence of some Rus laws. 1) He noted the value of the oath when concluding contracts. 2) He emphasized that the penalty for murders (the death penalty, not the fine) put the rich and the poor on the same level, because the rich could no longer redeem themselves and that meant their formal equality before the law. 3) The treaties showed that in Russia a woman was not disenfranchised – after the death of her husband, his wife could inherit his property. 4) The wife and children of the offender were responsible for his crime. 5) If the wound was inflicted with a weapon, the "eye for an eye" rule did not apply – a fine had to be paid for the damage. 6) Theft of another's property provided for double or triple compensation from one's own property. 7) A thief caught at the scene of a crime could be killed on the spot if he resisted and did not surrender. 8) The property of a foreigner who died without leaving a will must be transferred to his relatives in the country from which he came. G. Uspenskyi believed that these laws were in force throughout the X century, and then

were corrected, in particular by Vladimir Sviatoslavovich (Uspenskyi, 1818, pp. 454–455).

Another pioneer of historical and legal science at that time at Kharkiv University was Capiton Mykhailovskyi (1789–1823). Holding from February 1812 to 1819 the position of professor at the Department of History, Geography and Statistics of the Russian state he conducted lectures and practical classes with students on Russian civil law (1812, 1813, 1819), Theory of Russian jurisprudence (1813), History of the legislation of the Russian Empire (1815–1816), History of Russian law (1819), Russian criminal law (1816). Since 1823 he has been an extraordinary professor at Kharkiv University. In 1823 he delivered an act speech "On the Beginnings and Origins of Russian Legislation" in which he pointed out that the first written source of Russian law was Rus'ka Pravda, and its author was Yaroslav the Wise. He also believed that the Slavs borrowed criminal laws from the Germans and civil laws from the Romans. Quite an early death (January 1, 1823, at the age of 34) prevented him from doing anything more (Faculty of Law, pp. 8, 191–193).

Some more information about another pioneer of historical and legal science at the university (and not only!) Alexei Kunitsyn (1805–1883). In 1834, defending the thesis "On inheritance under the law on the basis of Russian law" at St. Petersburg University, was approved as a doctor of law and appointed a lecturer at Kharkiv University. Since 1837 he has been an extraordinary professor, and since 1838 he has been an ordinary professor at the Department of Civil Law. Kunitsyn was approved by St. Petersburg University with a doctorate in law (Faculty of Law, p.193). He defended his doctoral dissertation on "On the right of inheritance in accordance with the law, on the basis of the laws of the Russian Empire, in its historical development" (published in 1842). In 1839–1841, 1849–1850 and 1852–1853 he served as a rector. In 1874 he retired and settled in Kharkiv. Died 7 (19) February 1883 in Kharkiv (Servants of Themis, 2015, pp. 85–86).

The peculiarity of his views on the Old Rus legislation was that he generally considered the provisions of the Rus'ka Pravda on family law hypothetical (Kunitsyn, 1844, p. 73). It should be noted that here his views were close to the "skeptical school" in the Russian historiography. These views were based on the position of A. Schletzer, who considered unreliable some of the Old Russian treaties (Schletser, 1816). A. Schletzer's theses, which questioned the authenticity of the original Russian chronicle, were supported by a native of Kharkiv and a graduate of the Kharkiv Collegium, and later – the rector of Moscow University, M. Kachenovskyi, who argued that the creation of the Rus'ka Pravda dated back to later than the XI century time and it contained inaccurate data (Kachenovskyi, 1829). But most scientists had a different opinion. These views were analyzed in detail in the book of V. Ikonnikov, Professor of Kyiv University (1841–1923) (Ikonnikov, 1871, p. 106).

Oleksandr Paliumbetskyi (1811–1897) made the greatest contribution to the development of historical and legal science at that time. Since 1838 he worked at Kharkiv University. He was repeatedly the dean of the Law Faculty, as well as the

rector of this university (Bakirov & Posokhov, 2002, p. 413). In 1844, O. Paliumbetskyi defended his doctoral dissertation "On the system of judicial evidence of ancient German law in comparison with Rus'ka Pravda and later Russian laws that are in close contact with him". The main theses of the dissertation were as follows. Firstly, he showed the difference between Old German law and Rus'ka Pravda in terms of revenge and private reward. He wrote that "private revenge turned in general against crimes…, against violations of peace (Paliumbetskyi, 1844, p. 7). The scientist showed the importance of private remuneration to victims for violating their rights. He believed that the establishment of such a reward was a step forward in the development of law, as it restricted the freedom of revenge that had previously dominated, replacing it in cases where it was prohibited by law. The novelty of the O. Paliumbetskyi's study was that he revealed the importance of private reward to victims for violating their rights, proving that this was an important shift in the evolution of law, as it narrowed the scope of revenge. Secondly, the dissertation analyzed in detail the court evidence on Rus'ka Pravda and the author concluded that the code did not belong to the court evidence. Third, the scholar believed that the appointment of assistants at the oath was a precursor to jurors. Fourth, the author proved that the right to prove by oath and ordeals according to Rus'ka Pravda belonged not only to the plaintiff but also to the defendant. Fifth, a duel between the parties under the same set of laws was applied only when the plaintiff did not have enough evidence. For the defendant, it could be proof that he replaced everyone else except the oath. Sixth, the author of the dissertation came to the conclusion that the influence of Old German law on Old Rus law in the field of judicial evidence was insignificant (Faculty of Law, p. 293).

It seems to us that the Ukrainian researcher V. Zaruba, in that period, in general, the actual Ukrainian historical and legal science has not yet separated and was part of the Polish and Russian, and its delimitation was not even discussed at the discussion level (Zaruba, 2010). But we should add that all Russian historical and legal scientists, including scholars who worked at Kharkiv University, were under the strong theoretical influence of the Dorpat School of History and Law, in particular the views of its main representatives J.F.G. Evers and A.M.F. Reitz. His textbook on the History of Law was one of the most popular at that time in the universities of the country. The merit of this school is that they initiated the study of the History of Law of Ancient Russia, were supporters and popularizers in Russian law of a new, as at that time, methodological approach – historical and dogmatic direction. Their scientific achievements are the cornerstone of historical and legal science in this country, and they are, by right, its pioneers in many specific historical and legal problems (Holovko & Grechenko, 2016).

Conclusions.

Thus, a number of professors at Kharkiv University, who taught there in the first half of the XIX century, made some contribution to the deepening and expansion of

knowledge about the law of Kyiv Rus. Oleksandr Paliumbetskyi should be especially noted in this sense. These scientists were the first – and this is their advantage and disadvantage. The advantage of primacy needs no explanation, and the disadvantages were explained by the search for new concepts and ideas, not all of which remained in the history of science. During the period under study, the History of Law began to become a science gradually, including the efforts of the above-mentioned scholars.

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Внесок учених Харківського університету в розвиток історико-правової науки (перша половина XIX ст.)

Анотація. *У статті автор, базуючись на методологічних принципах історизму, об'єктивності, системності, дослідив конкретний доробок вчених Харківського університету, які працювали в першій половині XIX ст., у становлення та розвиток науки «Історія держави та права». Їхні наукові розробки, відповідно до основної тенденції в генезі цієї науки в той час, були зосереджені навколо права Київської Русі і, зокрема, змісту Руської Правди. Цей напрям їх діяльності недостатньо досліджений в науковій літературі, як вітчизняній, так і зарубіжній. Це пояснюється тим, що основний внесок в розробку вказаних питань було зроблено у другій половині XIX ст. - тоді вийшла значна кількість праць з даної тематики, що давало можливість для їх системного аналізу. Діяльність же вчених вказаного університету першої половини XIX ст. стосується періоду становлення історико-правової науки. Звідси й основні недоліки їх робіт: певна фрагментарність у висвітленні проблем, вузька історіографічна база, гіпотетичність деяких тез. Першим, хто почав розробляти питання історії права у Харківському університеті, був професор Г. П. Успенський, який розглянув питання «про давність законів руських та їх достоїнства». У той час вченим багатьох університетів на теренах імперії доводилося доводити достовірність цих законів та Руської Правди, що не було ще загальноприйнятою думкою. Певні сумніви у цьому висловлював і професор Харківського університету О. В. Куніцин, хоча його не можна цілком віднести до прихильників «скептичної школи» в російській історіографії. Найістотнійший внесок в розвиток історико-правової науки в цей час у Харківському університеті зробив О. І. Палюмбецький. Він провів одне з перших порівняльних досліджень давньогерманського і давньоруського права, переконливо показав їх відмінності, деякий вплив германського права на руське, який він вважав незначним. Досить ґрунтовним і одним з найкращих було його дослідження договорів між Руссю та Візантією у X ст. Спираючись на положення цих договорів, вчений зробив вдалу спробу визначити суть деяких з давньоруських законів, зокрема щодо помсти, винагороди потерпілому та судових доказів. Більшість з цих його аргументів пройшли перевірку часом і не заперечуються сучасними вченими. Вчені – юристи Харківського університету у вказаний період не утворили окремої наукової школи, як це відбулося у Київському університеті завдяки діяльності М. Д. Іванішева, вони працювали в руслі пануючих тоді в російській історіографії парадигм, але зробили певний*

внесок у становлення історико-правої науки. Тому їх наукова діяльність заслуговує на подальше вивчення.

***Ключові слова**: Україна; право; давньоруське законодавство; Київська Русь; Руська Правда*

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Вклад ученых Харьковского университета в развитие историко-правовой науки (первая половина XIX в.)

***Аннотация.** В статье автор, основываясь на методологических принципах историзма, объективности, системности, исследовал конкретный вклад ученых Харьковского университета, работавших в первой половине XIX в., в становление и развитие науки «История права». Их научные разработки, в соответствии с основной тенденцией в генезисе этой науки в то время, были сосредоточены вокруг права Киевской Руси и, в частности, содержания Русской Правды. Это направление их деятельности недостаточно исследовано в научной литературе, как отечественной, так и зарубежной. Это объясняется тем, что основной вклад в разработку указанных вопросов был сделан во второй половине XIX в. – тогда было опубликовано значительное количество работ по данной тематике, что давало возможность для их системного анализа. Деятельность же ученых указанного университета первой половины XIX в. касается периода становления историко-правовой науки. Отсюда и основные недостатки их работ: определенная фрагментарность в освещении проблем, узкая историографическая база, гипотетичность некоторых тезисов. Первым, кто начал разрабатывать вопросы истории права в Харьковском университете, был профессор Г. П. Успенский, который рассмотрел вопрос «о древности законов русских и их достоинства». В то время ученым многих университетов на территории империи приходилось доказывать достоверность этих законов и Русской Правды и это не было еще общепринятым мнением. Определенные сомнения в этом высказывал и профессор Харьковского университета А. В. Куницын, хотя его нельзя полностью отнести к сторонникам «скептической школы» в российской историографии. Самый существенный вклад в развитие историко-правовой науки в это время в Харьковском университете сделал А. И. Палюмбецкий. Он провел одно из первых сравнительных исследований древнегерманского и древнерусского права, убедительно показал их различия, некоторое влияние германского права на русское, которое он считал незначительным. Достаточно основательным и одним из лучших было его исследования договоров между Русью и Византией в X в. Опираясь на положения этих договоров, ученый сделал удачную попытку вычленить суть некоторых из древнерусских законов, в*

частности относительно мести, вознаграждения потерпевшему и судебных доказательств. Большинство из этих его аргументов прошли проверку временем и не отрицаются современными учеными. Ученые – юристы Харьковского университета исследуемого периода не создали отдельной научной школы, как это произошло в Киевском университете благодаря деятельности Н. Д. Иванишева, они работали в русле господствовавших тогда в российской историографии парадигм, но сделали определенный вклад в становление историко-правовой науки. Поэтому их научная деятельность заслуживает дальнейшего изучения.

Ключевые слова: *Украина; право; древнерусское законодательство; Киевская Русь; Русская Правда*

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Formation of the architecture of Ukraine based on longstanding measurement standards

Abstract. *The article, on the basis of a fundamental study of literature and its thorough analysis, highlights the importance of measurements in the cultural aspect of the development of the country and types of art. The analysis of literary sources is carried out, which confirms the influence of the formation of measurement standards on the development of the main types of art. The relevance of the topic is to show the connection between the development of technical thought and the formation of art forms, which has become one of the foundations of the general development of the culture of the state. I. Babenko, M. Bieliaiev, D. Mendelieiev, E. Kamentseva, B. Rybakov and others made a great contribution to the formation and development of measurement standards that influenced the cultural development of the state. In their fundamental works one can find information on the influence of measurement on formation and development of architecture, arts and crafts. But these materials do not give a complete picture of the conceptual significance of the influence of technical thought on art and the cultural development of the state. The purpose of the article is to show the influence of the technical thought development, namely the metrological foundations, on the development of the arts. The centuries-old history of metrology is useful for the development of society, although its origin and development are covered only in scattered sources. One of the fundamental studies of the origin of measures was the works of I. Babenko "Metrology", M. Bieliaiev "On ancient and modern Russian measures of extension and weight", and B. Rybakov in his writings presented fathoms as geometric lines of the calculation table of architects (Babylon). The history of measurements is highlighted in the literature and is mainly devoted to the processes on the formation of metrological concepts among the Skifiia, Sarmatiia, the Zarubinets and Cherniakhiv cultures, the Northern Prychornomoria, of Kyivska Rus, Moskoviia and other. Neither in the ancient world, nor in the Middle Ages there was a metrological service, but there is information about the implementation of standards and storage of measures, as well as about the verification of measuring instruments.*

Accurate measurements and calculations allowed the architect to achieve harmony in the creation of architectural monuments.

Keywords: *measurements; ancient architects; metrological concepts; architecture*

Introduction.

The article, based on a fundamental study of literature and its thorough analysis, highlights the importance of measurement in the culturological aspect of the country's development and arts. The analysis of the literature sources where the influence of formation of standards of measurement on development of the basic kinds of art is confirmed has been made. The relevance of the topic is to show the connection between the development of technical thought and the formation of arts, which has become one of the foundations of the overall development of state culture. I. Babenko, M. Bieliaiev, D. Mendelieiev, E. Kamentseva, B. Rybakov and others made a significant contribution to the formation and development of measurement standards that influenced the cultural development of the state. In their thorough works you can find information on the influence of measurement on the formation and development of architecture, decorative arts. But these materials do not give a complete picture of the conceptual significance of the influence of technical thought on art and cultural development of the state. The purpose of the article is to show the impact of the technical thought development, namely metrological foundations on the development of arts.

Research methods.

The research methodology is based on the universal principles of scientific knowledge – historicism and scientific objectivity, as well as on the widespread use of comparative-historical, systematic methods. The comparative-historical method made it possible to study the development of measurement standards in the formation of art, in particular architecture. The system method makes it possible to comprehensively investigate complex systems, such as architecture in general and the impact of measurement standards on its development.

Results and discussion.

The history of measurement is highlighted in the literature up to the twentieth century, which is devoted to the formation of metrological ideas in the Skifiia, Sarmatiia, Zarubynets and Cherniakhiv cultures, the Northern Prychornomoria, Kyivska Rus, Moskoviia and the Russian Empire and the impact on art. It is established that the development of research in the field of metrology was associated with the publication in 1827 in the article of A. Lamberti «On the origin and current state of the Russian linear measure and weight and the comparison of those with foreign» in the "Military Journal" and in 1849 in the work of F. Petrushevskyi "General Metrology", the concepts of which were adopted and further developed (Lamberti, 1827; Petrushevskiy, 1849). The analysis on some aspects of the development of weights and

measures was initiated from the city-states of the Northern Prychornomoria and Kyivska Rus, but these were only primitive ideas and it was not a question of settling all kinds of measures. Some information, the first ideas about measures, weights, standards are found in the Ipatiiev and Lavrentyi chronicles, "Pravda Ruska", which testifies to the interest of the state from antiquity to the unification of measures.

In the VIII – VI centuries BC the Great Greek colonization and one of the ways of its development was the development of the Northern Prychornomoria. Among the Greek city-states the most famous are: Tira (Bilhorod-Dnistrovsky), Chersonesus (Sevastopol), Pantikapaeum (Kerch) and others. From the first century BC. ancient cities under the influence of Rome fought with nomadic tribes. Crimea is filled with remnants of architecture, remnants of sculptures, amphorae, tiles. The Kerch assembly numbers more than two thousand units, and the most important feature of urban planning was the presence of a colonnade. Cities were surrounded by walls, and quarters of clear form were formed in them, gymnasiums and theaters were also built (Ponomarov, Artiukh, & Betekhtina, 1994).

For example, there were metrological institutes in Chersonesus that monitored the operation of norms in the metrological system of the state. From the end of the IV century BC there was an institute of magistrates, which exercised periodic control over the observance of measures and their regulation. In Chersonesus there were standards for amphorae, tiles of marble and stone. Potters constantly removed from them the dimensional parameters for reproduction in their products. Chersonesus is one of the oldest cities and its construction was carried out according to a strategic plan using standard measures. The blocks for construction were of the same length (orgy – 1.8 m), the quarters were (52.5×52.5) square meters. The width of the streets adjacent to the quarters was 6 meters. The city was divided into quarters by longitudinal and transverse highways according to the Hippodame system. In Chersonesus, the measure "pus" (Greek foot – 29.62 centimeters) was used in construction. For example, Felon Vizantiiskyi pointed out that when building walls in the lowlands of Chersonesus, the norm was a thickness of 10 cubits (4.6 meters) (Belyaev, 1917). The philosopher Vitruvii believed that when building a house, the architect should have paid more attention to compliance with the proportions, and indeed the size of the buildings of Chersonesus meet certain standards. The largest number of houses had dimensions along the masonry axes of (12.4×2.4) square meters; the delimitation of agricultural plots was also carried out according to standards. The land-surveyor broke a grid of squares in the area; the length of the side of the square was 52.5 meters. During the excavations of Chersonesus on some streets, additional walls were added to the walls of the houses, reducing the width of the streets. Archaeologists have long thought about the purpose of these walls, and after making measurements came to the conclusion that in the Roman period the width of the streets was adjusted to their standards. In V – IV centuries BC the construction of temples and altars was widespread, for example, the temple of Apollon Delfinii in Olbia (5th century BC) and the temple in Patikapei (4th

century BC), which had an area of up to 1000 square meters (Kamentseva & Ustyugov, 1975).

Changes in the history of the ancient Slavs took place in the first millennium AD, which is associated with large settlements. The creativity of the ancient Slavs was manifested in the Zarubynets (II century BC – II century AD) and Chernyakhiv (II-V centuries AD) cultures, which were discovered by V. Khvoiko in 1899 – 1901 near the villages of Zarubyntsi and Chernyakhiv in the Kiev region. The Zarubynets culture was spread on the territory of the Prypiat and Dnipro basins, where a moundless burial ground was excavated and bronze fibulae and ceramics of the 3rd century were found. B. C. Zarubynets culture is characterized by dugouts with an area of 18–20 square meters and wooden-frame construction, and the source of heat was an open hearth. Chernyakhiv culture is characterized by finds in the Kaborga cemetery near the village of Osetrivka, Mykolaiv region. In the III – IV centuries. Chernyakhiv culture occupied most of Ukraine, Moldova, and part of Poland, Russia, and Romania. Chernyakhiv culture (II–IV centuries) became the basis of Ukrainian cultural soil. All this was manifested in the nature and type of settlements, the territory of some stretched up to a kilometer, others – up to 200–300 meters. Architectural structures had features of Zarubynets, Skifo-Sarmatska culture. The forest-steppe of Ukraine was characterized by the construction of dugouts and semi-dugouts on the basis of a pillar structure, then these buildings were treated with bushes and clay, and log structures were spread. According to the characteristics of the arts development, it can be determined that measurement standards were not practically used.

The system of ancient Egyptian measures was mastered in Kyivska Rus. For example, the ancient Russian sazhen is 2154 mm, and the ancient Egyptian sazhen is 2160 mm, the ancient Russian yardstick is 718 mm, and the ancient Egyptian yardstick is 720 mm. The measure of elbow length (the distance in a straight line from the elbow bend to the end of the extended middle finger) was first mentioned as a measure of length in Yaroslav the Wise's Pravda Ruska and Pateryk Kyievo-Pecherskyi (Hrekov, 1947; Kolpakova, 2001). Kyivska Rus traded not only with its nearest neighbors, but also with distant countries. Waterways occupied a significant weight in trade. From the tenth century famous boats made of wood. They were small and could accommodate no more than three people and only some of them reached 20 meters in length (Hancho, 2000). Later, the carrying capacity of the boats began to increase, and printed boats and planks appeared. In Kyivska Rus, various measures were used, which were available to the princes and provided by them for use in trade, construction, and so on. With the advent of exemplary reference measures, they had to be carefully stored. Standards of measures were consecrated and kept in temples and churches.

Ancient Kievans lived in small settlements of 10–15 yards. Representatives of the Zarubynets culture lived in large settlements, where housing was located by groups of families and communities. Families from such a community consisted of large and small patriarchal families. All national features, such as settlements, frame construction of architecture, family structure, indicate on the formation of a developed type of

management within the Kiev culture, which is based on agriculture and livestock. The culture of ancient Kiev became the basis of ethnic traditions. As for measurement, according to chronicles, as well as the results of excavations, we can judge that the old masters were familiar with primitive metrology and measuring instruments. Many measures were of anthropometric origin and were associated with human activities. For example, in Kyivska Rus in everyday life there were introduced the following (Babenko, 1905; Kamentseva, & Ustyugov, 1975):

a) cream "fingertip" – the length of the index finger;

b) span from "five", "five" – the distance between the outstretched thumb and forefinger. Span was mentioned in descriptions of travels of the XII–XVI centuries and was used to determine small lengths;

c) elbow – a measure of length from elbow to middle finger;

d) sazhen – from «reach».

Thus, the ancient Russian system of length measures had the following form: 1 verst = 750 sazhens = 2250 cubits = 4500 spans. Folk methods of measuring the area were rectangles measuring 30 by 80 and 40 by 60 sazhens. Folk measures such as tithe, day, lan, morgue, cage were common, which meant either the time for cultivation or the amount of harvest harvested in a certain area.

Neither in the ancient world nor in the Middle Ages there was a metrological service, but there is some information of standards and their storage, as well as checks on measuring instruments. Documents of the Xth century certify the existence of state supervision of measures. For example, the Statute of Volodymyr the Great on ecclesiastical courts (996) emphasized the need to comply with the measures applied in everyday life and trade, and the belt of Volodymyr became the standard length (108 cm). In Great Novhorod in the Church of Ioana Predtechi there was a Chamber of Weights and Measures, which adopted the Charter of Prince Vsevolod of Novhorod "About the court of the church, on people and on measures of trade" (1136) (Prozorovskiy, 1854).

Accurate measurements and calculations made it possible for architects to achieve harmony in the creation of architectural monuments. Next to the Church of St. Sophia in Kiev another church - the Church of the Tithe, built in 989-996. During the excavations of the Church of the Tithe, three furnaces were found for firing plinths (bricks). Near one of them there was found a drawing of a three-nave church, which is the facade of the church, its scale is 1/75 of the actual size of the central part of the church. This was the first drawing found on the construction site. Construction of bridges required great skill from builders. The chronicle "The Tale of Bygone Years" (XI century) mentioned the bridges in the ancient Russian cities of Ovruch and Vasiliev. In 1115, Volodymyr Monomakh, according to the Ipat Chronicle, built a bridge across the Dnipro (Ponomarov, Artiukh, & Betekhtina, 1994). At the same time, different types of fathoms, which were provided for the architects by ancient Russian metrologists and thanks to which they obtained aesthetic architectural proportions were used.

Sazhen was mentioned in the "Pateryk Kyievo-Pecherskyi" by the chronicler Nestor, where in 1017 it was reported that Hilarion (a monk) dug a cave for himself in two sazhen (Kolpakova, 2001). To determine the sazhen, the discovery of a stone in the Tmutarakan River near the Kerch Strait was important, on which an inscription was carved that Prince Hlib in 1068 measured the sea on ice in sazhen (10,000 and 4,000 sazhen). Comparison of these measurements of the width of the Kerch Strait and the results obtained by topographers in the first half of the XIX century in measures, almost coincided M. Ustiuhov (Kamentseva & Ustiuhov, 1975) found a value equal to 142 cm for the ancient sapling. It differed from the one that followed from the value of the verst, so B. Rybakov (Rybakov, 1957; Rybakov, 1984) compared the results of measurements of the width of the Kerch Strait in the time of Prince Hlib with the measurements of topographers from Vizantiia (952) and came to the conclusion that the measurements almost coincided.

The name "pud", according to D. Prozorovskyi, means weight. In ancient metrology, the pud meant not only a measure of weight but also a device, and when weighing metals, the pud was taken as a unit of measurement. The word "hryvnia" was used to denote both weight and currency (a measure of value), found in "Pravda Ruska" (Hrekov, 1947). The hryvnia was the most common measure of weight in trade and crafts, it was used in weighing gold and silver. During the period of feudal fragmentation of Kyivska Rus, specific local measures appeared. But even in this period marks were placed on the measures, which testified to their legitimacy and made it possible to distinguish them (diploma of Bielozerskyi Mykhailo Andriiovych of the XV century) (Prozorovskiy, 1854).

B. Rybakov presented sazhens as geometric lines of the calculation table of architects – "Vavylons" (Rybakov, 1957; Rybakov, 1984). Vavylons are tablets with a diagram of proportional relations depicted on them, thanks to which the architects found the necessary proportions for the building. When comparing the Vavylons found with the architecture and system of measures, it turned out that all the ancient measures fit into the schedule of Vavylons with the side in the measured sazhen. Analyzing the architecture, B. Rybakov determined that from the XI to the XVII century there were seven types of sazhens: large sazhen – 1494.6 mm, sazhen without four – 1972 mm, measured sazhen – 1764 mm, oblique sazhen – 2160 mm, straight sazhen – 1527.6 mm, pipe sazhen – 1870.8 mm, sea sazhen – 1830 mm (Rybakov, 1957; Rubakov, 1984). For the construction of temples after the XIV century oblique sazhens were introduced, for which convenient anthropometric methods were introduced. The sazhen is defined as the distance between the outstretched arms. In the XIV-XV centuries oblique sazhens came out of the use of a narrow circle of builders and to the XVI century used in other industries, where it replaced the direct sazhen. In the XVI century oblique sazhen had several types: pipe, bridge, which were fixed by metal standards. B. Rybakov established the relationship between the measures that provided functionality and ease of use. This concept was implemented as a geometric construction of a system of circles and squares inscribed in them. Based on a simple

and flywheel, for each system of measures used the same factor – two. With the help of this system, the dimensions of bridges and supports were determined, which had a considerable height for observing the enemy and firing at him. According to the same system, deep works (wells, underground passages) were determined and used for the construction of temples. These measures were preserved in construction practice in the XI–XVII centuries (with sazhens 152, 176 and 216 cm). The existence of these interconnected measures made it possible to do without fractions, which facilitated the measurement, planning and construction of structures. Proportionality and harmony of architecture was achieved by the use of builders not one system of measures, but two or three, which were in certain proportions. Confirmation of B. Rybakov's hypothesis was the discovery of the Novhorod architectural expedition (1972), when in Novhorod they found fragments of a measuring rod (measure), on which three scales were applied, which testified to the simultaneous use of three different sazhens. However, the notches on the rod, placed at 6, 7 and 8 cm, did not coincide with the known division of sazhens (span, cream) and checking the proportionality of the ratios of these notches showed that they coincide with the straight, measured and large sazhen. So, it was necessary to find out what proportion of sazhens these notches were on the scale and it turned out that they corresponded to 1/21 of the straight sazhen, 1/21 of the dimensional sazhen and 1/21 of half of the large sazhen. Therefore, B. Rybakov suggested that these notches related to the ratio of the length of the circle and the diameter of the circle, if we take the diameter of the circle of sazhens, composed of 21 notches of the scale, the circle will be equal to 66 notches. Therefore, this ratio is equal to 66/21 = 3.14285, we get an approximation to the number $\pi = 3.1416$. This allowed architects to make circles for arches, curved surfaces of temples and other structures (Rybakov, 1957; Rybakov, 1984). D. Mendelieiev made a significant contribution to the development of measurement and implementation of standards in construction and architecture, which can be observed in his researches in the field of theoretical and applied metrology (Elkin, 2007).

Conclusions.

The first authors, who began to reproduce the emergence and formation of measures, focused their efforts on identifying the origins of measures. These works have become a historiographical phenomenon in the history of weights and measures. The question of the formation of metrology is analyzed in the works of: M. Pauker on the measures of Russia in comparison with the German (1832), D. Prozorovskyi on ancient measures, J. Veks on measures in Greece and Rome (1883), O. Khvolson on the metric system (1884), V. Vulkhauz on national measures, weights and currencies (1890), F. Blumbakh on the verification of weights and measures (1897), M. Yehorov on the Main Chamber of Weights and Measures, etc. The centuries-old history of metrology is useful for the development of society, although its formation is analyzed only in scattered data. Applied metrology studies the practical use of the results of theoretical knowledge in various fields. Literature of the twentieth century in

monographs, textbooks and scientific articles showed the formation and development of metrology after the signing of the International Metric Convention (1875) and was mainly devoted not to the influence of metrology on the development of art, and comparative tables and new measuring instruments. One of the most thorough studies of the origin of measures in this period were the works of I. Babenko "Metrology" (1905), R. Guter on the analysis of comparative tables of measures and weights from around the world (1911), M. Bieliaiev "On ancient and current Russian measures of extension and weight" (1917). Thanks to the fundamental research and thorough analysis of the literature, it was possible to highlight the importance of measurement in the cultural aspect of the development of Ukraine and architecture. The study confirms the influence on the formation of measurement standards on the development of architecture and shows the connection with the arts formation with the development of technical thought of the state.

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Становлення архітектури України на основі давніх стандартів міряння

Анотація. *В статті, на основі фундаментального дослідження літератури та її ґрунтовного аналізу висвітлюється значення міряння в культурологічному аспекті розвитку країни та видів мистецтва. Зроблено аналіз літературних джерел, де підтверджується вплив становлення стандартів міряння на розвиток основних видів мистецтва. Актуальність теми полягає в тому, щоб показати зв'язок розвитку технічної думки зі становленням видів мистецтва, що стало одним з фундаментів загального розвитку культури держави. Вагомий внесок у становлення і розвиток стандартів міряння, які вплинули на культурологічний розвиток держави зробили: І. Бабенко, М. Беляєв, Д. Менделєєв, Є. Каменцева, Б. Рибаков та ін. В їх ґрунтовних працях можна знайти відомості про вплив міряння на становлення і розвиток архітектури, декоративно-приладного мистецтва тощо. Але ці матеріали не дають повного уявлення про концептуальне значення впливу технічної думки на мистецтво та культурний розвиток держави. Мета статті полягає в тому, щоб показати вплив розвитку технічної думки, а саме метрологічних основ на розвиток видів мистецтва. Багатовікова історія метрології корисна для розвитку суспільства, хоч її зародження і становлення висвітлюються лише у розрізнених даних. Одним з найбільш ґрунтовних досліджень походження мір у цей період стали праці І. Бабенко "Метрология", М. Бєляєва "О древних и нынешних русских мерах протяжения и веса", а Б. Рибаков в своїх працях представив сажені як геометричні лінії розрахункової таблиці зодчих (вавилони). Історію міряння висвітлено в літературі до XX ст., яка присвячена процесу становлення метрологічних уявлень у скіфів, сарматів, зарубинецькій і черняхівській культурах, Північному Причорномор'ї, у Київській Русі, Московії, Речі Посполитій та впливу на становлення видів мистецтва тощо. Ні в давньому*

світі, ні у Середньовіччі не було метрологічної служби, але існують відомості про впровадження еталонів і зберігання їх, а також про перевірки засобів вимірювань. Точні вимірювання й розрахунки дали можливість досягти зодчим гармонійності в створенні архітектурних пам'ятників.

***Ключові слова**: міряння; давні зодчі; метрологічні уявлення; архітектура*

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Становление архитектуры Украины на основе давних стандартов измерения

***Аннотация.** В статье, на основе фундаментального исследования литературы и ее основательного анализа освещается значение измерений в культурологическом аспекте развития страны и видов искусства. Проведен анализ литературных источников, где подтверждается влияние становления стандартов измерения на развитие основных видов искусства. Актуальность темы заключается в том, чтобы показать связь развития технической мысли и становления видов искусства, что стало одним из фундаментов общего развития культуры государства. Большой вклад в становление и развитие стандартов измерения, которые повлияли на культурологическое развитие государства сделали: И. Бабенко, М. Беляев, Д. Менделеев, Е. Каменцева, Б. Рыбаков и др. В их фундаментальных трудах можно найти сведения о влиянии измерения на становление и развитие архитектуры, декоративно-прикладного искусства. Но эти материалы не дают полного представления о концептуальном значении влияния технической мысли на искусство и культурное развитие государства. Цель статьи заключается в том, чтобы показать влияние развития технической мысли, а именно метрологических основ на развитие видов искусства. Многовековая история метрологии полезна для развития общества, хотя ее зарождение и становление освещаются только в разрозненных источниках. Одним из фундаментальных исследований происхождения мер стали труды И. Бабенко "Метрология", М. Беляева "О древних и нынешних русских мерах протяжении и веса", а Б. Рыбаков в своих трудах представил сажени как геометрические линии расчетной таблицы зодчих (вавилон). История измерений освещена в литературе и в основном посвящена процессам становления метрологических представлений у скифов, сарматов, зарубинецкой и черняховской культурах, Северном Причерноморье, в Киевской Руси, Московии, Речи Посполитой. Ни в древнем мире, ни в средние века не было метрологической службы, но существуют сведения о внедрении стандартов и хранения мер, а также о проверках средств измерений. Точные измерения и расчеты позволили достичь зодчим гармонии в создании архитектурных памятников.*

Ключевые слова: *измерения; древние зодчие; метрологические представления; архитектура*

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The birth of a science

Abstract. *Physics, biology, chemistry, for example, do not already only study programs in many universities but are at the forefront of the development of science, and that is science itself. The development of the basic foundation becomes the mother of science, such as mathematics, as a suspicion of the birth of new sciences. The interests related to the life and welfare of humans always invites the possibility of the birth of science in concepts, but mathematics confirms it. In certain cases, as an application, or it gives birth to answers in technology form, which is distorted according to the social demands of society. Every science has its methodology, which is based on the logic that helps to reason. A natural model is an approach to generating methods, as well as the principles that develop in artificial intelligence based on mathematics. This principle not only changes the way of perceiving data, but it also establishes new definitions of data, and changes statistics, optimization, and other fields. Each science also has implications for other sciences but also has applications that are also related to other sciences. Every science supports technology to improve social welfare. Historically, century by century, many new scientific fields were born, and it has evidence from the publication of scientific works to books as scientific standards. Then, the teaching curricula supported its initial dissemination and its development through research with evidence of scientific publications either through papers in proceedings of scientific meetings or articles in the journals. A study program about science in the related faculty is mandatory, and it is as the spearhead in further scientific and technological development. So everything starts and ends at one point, namely the birth of new science, as the birth of data science. This paper describes the birth of science by involving historical traces. The reflection of scientific development is starting from the foundation to become a scientific field, namely data science. It also illustrates the roadmap of a scientific indirectly.*

Keywords: *Data science; mathematic; artificial intelligence; science-technology-humanities; engineering-economy/business-social*

Introduction.

Today a new science has been born, known as data science (Cleveland, 2001). The birth of science has reasons of its own but has a background that goes far back (Hancock, 1837). Physically, the earth had spread before humans existed (Calvin & Bond-Lamberty, 2018). Before the presence of humans, many creatures were present, and a part is extinct even though some survived, some did not survive (Usami, Saburo, Inaba, & Kitaoka, 1998). At that time, all of it currently grouped as plants or as animals. Plants, animals, and humans share a place on earth. They are related to and support each other. The land and its surroundings are the living environments between them. In their relationship, they interact and raise several problems (Manuri et. al., 2017; Onrizal, 2019; Onrizal, Amelia, Amri, Sulistiyono, & Mansor, 2019; Kurniawan et. al., 2020). Every creature has unique characters and properties, but they also have the general characteristics that apply to each other. The clashes between their personalities and their properties have triggered the presence of options (Rahmawati & Basyuni, 2019; Nuruddin, Noor, & Abidin, 2020). The option presents different problems, including making the option itself.

The continuous presence of options, following the interaction of humans and their environment with other creatures (Deutsch, Reimes, Fiebig, & Oehler, 2019), gave birth to ideas and discourses. Systematically these ideas and discourses form something that we recognize today with the name of science (Ishihara & Sofronis, 2018). Ideas are collection of thoughts poured into a media called discourse, with it and infrastructure being science (Liu, 2004). However, discussions about science have not yet complete. There is a possibility of the birth of new science. Therefore, this article presents some specific notes about science, where it is to solve problems that arise in that life. Primarily the implications which give rising to data science.

The overall physical reality can be recognized by the human senses (Liengme, 2015). It is data. The existence of reality depends on the concept in the form of logical (Birkhoff, 1936), or logically it is valid, where the argument is determined in its logical form (Kempson, 1988), for example: “Every mammal has a heart.” It is information. Arguments under reality are given a value true (T) (Fettweis, 2005), while the opposite is false (F) (Thorpe, 1930; Nasution, 2018a; Burrieza & Yuste-Ginel, 2020; Kürbis, 2019). Symbols F and T summarize the values so that they are easily recognized (Stalnaker, & Thomason, 1968), but also abstract the logic so that it is easy to implement (Broadrick, 1950; Nasution, 2018b; Lennartson, Liang, & Noori-Hosseini, 2020; Li & Wang, 2020). Two values (true and false) are concepts that logically become an integral part of human life. True and false always the determinant of taking the next necessary steps also becomes the future reasoning material (Texley & Norman, 1984; Lee, 1987; Nasution, 2018c, Yuen, Reyes, & Zhang, 2019).

In reason, humans apply logic to composing word by word (Lathan, 1856), to build sentences, to convey concepts, and we can understand that it has value or gives answers (Yeshurun, 1976; Kara, Schwentick, & Zeume, 2010; Nasution, 2018d; Morales-Garzón, Gómez-Romero, & Martin-Bautista, 2020). A sentence that can be

proven true or false (Nota, Orefice, Pacini, Ruggiero, & Tortora, 1993), it is stated as the statement, p (Harrop, 1956; Godlovitch, 1969; Nasution, 2018e). Let p_1, p_2, and p_3 are statements (Novoselov, & Fadeev, 1982), where p_1 = "a distance of two cities Medan and Jakarta 1,420 km", p_2 = "a distance of two cities Medan and Kuala Lumpur is 338 km", and p_3 = "a distance of two cities Kuala Lumpur and Jakarta is 1,166 km". Thus there is a statement p where p = "$p_1 < p_2 + p_3$" (Ohrstrom & Klarlund, 1986; Martin, 2005; Ma, Liu, & Xu, 2013). So far, some flights only connect three cities: Medan, Jakarta, and Kuala Lumpur. The price of flight tickets for closer distances is assumed to be cheaper than flight for longer distance. Let q_1, q_2, and q_3 are statements, where q_1 = "a price of flight ticket from Medan to Jakarta", q_2 = "a price of flight ticket from Medan to Kuala Lumpur", and q_3 = "a price of flight ticket from Kuala Lumpur to Jakarta". The facts, however, have revealed that the ticket prices for a flight to Jakarta directly from Medan are higher than through Kuala Lumpur, namely q = "$q_1 > q_2+q_3$". Thus, one concept is not always the same as another concept (Nasution, 2018f; Marlasari, Nashiruddin, & Adriansyah, 2019). If p then q means that if $p_1 < p_2+p_3$ applies then $q_1 < q_2+q_3$ applies. However, if $p_1 < p_2+p_3$ applies then $q_1 > q_2+q_3$ applies based on reality. It means that other behaviours affect the original reality, such as inefficiency in-flight management. Reality is expressed based on data for facts to speak, but both data and metadata never without together with time. In general, disclosing data as fact in a conversation without involving a time when the data was encoded, it causes that fact to be inappropriate, or we call it the "*hoax*" (a falsehood) (Nasution, Aulia, & Elveny, 2019; Hamsal & Zein, 2019). For example, a sentence "if $p_1 < p_2+p_3$ applies then $q_1 > q_2+q_3$ applies" is a statement of true value had been valid during the reign of Jokowi era in Indonesia, where data and information do not support each other (Adang, 2019). It is not science. Thus, the statement is not hoax. Therefore, all of that requires a strong foundation.

Facts that apply on a case-by-case basis or specifically unearthed together will be a sample, which is collected in space and recognized as data samples (Keyfitz & Robinson, 1949; Nasution, 2018g; Chatterjee & Bhuyan, 2020). The fact is universally valid in talks based on data. The data are called population. In the universe of discourse U, association by association well-express accordance with what to be a discussion, each case is a member of the intended association or set (Usó-Doménech, Nescolarde-Selva, & Gash, 2018). For example, elephants are mammalian animals. Elephants are members of the mammalian collection (community) or we note as g in M. In other cases, when we talk about truth the universe of discourse is U_M = {T,F}. It expresses science through membership, for example, an association of words is to define a science (Richards, 1928; Barnes, 1961; Nasution & Noah, 2012; Laufer, 2019, Menadue, Giselsson, & Guez, 2020), where the word by word have semantically different meanings, and as data, this requires a science, namely data science (Gentle, Härdle, & Mori, 2012; Pop, 2014; McMaster, Rague, Sambasivam, & Wolthuis, 2015).

Research methods.

In general, what is called the universe, global, or the public, they cannot be authorized to the parts, local or specificity (Evans, 2002). The universality of generality can only be abstracted to make it easier to understand. Like using optimization for realizing effectiveness and efficiency (Martorell, Sánchez, Carlos, & Serradell, 2002), which in certain cases refutes economic principles (Nuykina, 2020), it cannot be proven uneconomical (Nasution, 2012). Physically the earth is flat or round, depending on the viewer and the evidence submitted. Humans step by step walking on the land, each step measured the land in discrete with flat surface properties, $i = 1,2,\ldots,n$ (Gorenflo, Mainardi, Moretti, & Paradisi, 2002), but vehicles move from one place to another crawling the earth's surface continuously through wheels $2\pi r$, r = radius of a circle (Gao, Chen, & Yang, 1990). Mapping the surface of the earth, both discrete and continually results in the development of set theory into a part of mathematics called topology (Grayson, 1981; Nasution, 1990), which is science (Kuratowski, 1972). The topology tells us that the round and flat earth are the same, even though the physical reality of the earth is round. It reveals that every birth of science requires a methodology.

In terms of topology, in abstract geometry, the earth loses absolute distance and is independent of size (Bredon, 1993), but we need it. Whereas in terms of algebra, it is in invariant of geometry, on earth, there is the distance that can be measured (Dress & Havel, 1993), but we lose it. In terms of statistics, in the implication of geometry, the earth studded with numbers (Shamos, 1976), but we un-get the predictions. All of these are problem that are naturally present when science has a confrontation with the interests and needs of life. Historically mathematics is not part of philosophy, even though mathematics is considered as a science (Nasution, 2020a). It proves that philosophy and geometry are twins and born together (Bird, 1996), whereas geometry is part of mathematics. Indirectly, mathematics becomes a method for most of the sciences, while philosophy becomes a method of meaning from it.

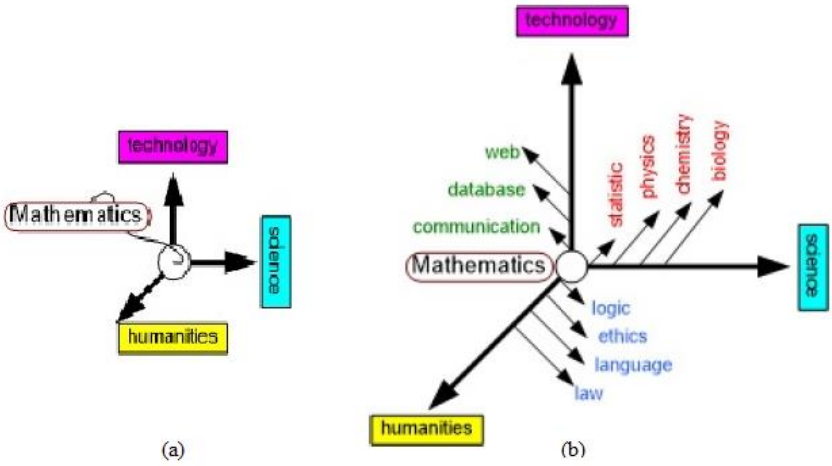

Figure 1. a – Science from origin; b – Lines with the studies for science, technology, and humanities

In general, the systematic relationship between things, the character of sense experience (Suratno, 2012), thought (Vygotsky, 1964), and imagination (Warnock, 1976) bridge the birth of science, which is compelled by the need to state (through cases, examples, and outcomes). The need perhaps necessary for a change in origin exits (Grant, 2016), the determination of the authenticity of the change itself becomes a problem in that change, and this requires and becomes science (King, 2004). The earth is composed of numeric, but we are unable to compute. However, it is good to state science and then distinguishes it from technology and humanities, as their relationship in Figure 1(a). In history, science generally expresses as a way to study various aspects of nature in an organized, systematic, and through different standardized scientific methods (Bryman, 1989; Wilson, 1999; Oliinyk, 2020). The term technology refers to the overall means for providing goods needed for the survival and comfort of human life (Geroski, 2000). Whereas, humanities state that it is a study to elevate humans. Then, become more civilized with science through methods (Peterson & Seligman, 2004). It fills the history of science.

We physically can explore the earth and the world in various directions, and this drives many different fields of study, and then presents science (Faure, Trap, Lin, Monié, & Bruguier, 2007). Thus the study of the universe (Chopra & Kafatos, 2017), the discussion extends as far as the assumptions can be thought of (Lewis, 1998), and reveals many axioms, and as supplement of definitions (Kroeber & Kluckhohn, 1952), facts are elaborated and proven through lemma (Kuhn, 1960), propositions (Stoker, 1998), and theorems (Sion, 1958), or to the conjecture (Moretti, 2000). An approach for a study is by establishing themselves into the science.

Based on ontology (Bergmann, 1950; Taylor, 1959; Hanneborg, 1966; Nasution, 2017a), some things are reviewed and studied that establish themselves. There is among them become the basis of almost all science. For example, physics F being the implications of the mathematical universality M (McCarthy, 1972). In this case, M is relevant to F if it means physics as a science. In other words, if F can be proven based on mathematics M, or in short $F \Rightarrow M$, and physics becomes science (Nasution, 2018g). However, among those that were examined and studied, some continued to change or not could un-proven for establishing themselves (Comroe Jr., 1977). In this case, the universe of discourse state that as $U(F) = 1$ if F can be proven based on mathematics M, or $U(F) = 0$ otherwise. Thus $U(F)$ is temporary or provides opportunities, and looks for proof both logically, naturally, or experimentally. Opportunities for it, is experimentally justifying a portion of the whole. Generally, we recognize it as a statistic, but it remains subject to mathematics (Cobb & Moore, 1997) (Fig. 1(b)). Opportunities it, is experimentally justifying a portion of the whole.

Science has its completeness. Completeness such as methodology is not outside of any science. Thus, when someone gets a methodology (Rawlins, 1949; Novikov & Novikov, 2013; Nasution, 2013; Martineau, Traphagen, & Sparkes, 2013; Nasution, 2020b; Simmel, 2020), science is being born. All of that involves mathematics. In this case, the methodology for expressing the birth of science is offer: As the order in which

the terms appear (if there are in various means such as dictionaries); Study programs (academic facilities for organizing it); Scientific meetings or journals (as a means of accumulation and dissemination) or also the number of documents (as an evidence of growth) (Ben-David & Loewy, 2000; Gupta, 1997; Green, Johnson, & Neal, 2003; Lin & Liao, 2008; Zanotto, Vanz, & Stumpf, 2017; Nasution, 2019).

Results and discussion.

What makes a study mature into science is the methodology (Kaplan, 1998; Dionisio & Casola, 2003; Kyrö & Kansikas, 2005). As a tool that complements the essential equipment, in other words. In other words, science is change, but science is also origin. Far humans are so concerned with the work of the brain. Historically, birth of a science is dependent on the meaning of words. Historically, the birth of a science is dependent on the meaning of words. Historically, the description, explanation, approaches, methods, innovation, reasoning, and implementation of the birth of a science is dependent on the meaning of words. Initially, for example, the "work" word (verbs) as origin, where the job (work, is a person's role in society) as an object. The "work" done the passive verb, employ (to make use of word "work") as order, do (make the work) as the commands, the performance (work outcomes) as signs of achievement, be at (more, most) work as adjectives (Erickson & Mattson, 1981). Either science or data, it is not only related to the procedure, the logic. It is not only limited to the composition and sequence, but that is also systematic. It is not comfortable with the forms and the relationships, i.e., structure. However, it also has a model and simulation where they as a complete guide and they also are a particular science (Nasution, 2017b). The presence of the neural network in artificial intelligence is a result of technological advancements such as computers, the internet, and their relations. The neural network, for example, is a science not only a method to solve any problems but also a model and a simulation of the workings of the brain or brain structure (Azmi, Nasution, Zarlis, Mawengkang, & Efendi, 2019).

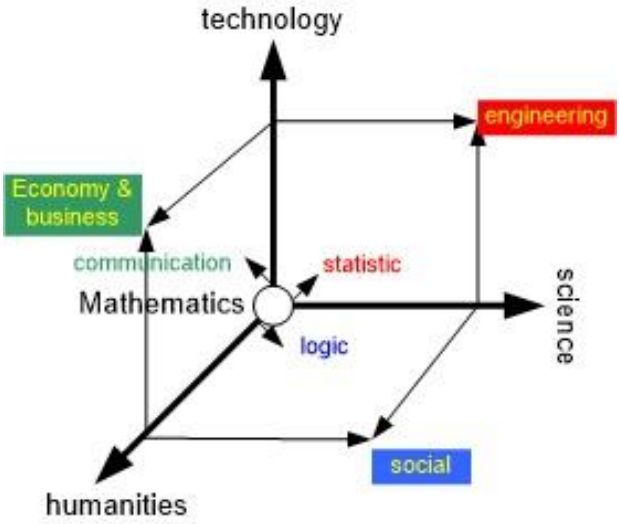

Figure 2. Slices between fields of knowledge

Every science has a basic foundation in what is we call it mathematics (Graham, Knuth, Patashnik, & Liu, 1989), a principle about the truth methodology (Fig. 2). The logical structure of mathematics that expresses a structure that is equipped with a valid form. Structure become subject to the method of logic. It requires accuracy and conclusions to be concluded without regard to the actual state and the power in behind. Therefore, mathematics is determined as a logical collection system (Kac & Ulam, 1968). Naturally, mathematics does logic and logic becomes the core of mathematics, and all the knowledge from it in its writing also needs to be in a consistent style. It is what makes science in it entirely. Each science that exists requires packaging. The theory of physics, for example, is not enough if it is not packaged in proofs, for example, by experiment. All collections of logical arrangement both in formulas and a series of definitions are the logic that is arranged systematically and integrated as a result of thinking. While the real proof (materially), that is the experiment, can only give it based on the laboratory report or hook-connected with the nature or characteristic of their material (Clauser, Horne, Shimony, & Holt, 1969). Thus, in experiments, the variables are presented in which observations reveal facts in the data, and the relationships among those variables are thus arranged (Bronzan, Kane, & Sukhatme, 1974). The event that arises through observation provides complementary evidence of the existence of science.

Science may not have anything to do with values, although it contains certainty the importance of truth, but how it has a relationship with the environment where values are useful. Imagine, physics, in this case, is not materials only, but is an expression of realizing to nature: large celestial bodies, such as the sun, too small objects like atoms, and not enough until that. It is expression in big data, through computation, and need a science, namely data science. The stationary properties of objects become part of physics based on their interactions with nature. Therefore, the environment is not only materials, but also about living things, where Internet of Things has a role. Thus, every science is born through the originator and socially distribute to other scientists who confirm and disseminate. For example, the view about a right triangle states that $c_2 = a_2+b_2$, is a theorem by Phytagoras, where its interpretation as follows. A form of a square wide unit is the result of the sum of two square wide units with one side of the squares forms a right triangle (Quadrat, Lasserre, & Hiriart-Urruty, 2001). This formula is algebraically justified, and in the field of trigonometry it becomes a major proposition. Algebra too based on a designation derived from the Arabic, prevailing in a particular society and society, “al-jabr” (in Arabic language) for “gathering broken parts (Gandz, 1936).

In what is stipulated, the principles are explicitly stated and systematically accumulated. The preparation of science is on-going. Changes to principles are including changes to change or form a permanent nature to change. Such as chemistry, is now born as a science, used to be different assertions and of course systematically in different ways than other studies. It causes the affirmation to always be stated again (Lyell, 1847). At that time, physics in a methodology like a human child continued to

grow under his mother. Likewise, biology before becoming a science, it is the changes occur to changes with an emphasis on life as the opposite of the major of inanimate objects (Munir, Hattori, & Shimada, 2002). The principles of life change, but also the origin. Likewise, the foetus continues to change in the womb in a measured a systematic way, but it also establishes itself as something original like the DNA in that embryo (Hayati et al., 2019).

The softening of firmness in theory either by involving variables, adding parameters, or accommodating human characteristics and behaviour, has caused mathematics as a mother of knowledge to contain new science. As an analogy, when a baby is born, the environment accepts it as something new, and then the baby grows in the environment and society. Like it, the social knowledge is born as a science, for example, but the umbilical cord is still attached to the line of science and however mathematics keeps provide intake (Fig. 2). Social science has been born, but it still bounded by statistical methodology (Solis, 2020), for example, and social science is not able to be present at the main lines of science (Goldthorpe, 2001). This expression is a logical implication that social science is the context in the statistics S is relevant to the possible mathematical M proof, or $U(S)_o \cap S = 1$ if $S_o \cap S$ can be proven based on mathematics M, $U(S)_o \cap S = 0$ otherwise. The symbol $\cap$ is the umbilical cord attached to the science line.

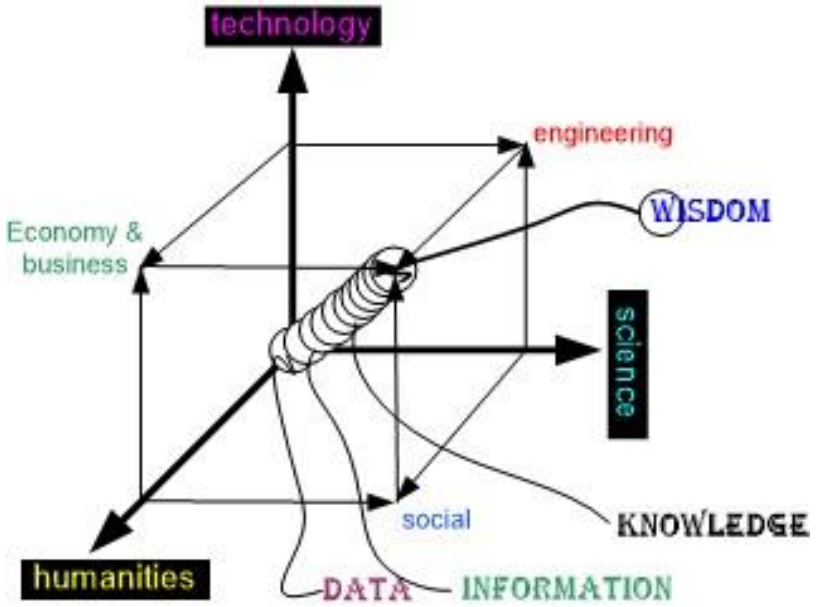

Figure 3. From data to wisdom

Conversely, assertiveness accompanied by application by involving various approaches to natural behaviour and human desires has caused mathematics as a mother of knowledge to contain the twins of new science, namely as a result of calibration of well-being. It's birth, accepted as something new, the social environment becomes a place of growth on earth, but like its twin, the umbilical cord continues to be bound to the lines of science and depends on how to the parent treat it. Just imagine,

however computer science can be separated from mathematics when doing computing. How computer science disproves mathematics when the program flow requires logic (Graham, Knuth, Patashnik, & Liu, 1989), especially when optimization must play a role or the intelligence is implanted to overcome human behaviour (Delle Monache, 2016; Gillen, Freeman, & Tootell, 2017; Nasution, 2018g; Pagan & Dörfler, 2019; Hosni, Li, & Ahmad, 2020). Not only is the study of program complexity at the core of computer science (McCabe, 1976), but the efficient use of energy is the accompaniment of program implementation (Mayer & Dänekas, 2013; Karanikolas & Liaramantzas, 2017). The heart line science-technology-humanities and engineering-economy/business-social is a line that is related to data-information-knowledge and wisdom. This core line comes from the origin where mathematics is positioned and meets the three-lines meeting between engineering, economy & business, social. Thus, by using the interpretation of Figure 3, it can reveal that some new science was born and the umbilical cord remained attached to mathematics.

Table 1. The means of dissemination

No.	Publication	Publisher	First time
1.	Knowledge-Based Systems	Elsevier	1(1) December 1987
2.	Journal of Innovation & Knowledge	Elsevier	1(1) January 2016
3.	Data & Knowledge Engineering	Elsevier	1(1) 1985
4.	Knowledge and Information Systems	Springer	1 February 1999
5.	Technology, Knowledge and Learning	Springer	1 January 1997
6.	Knowledge, Technology & Police	Springer	1 March 1988
7.	Knowledge Management Research & Practice	Springer	1 July 2003
8.	Data Mining and Knowledge Discovery	Springer	1 March 1997
9.	Knowledge and Space Clashes of Knowledge	Springer	Book Series Vol. 1 2008
10.	Journal of the Knowledge Economy	Springer	1 March 2010
11.	Knowledge Management and Organizational Learning: Advances in Knowledge Management	Springer	Book Series Vol. 1 2015
12.	IEEE Transactions on Knowledge and Data Engineering	IEEE	1(1) March 1989
13.	ACM Transaction on Knowledge Discovery from Data	ACM	1(1) March 2007

The term data (plural of datum) has been recognized for a long time (Anonim, 1824; Nasution, Aulia, & Elveny, 2019, Lederer, Capone, Umlauft, & Hirche, 2020). While the presentation of the term data science has so far only in several context of discussion in the last thirty years. Data science is not yet born; the content is still young so that it can be present in the form of a study program (Karbasian & Johri, 2020;

Krystina, 2020; Leidig & Cassel, 2020; Mike, 2020). However, data science we expressed as a multi-disciplinary study that uses scientific methods, processes, algorithms, and systems to extract knowledge and insights from structured and unstructured data (Dhar, 2013). Disclosure of this description took place in 2013, where there is an article explain it in *Communications of the ACM*, and furthermore continue to accumulate to a systematic form, namely scientific organization. On the other, the term data science has become the name of a journal, namely *Data Science: Journal of Computing and Applied Informatics* (JoCAI) published by Talenta Publisher (Nasution, et al., 2018): https://talenta.usu.ac.id/JoCAI, where the first article is about data collection (Gunawan, Amalia, & Najwan, 2017). This journal was published for the first time in 2017. The standard dissemination facilities, Elsevier has published a book with the title "*Data Science*" for the 2nd edition in 2018 as a form of support to the development of this science (https://www.elsevier.com/books/data-science/kotu/978-0-12-814761-0). Based on the point of dissemination, the data science continuous establish itself as science with the launch of the *Springer Series in the Data Science* (https://www.springer.com/series/13852). Whereas in IOP Publisher (https://iopscience.iop.org/), searches have resulted in the top 500 results of open access articles in the journal. Thus data science is not data and it is science (Leek, 2013). So, data science has become a combination of several scientific disciplines that closely link with mathematics. Today, there is a plan to establish the position of data science as knowledge (Lausen, Böhmer, & Krolak-Schwerdt, 2015; Priestley & McGrath, 2019; Oyamada, 2019; Vedula & Hager, 2020). That is by establishing a Study Program of Data Science at Universitas Sumatera Utara (Nasution, Sitompul, & Nababan, 2020).

At the core line, there is also information, but unlike data, the term information science already long use, and for the first time in the dictionary, it was raised in 1955. Expression of information science is a field relating to analysis, collection, classification, manipulation, storage, retrieval, movement, dissemination, and protection of information (Stock & Stock, 2013). The journal as a means of research dissemination was published under the name of information sciences in 1968 the first time by ScienceDirect (https://www.sciencedirect.com/journal/information-sciences/vol/1/issue/1) as well as several book series that publish in Springer Series in Information Science (https://link.springer.com/bookseries/710). Currently, the number of documents related to information science has reached 6680000 results based on searches on Google Scholar. In particular, the birth of information science with information system or not, has grown in such a way as to form the curriculum in this field in 2002 (IS2002) for the Bachelor program (Gorgone et. al., 2003) and was perfected in 2010 (IS2010) (Topi et. al., 2010), while for Postgraduate students compiled in 2006 (MSIS2006) (Gorgone, Gray, Stohr, Valacich, & Wigand, 2006), and upgraded in 2016 (MSIS2016) (Topi et al., 2017). Thus, information science has been born and grew in such away. Knowledge is much older than information. Perhaps experience is as old as conscious existence about what they must know in the form of

data itself. “Knowledge is human intimacy, awareness, or understanding related to facts, information, descriptions, or skills obtained through experience or education by agreement, discovering, or learning” (https://en.wikipedia.org/wiki/Knowledge). However, many fields of study depend on exposed knowledge, for example, knowledge-based management, knowledge-based economics, and so on. When information science has grown to become a science, the baby of data science has not yet been born. Knowledge is still looking for seeds to be planted in the womb of mathematic, where the mathematic is a scientific basis. The study continues, therefore, although several means of dissemination in publishing have been present, Table 1, which is present to date, only relates to the theory of knowledge. Further study of experience requires lengthy research, perhaps including research on education itself. Probably, the experience is more challenging to systematize so that it is not organized into a scientific form than the organizing, forming, and presenting the knowledge technology. When both sides of the study of information are so challenging to becomes a science. It may be too challenging for mathematics to accept wisdom as a process output from the arrangement of data-information-knowledge as a process of becoming or birth as a science. Wisdom, organizationally, is outside the organized scientific methodology based on the lines of the science-technology-humanities as well as the lines of the engineering-economy/business-social, Figure 3. However, wisdom is the outcome of the whole. So, wisdom is the outcome of science, and new science will be born because of that. It is a history that follows data-information-knowledge-wisdom for data science.

Conclusions.

The birth of new science depends on the basic foundation of being the mother of science itself. Mathematics is the basis of science. Furthermore, for supporting science, some efforts build the methodology in such away. Its existence test is based on the introduction of related terms, formulating concepts and principles, proving theories, and carrying out scientific dissemination through scientific meetings, journals, and books. This is all at the core of the community activities: education, research, and community services, where a study program is a scientific community itself.

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Народження науки

Анотація. *Фізика, біологія, хімія, наприклад, вже не тільки вивчаються за програмами в багатьох університетах, але і знаходяться в авангарді розвитку науки, і це і є сама наука. Розвиток основного фундаменту стає матір'ю науки, такої як математика, як передумови для зародження нових наук. Інтереси, пов'язані з життям і добробутом людей, завжди припускають можливість народження науки в концепціях, і математика це підтверджує. У деяких випадках як додаток, або ж вона дає відповіді в технологічній формі, яка спотворюється відповідно до соціальних вимог суспільства. У кожної науки є своя методологія, заснована на логіці, що допомагає міркувати. Природна модель – це підхід до створення методів, а також принципів, які розвиваються в штучному інтелекті на основі математики. Цей принцип не тільки змінює спосіб сприйняття даних, але також встановлює нові визначення даних і змінює статистику, оптимізацію і інші області. Кожна наука також має причетність до інших наук, але в той же час має і застосування, пов'язані з іншими науками. Кожна наука підтримує технології для поліпшення суспільного добробуту. Історично, століття за століттям народжувалися багато нових областей*

науки, і це підтверджується публікаціями наукових робіт і книг в якості наукових стандартів. Потім навчальні програми підтримували її початкове поширення і розвиток за допомогою досліджень з підтвердженням наукових публікацій або в матеріалах наукових зібрань, або в журнальних статтях. Навчальна програма з природознавства на відповідному факультеті є обов'язковою і є відправною точкою для подальшого наукового і технологічного розвитку. Тому, все починається і закінчується в одній точці, а саме в народженні нової науки, як зародження науки про дані. Ця стаття описує народження науки з залученням відбитків історії. Відображення наукового розвитку починається з формування основ для становлення наукової області, а саме науки про дані. Стаття також опосередковано ілюструє наукову дорожню карту.

Ключові слова: *наука про дані; математичний; штучний інтелект; наука-техніка-гуманітарні науки; інженерно-економічний/бізнес-соціальний*

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Рождение науки

Аннотация. *Физика, биология, химия, например, уже не только изучаются по программам во многих университетах, но и находятся в авангарде развития науки, и это и есть сама наука. Развитие основного фундамента становится матерью науки, такой как математика, как предпосылки для зарождения новых наук. Интересы, связанные с жизнью и благополучием людей, всегда предполагают возможность рождения науки в концепциях, и математика это подтверждает. В некоторых случаях как приложение, или же она дает ответы в технологической форме, которая искажается в соответствии с социальными требованиями общества. У каждой науки есть своя методология, основанная на логике, помогающей рассуждать. Естественная модель – это подход к созданию методов, а также принципов, которые развиваются в искусственном интеллекте на основе математики. Этот принцип не только меняет способ восприятия данных, но также устанавливает новые определения данных и изменяет статистику, оптимизацию и другие области. Каждая наука также имеет причастность к другим наукам, но в то же время имеет и применения, связанные с другими науками. Каждая наука поддерживает технологии для улучшения общественного благосостояния. Исторически, столетие за столетием рождались многие новые области науки, и это подтверждается публикациями научных работ и книг в качестве научных стандартов. Затем учебные программы поддерживали её первоначальное распространение и развитие посредством исследований с подтверждением научных публикаций либо в материалах научных собраний, либо в журнальных статьях. Учебная*

программа по естествознанию на соответствующем факультете является обязательной и является отправной точкой для дальнейшего научного и технологического развития. Поэтому, всё начинается и заканчивается в одной точке, а именно в рождении новой науки, как зарождение науки о данных. Эта статья описывает рождение науки с привлечением отпечатков истории. Отражение научного развития начинается с формирования основ для становления научной области, а именно науки о данных. Статья также косвенно иллюстрирует научную дорожную карту.

Ключевые слова: *наука о данных; математический; искусственный интеллект; наука-техника-гуманитарные науки; инженерно-экономический/бизнес-социальный*

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Formation components of technical science in Ukraine in the 60–70s of the XIX century

Abstract. *The article is devoted to the study of the formation of technical science in Ukraine in the second half of the XIXth century. The source of data for the research was found in the articles of the "Journal of the Ministry of Public Education" that was published in the 60–70s of the XIXth century. This historical source explains the chronological boundaries of the research mentioned. The authors draw attention to the formation of technical science as to a complex process that developed from the historical and cultural transformations in the field of scientific research of Ukrainian society back in the days. Paradigmatic shifts in Western European science that penetrated the scientific circles of the Ukrainian social environment contributed to the intensification of scientific and technological progress. It is noted that the latter had a great influence on education which, as shown in the article, became one of the components in the forming process in the field of science and technology.In particular, we are talking about the active work of scientific and technical intelligentsia, which became the driving force in this process, which was expressed in the creation of a theoretical and methodological basis for scientific activities. Based on a wide range of methods derived from the historical research, the progress factors in this scientific field as well as the growth of scientific schools of leading mathematicians, physicists, and other representatives of technical science were discovered. On the basis of the biographical method of analysis the creative way of heads of known scientific schools (V. Ya. Buniakovskyi, I. O. Vyshnehradskyi, M. V. Ostrohradskyi, F. N. Shvedov and others) in line with the trends of the then Ukrainian scientific and technical*

industry.The research points out the importance and invaluable contribution made by scientists for further motivation and actualization of the research in subsequent years. It is emphasized that the emergence of scientific schools and modernization of the technical education system have become the main components in the formation of the scientific and technical elite. It was made through an active scientific activity that contributed to the formation of technical science at the theoretical and methodological levels.

***Keywords**: Journal of the Ministry of Education; scientific school; scientific and technological progress; technical science*

Introduction.

The history of technical science in Ukraine has a complex mechanism based on the interaction of scientific, technical, theoretical, conceptual, and often paradigmatic studies. Those have been integral to Western European scientific traditions. Ukrainian science still impresses with a well-known constellation of scientists who for many centuries have contributed to the foundation of the modern direction in scientific knowledge. A special place is occupied by the field of natural science, which played a significant role in the formation of technical science in Ukraine. The theoretical design of natural science dates back to the XIXth century.

The specificity of this topic, which simultaneously enhances its relevance, as well as theoretical, and methodological apparatus, is manifested in its source base. The source base consists of the study based on two types of components: the first source covers technical inventions, devices, and research experiments, while the second one is derived from the written sources that contain information about the first type and most importantly reveal the process of forming representatives of a certain scientific elite and science in general. The presented article is the result of research related to the second type.

It should be noted that the source base for this research was gathered from the articles written by prominent scientists, teachers, and public figures of Ukrainian science of the second half of the nineteenth century. Those were published in the "Journal of the Ministry of Education" (hereinafter - "Journal") – the official body of the Ministry of public education. The choice of this periodical was made due for several reasons. Firstly, royal decrees, ministerial orders, and orders made by the Academic Committee of Public Education have been published in the section "Government orders" of this journal. These documents provide an opportunity to assess the state direction in creating a base for technical education. Secondly, the articles in the section of the journal entitled "Criticism and Bibliography", which contained headings such as: "Our educational literature", "Reviews of foreign journals", "Critical and bibliographic notes", "Modern Chronicle" cover the problematic aspects in the process of technical and natural science formation.

The attention is placed on the articles under the heading "Department of Sciences" since the prominent scientist I. I. Mechnykov as well as economist, president of Kyiv

University, and future Minister of Finance of the Russian Empire M. Kh. Bunhe published their researches in these articles. The works of Mechnykov and Bunhe as well as other prominent scientists reflected new trends and significant steps made in the field of physics, mathematics, chemistry, biology. The fact that world-renowned scientists have been published in this journal indicates the creation of a field dedicated to the scientific research that united the intellectual environment of that time.

In the post-Soviet period, the issues of formation and development of technical education were studied through two main directions. Historians paid attention to the general and regional directions of education development in the XIX century and also touched upon the formation of technical educational institutions. For example, the articles by H. Shevchuk, Ya. Plavutskoi – Lutsenko (Shevchuk, 2011; Plavutska-Lutsenko, 2013). The article written by S. Hushchyna considered the formation of private educational institutions in the XIXth – early XXth centuries (Hushchyna, 2007). The questions of the formation of professional education and the generalizing monograph of S. Siropolko are also considered in the research (Siropolko, 2001). The second direction is represented by works that analyzed the history of the formation and development of vocational education in Ukraine. This view on the problem is also reproduced in the article by O. Tovkanets and in the dissertation of M. Honchar (Tovkanets, 2011; Honchar, 2016). Aditionally, in the monograph of I. L. Likarchuk, the historical retrospective of the formation of vocational schools in Ukraine is outlined (Likarchuk, 1999). Nowadays, there is a lack of historical research that would consider the complex question of the relationship and dynamics of science and education in the 60-70s of the XIX century.

Therefore, the purpose of this study is to determine the components of the technical science formation in Ukraine, which consequently created a theoretical and methodological basis for its further development as a separate scientific field of knowledge.

The chronological boundaries of the work cover the period of the 60–70s of the XIXth century. This is the time frame when technical knowledge in the Ukrainian scientific environment formed the basis of technical science.

Tasks:

– to reveal the factors of formation of technical science in the specified period;

– to identify the components of the formation of technical science, in particular, the formation of scientific schools in this field and the modernization of the education system of technical specialties.

Research methods.

The methodological basis for the study of this problem was the following methods: analysis and synthesis (based on their interpretation of the articles of the "Journal" as a source on the history of technical science of the second half of the XIXth century. |Followed by the generalization and systematization in connection with historical and cultural reality; biographical method (aimed at identifying the main

milestones in the life and scientific activity of leaders and participants of scientific schools), and the principles of historicism (a principle which allows revealing the historical and cultural foundations of the technical branch of science), objectivity (this principle is mandatory in the process research of scientific achievements of scientists since it rejects the possibility of subjective judgments about the practical significance of scientific achievements of the scientist).

Results and discussion.

Examining this issue, several factors should be identified, the main of which are the following:

– The beginning of the Alexander II reign was marked by expectations of changes in the socio-political and economic life of the Russian Empire. Reforms that took place in the '60s of the XIXth century contributed to the increase in the pace of industrial modernization. In turn, the acceleration of the capitalist development of the state was inextricably linked with the development of the exact and natural sciences. They provided scientific and technological progress in the field of production and trade;

– as a result, derived from conditions of increasing rates of capitalist development, the state urgently needed personnel who would combine both scientific potentials, and would guarantee successful development of trade and industrial activity. That is why the problem of modernization of educational institutions became a foundation for vocational education. There was an urgent need to introduce new standards for this kind of education.

The large-scale transformations were impossible without in-depth research that would cover all possible issues, form a proper framework, and ensure the functioning of the entire system. A professional and scientific approach for solving new problems in the field of technical science was presented in the publications of the "Journal" in the 60–70s of the XIXth century. Therefore, the research turns to the most thorough articles that showed the rapid pace and expansion of development vectors of exact and natural sciences. It also touches upon the emergence of scientific schools in this field in Ukraine at this time.

An important scope of information on the development of science is contained in the article "Report of the Imperial Academy of Sciences on the Department of Physics, Mathematics, and History and Philology for 1860". (Otchet Imperatorskoj Akademii nauk po fiziko-matematicheskomu i istoriko-filologicheskomu otdeleniyam za 1860 god, 1861, p. 121–142). This article publishes a report that contained three works by Mykhailao Vasylovych Ostrohradskyi, entitled as: "On the curvature of surfaces", "Note on one definite integral" and "On a new presentation of the theory of largest and smallest quantities" (OIAN, 1861, pp. 135–136). The author of these articles was one of the most outstanding, world-class mathematicians and mechanics. Born in the village of Pashenivka, Poltava region, he entered Kharkiv University in 1817. After graduating from high school, he received the title of Candidate of Sciences, but unfortunately, bureaucratic conflicts did not allow him to approve him in this title.

From 1822 he continued his studies in Paris, at the Collège de France, where at that time the brilliant scientists – Ampère, Laplace, Fourier was providing lectures. Upon his return, he was elected adjunct professor at the St. Petersburg Academy of Sciences. In 1831, he received the title of ordinary academician in applied mathematics, and later took the position of the head of the Department of Mathematics, after the death of his colleague and academician P. M. Fuss.

It is fascinating that the scientific interests of M. V. Ostrohradskyi were not limited to mathematics. He was engaged in mathematical analysis, mathematical foundations of physics, and mechanics. M. V. Ostrohradskyi was a man of Enlightenment views, who paid attention not only to scientific research but also to the dissemination of scientific knowledge. His teaching activities at the Marine Cadet Corps, the Main Engineering School, left his students with a lot of memories. Students of schools and St. Petersburg University remembered his lectures throughout their lives, they noted the scientific and unsurpassed skill to teach educational material, focusing on the latest achievements in the field of exact sciences (Tripol'skij, 1902).

The scientific school was presented by I. O. Vyshnehradskyi. After the founding of the branch of the Academic Committee for Technical and Vocational Education on January 13, 1884, the professor of the St. Petersburg Institute of Technology I. O. Vyshnehradskyi was directly in charge of the branch (Georgievskij, 1902, p. 44). In this case, it must be noted that a large number of prominent scientists became a part of this school. For instance, Ye. F. Sabinin (the first scientist at Novorossiysk University who defended his doctoral dissertation on pure mathematics), I. I. Rakhmaninov (mathematician and mechanic, doctor of mathematical sciences and Astronomy, Dean of the Faculty of Physics and Mathematics of St. Vladimir's University, who was also elected as the president of this university in the 80's), V. O. Panaiev (an engineer and creator of railways, who, incidentally, made significant efforts to scientific substantiation and technical examination of the construction of the railways in the eastern region of Ukraine. He was also in charge of building the road between Kyiv and Kursk).

In the "Report of the Imperial Academy of Sciences on the Department of Physics, Mathematics, and History and Philology for 1860" a note about the scientific works of Viktor Yakovych Buniakovskyi was found. The first report was entitled "On the special transformation of integrals", the second report touched upon the issues of planimetry and was an addition to scientific and applied value (OIAN, 1861, p. 124). It is known that V. Ya. Buniakovskyi was born in the city of Bar. An important role in the education of the young man was played by a friend of is father Earl O. P. Tormasov, who sent V. Ya. Buniakovskyi to Germany and then to Switzerland. V. Ya. Buniakovskyi also continued to obtain his mathematical education in France, where he met his mentor – O. L. Koshi, who played an important role in the life of M. V. Ostrohradskyi. He also attended courses for famous mathematicians and physicists at the Collège de France. In 1825 he defended his dissertation at the Sorbonne and received a doctorate in mathematics. After moving to St. Petersburg, he became a lecturer of analytical

mechanics at St. Petersburg University and made significant strides in solving problems related to probability theory. By following this research field, he gained worldwide recognition. In 1836 he received the title of ordinary professor, and later in 1864, he was elected vice-president of the Academy of Sciences. The scientific achievements of the scientist consist of more than 100 scientific works (Samoilenko, Melnyk, V. & Melnyk, O., 2004).

A special place in the "Journal" is dedicated to the Order of the Minister of Education on February 26, 1877, which referred to the appointment of title "Ordinary Professor of the Imperial University of Novorossiysk, State Counselor to Shvedov – Dean of the Faculty of Physics and Mathematics of this university for three years" (Prikaz ministra narodnogo prosveshheniya 26 fevralya 1877 g., № 2., 1877, p. 23). F. N. Shvedov was born in the small town of Kiliya in 1840. He received his primary and secondary education at the 2nd Odessa Gymnasium, followed by the studies at the Richelieu Lyceum. He graduated from the Faculty of Physics and Mathematics of St. Petersburg University, where he began his scientific career under the guidance of Professor F. F. Petrushevskyi.

In 1865 F. N. Shvedov was sent to Berlin to the physical laboratory of Henrikh Hustav Mahnus. In 1868, after defending his dissertation in St. Petersburg, he received a master's degree in physics and was invited to work at Novorossiysk University. Here F. N. Shvedov began to research various areas of physical science. In his scientific work, he contributed more than fifty scientific articles on rheology (elasticity of form and viscosity of colloids), electricity, geophysics. F. N. Shvedov also studied the physics of celestial bodies (Vejnberg, 1907, p. 11–15). The scientist paid attention to technical inventions. He developed a device used in military affairs to measure distance with great accuracy, the so-called sighting rangefinder (Ergin, 2015).

It should be noted that F. N. Shvedov is considered as one of the most prominent developers of the theoretical foundations of methods in teaching physics. His work "Methods of Physics" contains the views of the scientist on new trends in the development of physics and its philosophical foundations. The scientist considered the problems of didactics, methods of teaching physics in educational institutions, and proved the need for newly structured physics textbooks (Shvedov, 1894).

"Report of the Imperial Academy of Sciences on the Department of Physics, Mathematics, and History and Philology for 1860" contains information concerning the natural sciences in Ukraine. In particular, the need to organize a paleontological museum. This proposal was made by Academicians Halmerson and Brand. They advised to conduct a detailed geological study of the southern region of Ukraine: "The compilation of such a museum ... and such knowledge could be useful for the needs of agriculture, manufacturing, in short, for technical practice" (OIAN, 1861, p. 124). At this time the Academy of Sciences received a report from Admiral Butakov on the discovery of a mastodon. In the report it was stated that "12 miles away from Nikolaev in the settlement Voskresenka (Horokhivka) quite a large fossil animal was found" (OIAN, 1861, p. 125). It was decided to send paleontological and zoological

expeditions to this area, led by academicians Brand and Radko. The scientists found that the remains were perfectly preserved and belonged to a mastodon. Further in the report, it was emphasized that the expedition managed to collect a large number of remains of antediluvian animals found near the village of Nerubaiske. In Mykolaiv, members of the expedition paid special attention to studying the breeds of fishes found in river Bug. In the report, it was stated that "Odessa also brought several new species of this class of animals" (OIAN, 1861, p. 125).

Thus, the analysis of the articles placed in the "Journal" devoted the development of exact and natural sciences and proved the fact of their rapid development in the 60s of the XIXth century. It also underlined the fact of great public interest in the new achievements and trends in science. The above-mentioned scientists contributed to the foundation for the development of Ukrainian science in the field of mathematics, statistics, physics, astronomy, and mechanics. It should be noted that scientists were focused not only on scientific research but they also comprehended the applied value of their research, made significant efforts to disseminate scientific knowledge. It was a movement that caused the high pace of scientific and technological progress.

In connection with the above-stated facts, another question aroused. Specifically saying, the need to modernize the education system. The system that would put a focus on new ways for students to gain knowledge in mathematics, physics, science, train technical specialists, consequently providing opportunities to apply knowledge in practice. In this regard, it is necessary to consider the peculiarities of the formation of real education in the '60s of the XIX century, which sheds light on the creation of an educational base as the second component in the formation of technical science.

The first stage of reforms began with the approval of the Minister of Education O. V. Holovnin, who led the office in December 1861. It should be noted that the transformations of this time were largely aimed at creating an educational system, similar to the one that already existed for many years in Western Europe. One of the oldest real schools – Friedrich-Wilhelm, was founded by Johann Hecker in Berlin in 1747. According to accepted European practice, classical gymnasiums focused on the study of ancient languages – Latin and Greek, history, literature. They were a preparatory base for continuing education at universities. In turn, the real school curriculum had subjects as science, mathematics, anatomy, statistics, economics, and architecture. Latin and Greek were either not studied at all or taught to a lesser extent. Instead, real schools paid considerable attention to the study of so-called "new languages" – English, German, French. These educational institutions did not set the main task of preparing students for admission to universities. They contributed to the acquisition of real knowledge that would allow students to successfully apply the skills and information in their commercial and industrial activities. As a result, the students had shorter time frames of study than students in classical high schools.

The fact that children from middle-class families studied in real schools should be emphasized. Usually, those students were the descendants of entrepreneurs and traders who had to follow the family business. Alternatively, students who just wanted

to build a career in entrepreneurship were also entering the real schools. They did not aim to gain in-depth knowledge of the classical sciences but were focused on the acquisition of applied knowledge. Shorter terms of education, the option of saving money, and the ability to avoid significantly difficult subjects, such as Latin and Greek, gaining knowledge that will be useful in the labor market - all these factors have led to the rapid development of real schools across Europe. It should be noted that on the pages of the "Journal of Public Education" the discussions on key issues of implementation of new forms of real education began before the appointment of Minister O. V. Holovnin.

Clear evidence of this is the article "Report of printed reviews of the draft charter of secondary and lower educational institutions, which were in the department of MNP" (Svod pechatnyh recenzij na proekt ustava srednih i nizshih uchebnyh zavedenij, sostoyashchih v vedomstve Ministerstva narodnogo prosveshcheniya, 1861, pp. 244–293). In the article, Robert Vasylovych Orbinskyi presented his vision of the forthcoming reforms. Meanwhile, the scientist had also considerable pedagogical experience. In 1851 he took the position of associate professor of the Odessa Richelieu Lyceum at the Department of Pedagogy. In the mid-1950s, he repeatedly participated in various commissions composed of teachers of the Richelieu Lyceum to conduct tests on the topic of home teachers and attended classes of high school teachers to monitor their activities. In the article, R. V. Orbinskyi wrote the following: "Every system of educational institutions must be consistent with the requirements of life" (SPR, 1861, p. 244).

It is known that the scientist and educator R. V. Orbinskyi disagreed with the critics of the reform project who didn’t agree that students cannot continue their education at universities after graduating from a real gymnasium. R. V. Orbinskyi believed that a small amount of Greek and Latin, in real high schools would not allow students to build a university career. He paid special attention to the problem of organizing future real schools. In his opinion, the main factor in their arrangement should have been considered by the regional needs of society. He fully agreed with the fact that in the future, the charter of real schools should use the experience of countries such as Prussia and France. His article also contains opposing views on reform. Thus, the most criticized were the provisions of the charter, which closed the possibility for students of real high schools to enter universities. For example, Mr. Neverov article contains a proposal to allow realists to continue their education at the physics and mathematics faculties of universities (SPR, 1861, p. 244).

In addition to the before-mentioned facts, the data of the article "A few words about the introduction to the physics and mathematics faculties of teaching applied sciences" by I. I. Rakhmaninov should be studied. The article appeared on the pages of the "Journal" in 1863 (Rakhmaninov, 1863, pp. 350–378). At that time, the scientist held the position of ordinary professor of the Department of Applied Mathematics at St. Vladimir's University in Kyiv. He noted the fact that "applied physics, applied chemistry, practical mechanics, the science of building art entered the environment of

abstract sciences should take an honorable place ... factories, where they contribute their knowledge, their science ... The boundary between science and the routine industry is finally destroyed (Rakhmaninov, 1863, p. 355).

Also, the scientist provides an in-depth analysis of the real education system in Western Europe. He wrote about the experience of England, considered the activities of the Royal Society of Art, which organized the first and second world exhibitions and "took an active part in the dissemination of scientific knowledge directly related to industry" (Rakhmaninov, 1863, p. 359). "In many cities, so-called mechanical institutes have been established, where physics and chemistry and mechanics are taught in the evenings (Rakhmaninov, 1863, p. 360).

In his opinion, France took a different path. "Practical education is headed by a polytechnic school ... The purpose of the polytechnic school is to prepare young people for special schools, where young people receive a final practical education that corresponds to their type of service. Those who want to enter a polytechnic school must first provide a diploma confirming the fact of general education" (Rakhmaninov, 1863, p. 364).

The significant contribution of I. I. Rakhmaninov underlined the examination system in the polytechnic school, emphasizing the following: "With such a schedule and strict definition and thoughtful programs, it was possible to introduce examiners separate from teachers" (Rakhmaninov, 1863, p. 365).

In his opinion, a system, in which exams are assessed by invited teachers, guaranteed an objective approach to knowledge assessment. He also considered the experience of Germany in teaching applied sciences. "The rapid development of industrial activity in Germany was undoubtedly influenced by schools dedicated to technical education and concentrated in all major cities of Germany under the name of polytechnics, craft institutes, construction academies" (Rakhmaninov, 1863, p. 368).

Then I. I. Rakhmaninov stated: “In my opinion, the teaching of construction art should be introduced in the faculties of physics and mathematics as an application of statics; practical mechanics as an application of dynamics; industrial physics, as an addition to the laws of general physics; technical chemistry, as an addition to the laws of general chemistry, without a doubt, to add here descriptive geometry with all its important applications, exercises in drawing, drafting"(Rakhmaninov, 1863, p. 371).

Summing up the analysis of the current state of development of real education in Western Europe, he argues that "the nature of the study of practical sciences in universities should be strictly scientific and at the same time practical" (Rakhmaninov, 1863, p. 371).

Additionally, it should be noted that as a result of the reform activities of O. V. Holovnin in November 1864 in the Russian Empire adopted a new charter on gymnasiums, which divided them into classical and real (Ustav gimnazii i progimnazij vedomstva Ministerstva narodnogo prosveshcheniya, 1876). Another feature of the charter was the fact that the choice by the institution to become either classical or real gymnasiums were chosen by local societies, taking into account regional needs.

However, in practice, this choice was often made unreasonably. According to the statute, real gymnasiums did not give students the right to enter the university, which very soon led to a reduction in the student number, and caused further reform of the technical education system.

Conclusions.

The study of the formation components of technical science in Ukraine in the 60–70s of the XIXth century shows the following facts. Firstly, the development was made due to significant advances in scientific and technical thought and qualitative changes that have taken place in the basic sciences. During this period, the positions of Ukrainian scientists were significantly strengthened. They consistently implemented new principles and approaches in solving key issues of mathematics, physics, and natural sciences. Secondly, the use of research results began to be key in increasing the rate of the industrial revolution and the development of technological potential. Thirdly, the role of science in relation to public demand was changing. Social communication of researchers became an important characteristic of scientific activity. Scientists focused not only on solving theoretical scientific issues but also fully immersed themselves in the world of technology-oriented research. The vector of scientific developments was increasingly inclined towards the direct solution of applied scientific issues. Fourthly, new horizons in the development of science and technology necessitated radical changes in the education system. Training and providing professional and technical personnel to industrial enterprises became an urgent problem. This issue was about to be solved by the educational reforms that began in the 60s of the XIXth century. It found out that the main component of the formation of technical science in 60–70 of the XIXth century was its close connection with the advanced ideas of science and reforming the system of vocational education.

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Складові формування технічної науки в Україні у 60–70 роки XIX століття

Анотація. *Стаття присвячена дослідженню питання формування технічної науки в Україні у другій половині XIX століття. Джерельною базою роботи стали статі «Журналу міністерства народного просвітництва» 60–70*

років XIX століття, що і пояснює зазначені в темі хронологічні межі. Автори звертають увагу на формування технічної науки як складного процесу, що став результатом історико-культурних трансформацій в сфері наукових досліджень тодішнього українського суспільства. Парадигмальні зрушення в західноєвропейській науці, проникаючи у наукові кола українського суспільного середовища, сприяли активізації науково-технічного прогресу. Зазначається, що останній мав великий вплив на сферу освіти яка, як показано в статті, стала однією з складових у процесі формування технічної наукової галузі. Зокрема мова йде про активну діяльність науково-технічної інтелігенції, яка стала рушійною силою в даному процесі, що виразилося у створенні теоретико-методологічної основи напрямів наукової діяльності. На основі широкого комплексу методів історичного дослідження, було розкрито фактори прогресу в даній науковій сфері, зростання наукових шкіл провідних математиків, фізиків та інших представників технічної науки. На основі біографічного методу аналізу було розглянуто творчий шлях очільників відомих наукових шкіл (В. Я. Буняковський, І. О. Вишнеградський, М. В. Остроградський, Ф. Н. Шведов та інші) в руслі тенденцій тодішньої української науково-технічної галузі. Вказується на значимість та неоцінений вклад науковців для подальшої мотивації, і разом з цим актуалізації їх досліджень у подальші роки. Наголошується, що виникнення наукових шкіл та модернізація системи технічної освіти стали основними складовими у формуванні науково-технічної еліти, яка своєю активною науковою діяльність сприяла формуванню технічної науки на теоретико-методологічному рівні.

Ключові слова: *Журнал міністерства народного просвітництва; наукова школа; науково-технічний прогрес; технічна наука*

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Составляющие формирования технической науки в Украине в 60–70 годы XIX века

Аннотация. *Статья посвящена исследованию вопроса формирования технической науки в Украине во второй половине XIX века. Источниковой базой работы стали статьи «Журнала министерства народного просвещения» 60–70 годов XIX века, что и объясняет указанные в теме хронологические рамки. Авторы обращают внимание на формирование технической науки как сложного*

процесса, который стал результатом историко-культурных трансформаций в сфере научных исследований тогдашнего украинского общества. Парадигмальные сдвиги в западноевропейской науке, проникая в научные круги украинской общественной среды, способствовали активизации научно-технического прогресса. Отмечается, что последний имел большое влияние на сферу образования которая, как показано в статье, стала одной из составляющих в процессе формирования технической научной отрасли. В частности речь идет про активную деятельность научно-технической интеллигенции, которая стала движущей силой в данном процессе, выразившаяся в создании теоретико-методологической основы направлений научной деятельности. На основе широкого комплекса методов исторического исследования, были раскрыты факторы прогресса в данной научной сфере, рост научных школ ведущих математиков, физиков и других представителей технической науки. На основе биографического метода анализа были рассмотрены творческий путь руководителей известных научных школ (В. Я. Буняковский, И. А. Вышнеградский, М.В. Остроградский, Ф. Н. Шведов и другие) в русле тенденций тогдашней украинской научно-технической области. Указывается значимость и неоценимый вклад ученых для дальнейшей мотивации, и вместе с этим актуализации их исследований в последующие годы. Отмечается, что возникновение научных школ и модернизация системы технического образования стали основными составляющими в формировании научно-технической элиты, которая своей активной научной деятельностью способствовала формированию технической науки на теоретико-методологическом уровне.

Ключевые слова: *Журнал министерства народного просвещения; научная школа; научно-технический прогресс; техническая наука*

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Life and activity of Nasir al-Din al-Tusi

Abstract. *At the beginning of the VII century in the political life of the Near and Middle East, fundamental changes have taken place. The Arabs conquered a colossal territory, which included the lands of Iran, North Africa, North-West India, the Asian provinces of Byzantium, most of the former Roman Empire. In the conquered cities of the caliphate, observatories, madaris, libraries were built. At the end of VII century, the first scientific center, an academy, the House of Wisdom, was founded in Baghdad, in which scholars who spoke different languages were assembled. Here the translation and commentary activity were very developed, the main works of ancient thought, such as the writings of Aristotle, Ptolemy were published in the 9th century in the Arabic-speaking world. For two centuries from 750 to 950 years, the works of ancient authors on philosophy, mathematics, medicine, alchemy, and astronomy were translated into Arabic, which indicates the high scientific potential of that time in the East. At the same time, in the XII century, Ibn Rushd composed 38 commentaries on the works of Aristotle, the "Republic" of Plato, the treatise "On the Mind" of Alexander of Aphrodisias, which subsequently had an important influence on the work of Nasir al-Din al-Tusi. Thus, this period in the history of Eastern scientific thought is marked by high intellectual potential. To this day, historians of medieval Arabic literature face a sufficient number of difficulties, since the vast majority of manuscripts remain inaccessible to them. The works of many renowned Arab authors of the middle Ages are more than 1000 years old, so it seems obvious that the manuscripts of the vast majority of authors have not survived to this day. The researchers of the history of Azerbaijan and neighboring countries in the middle Ages, with all the variety of available sources on which they rely, still attract little factual material related to the Arabic-language works of the historical and scientific genre. Undoubtedly, a comprehensive study of the entire complex of information of Nasir al-Din al-Tusi on the history of science in Azerbaijan is of great importance.*

Keywords: *Nasir al-Din al-Tusi; history of science; scientific activity; Maragheh; astronomy*

Introduction.

There are special periods in the history of the nations when the creative powers of its individual representatives are most vividly and fully realized. In the Middle Ages in Azerbaijan in the XIII–XIV centuries, when trade and crafts were developing in the country, magnificent architectural structures were built (mosques, madrasahs, caravanserais, bridges, baths). In the madrasahs that were opening, along with theology, secular sciences were taught, libraries were completed. The most important place among the cultural achievements of that era is occupied by achievements in the field of writing, in particular, numerous works were created on mathematics, astronomy, medicine, logic, philosophy, fine literature, jurisprudence, poetry and fiction. The purpose of article is to study the life and scientific activity of Nasir al-Din al-Tusi on the basis of historical sources by using comparative method of analysis.

At the beginning of the VII century in the political life of the Near and Middle East, fundamental changes have taken place. The Arabs in a short time conquered a colossal territory, which included the lands of Iran, North Africa, North-West India, the Asian provinces of Byzantium, most of the former Roman Empire. In the conquered cities of the caliphate, observatories were built; libraries were created at palaces, mosques, and madaris. At the end of VII century in Baghdad, the first scientific center, an academy, the House of Wisdom, was founded, in which scholars who spoke different languages were assembled. During this period, the Arabic language became not only the state language of the Near and Middle East, but also the language of science and culture. Here the translation and commentary activity were very developed, the main works of ancient thought, such as the writings of Aristotle, Ptolemy were published in the 9th century in the Arabic-speaking world. In the history of the world's philosophical science, it is known that the peak of Arabic-speaking Aristotelianism was the work of Ibn Rushd, who turned to the study and commenting of Aristotle at the insistence of Ibn Tufail and stimulated the emergence of the interest of Eastern philosophical thought towards Antiquity. For two centuries from 750 to 950 years, the works of ancient authors on philosophy, mathematics, medicine, alchemy, and astronomy were translated into Arabic, which indicates the high scientific potential of that time in the East. Here developed such scientific disciplines as physics, chemistry, mathematics, medicine, astronomy, geography, botany. At the same time, Ibn Rushd composed 38 commentaries on the works of Aristotle, the “Republic” of Plato, the treatise “On the Mind” of Alexander of Aphrodisias, which subsequently had an important influence on the work of Nasir al-Din al-Tusi. Thus, this period in the history of Eastern scientific thought is marked by high intellectual potential.

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The study of the history of scientific thought of this era and activity of scientists show that Azerbaijani science reached a significant flourishing during this period, marking the processes of the Eastern Renaissance. Significant development is observed in astronomy, astrology, geography, mathematics, geology, engraving, music, etc. in

the late 13th – early 14th century. In many cities of Azerbaijan, rabats, madrasah, mosque and other structures were built by architects. Maragha and Tabriz were the main centers of the literary and scientific life of Azerbaijan at that time. Scientists from different countries worked in the Maragheh Observatory, even from distant China.

Results and discussion.

Nasir al-Din al-Tusi.

During the rule of Ilkhanate dynasty, Hulagu Khan (1256–1265) and Abaqa Khan (1265–1282), an outstanding scholar and organizer of science in Azerbaijan, Muhammad ibn Muhammad ibn al-Hasan al-Tusi made a significant contribution to the development of almost all the well-known branches of sciences, which the center for many years became Azerbaijan. Mathematics, ethics, cosmology, mineralogy, trigonometry, geography, history, law, calendars, medicine, education, morality, logic, theology, poetics, calligraphy are not only a complete list of research fields, which are deservedly headed by Nasir al-Din al-Tusi (Bunyatov, 1982a). Nasir al-Din al-Tusi Tusi is from Tus – many historians have spoken about this, one of whom – Hamdallah Mostovfi – reports: “His relatives moved from Sava to Tus and settled here”. He says in the preface to his work “Zij Ilkhani”: “I am the messenger of God from Tus” (Razavi, 1994, p. 12). Most people called him Khoja Nasir Tusi or Mawlana Nasir Tusi.

This outstanding Azerbaijani thinker and encyclopedic scientist is a unique phenomenon in the history of science of the XIII century. Along with the exact sciences, he deeply studied the problems of philosophy, literature, musicology, aesthetics. He knew Greek science well, was a commentator on the works of Archimedes, Autolycus, Euclid, Theodosius, Minelaus, Apolonius Aristarchus, Hypsicles, Ptolemy and others. Tusi was handsome in person, noble, generous. He was described as a person who possessed patience, faithful in friendship, responsive in trouble, in general – endowed with a huge number of high virtues (Bunyatov, 1982a, p. 70). Ibn al-Fuwati, a disciple of Nasir al-Din al-Tusi, the author of “Talkhis al-Majma al-adab fi mujam al-alkab” was with him until the end of his days. He wrote about him as follows: “He is a worthy scientist, generous with a moral, character and good biography” (Razavi, 1994, p. 67).

Tusi wrote a commentary for Avicenna's al-Isharat after Fakhr al-Din al-Razi's commentary and replied to Razi's critique intended against Avicenna's philosophy. Bar Hebraeus translated Al-Isha ra t under the influence of these discussions. In addition, Bar Hebraeus’ Book of Ascent of the Intellect was influenced by Tusi 's works on astronomy. However, Bar Hebraeus' special interest in Tusi 's ethical book can be understood from his statements which are found in his Chronicon and Arabic work on history: This year, Nasir al-di n al-Tu si is dead. He had a big observatory in Maragha and also, he worked on all kinds of wisdom. He wrote many books on logic, physics, theology, Euclid and Majesty. In his extraordinarily beautiful ethical book in Persian language, he collected all texts of Plato and Aristotle on practical philosophy. We understand from Bar Hebraeus' statements above that Tusi for him was a mediatory

figure who transferred Greek philosophy to him, as well as being his admired model, like Avicenna (Doru, 2017, p. 931).

Tusi had the broadest outlook, and this can be explained by the fact of his biography. He received a versatile education and was widely known in scientific circles in his youth. Later, in the prime of his young years, Tusi moved to Nishapur to continue his education.

He received his primary education from his father, a highly educated man. Already in his early years, he mastered the Quran. Then he began to study Arabic grammar - morphology, syntax, vocabulary, as well as jurisprudence. Then, under the guidance of his father, Tusi began to read prophetic hadiths, stories, learn fiqh and law. He studied logic and philosophy with his uncle, while studying natural science, theology, as well as mathematics, algebra, geometry and music.

Further, Tusi continues his education with various scientists – famous philosophers and faqihs of his time. His main teacher was the philosopher Farid al-Din Damadi al Nishapuri, known for his treatise "Kitabul Isharat". He taught Tusi the basics of logic. Damadi's mentor was Sadr ad-Din ibn Nasr at Sarakhsi, while Sarakhsi's mentor was Afzal ad-Din al-Gilani. Gilani's mentor was Abu-l-Abbas al-Lukri, the author of the book "Kitab-ul-badan al-haqq, who was a student of Bahmanyar. Bahmanyar's mentor was the great Ibn Sina. In the field of medicine and philosophy, Nasir al-Din al-Tusi studied with Qutb al-Din al-Misri, who was a student of Al-Fakhr ar-Razi, and studied Muslim jurisprudence with Sheikh Muin ad-Din.

At the same time, Nasir al-Din al-Tusi's mentor was Kamal ad-din ibn Yunis al-Mosuri, who excelled many scientists in the field of mathematics. Tusi was also among the students of Muin ad-Din Salim ibn Bidran al-Misri, the great scholar of imams. As some scholars mention, his mentor was al-Sheikh abu as Saadat al-Isfahani, while Tusi studied fiqh with Ibn Meisim al-Bahrani. In turn, Meisim learned philosophy from Nasir al-Din al-Tusi. Among the mentors of Tusi was Siraj ad-Din al-Kamri (Razavi, 1994, pp. 12–14).

In 1235, Tusi completed work on the treatise "Nasirean ethics (Akhlaki-Nasiri)", which he began to write at the request of the ruler of Kuhistan, which will be discussed below. By the end of the work, relations between the ruler and Tusi were strained, in connection with which in the same year Tusi was arrested and imprisoned in the Alamut fortress. Thus, he lived with the Assassins until 1256, that is, for more than 20 years, and it was during this period that he wrote his many famous works. In 1256 Hulagu Khan took the Alamut fortress and freed Nasir al-Din al-Tusi. In the preface to the Zij Ilkhani Astronomical Catalog, Mawlana writes the following: "At the time when Hulagu took over the command of the Assassin regions, I, the weak man, Nasir of Tus, was in the land of the Assassins. He freed me from there and ordered me to observe the stars..." (Maksudov & Mammadbeyli, 1981, p. 21). Subsequently, Nasir al-din al-Tusi becomes one of the influential people at the court of Hulagu Khan – his vizier.

Maragheh Observatory.

A colossal historical merit of the scientist is the founding of an astronomical observatory in the city of Maragha (1259–1260) (Bunyatov, 1982b, p. 73). Located on the territory of South Azerbaijan, it later became the largest scientific center of its era. This observatory had a huge impact on the development of astronomy in many countries. At the time mentioned, a decree was issued that "the great, happy Mawlana, teacher of the human race, the sultan of sages, the worthiest of the figures of recent times, Khoja Nasir al-Din al-Tusi, may the Lord embrace him with his forgiveness, build a place for observing the stars". Nasir al-Din al-Tusi arrived in Maragha with Hulagu Khan, who instructed him to build an observatory here. A high hill was chosen for the construction of the structure.

However, this episode was preceded by a number of other events. As Rashid ad-din narrates, "Mongke Khan [...] was distinguished by the perfection of his mind" and even "solved some Euclidean drawings. His excellent opinion and lofty thought were recognized as necessary for his state to build an observatory" (Rashid ad-Din, 2011, p. 68). However, some doubts arose among the people whom he entrusted with this business, while "the rumor about the excellent qualities of Nasir al-din flew around the world like the wind". Mongke Khan instructed Hulagu Khan to send him the Khoja Nasir al-Din al-Tusi. Nasir al-Din had long thought about building an observatory and was waiting for an opportunity (Razavi, 1994, p. 39). However, Hulagu khan decided that Nasir al-Din "was with him" and entrusted him with the construction of an observatory in Maragha. Hulagu Khan covered all the construction costs. Moreover, "he gave the scientist as much money as it was impossible to count" (Razavi, 1994, p. 46). At the same time, Hulagu invited several scientists-specialists in the field of mathematics, astronomy from different regions so that they help Tusi.

Thus, a magnificent observatory with an area of 150m×350m was built in Maragha (Rashid ad-Din, 1946, p. 48). The observatory began to be built in Yaum al-salis ar Rabia min jumad al-Ula in 657 (1259). The site was chosen in the upland part of the north-west of Maragha, known as Rasad Dagi (Jabal ar-Rasad). The first stone of the observatory was laid by Fakhr ad-Din Ahmad Osman Amin al-Maraghi (Razavi, 1994, p. 42). The observatory became one of the most famous for its time. Unfortunately, it survived only two generations, and after the first half of the 14th century, no one mentions it anymore. The remains of the observatory building have survived to this day (Seyidbeyli, 2015, p. 144). In 1990, Iranian archaeologists excavating in Alamut discovered the charred remains of this structure (Starr, 2017, p. 426).

According to sources, the Maragha (or Ilkhanid) observatory was built with the active participation of four scientists: Muayid ad-Din Urdi from Damascus, Fakhr ad-Din Maragi from Mosul, Fakhr ad-Khilat from Tiflis and Naji ad-Din al Dabirani Qazvini (Rashid ad-Din, 1946, p. 49). Another source notes that Tusi invited several scientists in the field of mathematics and astronomy for the construction. They are: Muayyid ad-din al Ardi from Damascus – a scientist in the field of geometry and

instruments for the observatory, Najmaddin Dabirani al Katibi from Qazvin – a scientist in the field of philosophy and logic, Fakhr ad din al Akhlagi from Tiflis – an expert in mathematics, Fakhr ad din al Maraghi from Mosul – a doctor and mathematician, Naj ad din al Katib al Baghdadi, known as an expert mathematics, geometry, astronomy and drawing.

Mukhi ad-din al-Maghribi, a scientist in the field of mathematics and astronomy, Qutb ad din Shirazi, Shams ad din Shirvani, Sheikh Kamal ad din Idji, Husam ad din Shami, Najm ad din Shami, Najm ad-din al-Ustrulyabi, Ibn al-Fuwati, Seyid Rukn ad din al-Ustarabadi, Sadr ad din Ali, Asil ad din Hasan, son of Nasir ad-din Tusi and a number of others took part in the construction of the Maragha observatory (Razavi, 1994, p. 41).

Until the end of his life, Tusi supervised the scientific and administrative work of the observatory (Maksudov & Mammadbeyli, 1981, p. 11). Only the information about the drawing up of the drawings of the Maragheh Observatory shows how comprehensive the nature of its activities was. Azerbaijani architects and researchers L. Bretanitsky and A. Salamzadeh suggested that Nasir al-Din al-Tusi was personally the author of the project of the Maragheh Observatory. Thus, the fact of his authorship of the observatory's drawings testifies to the closest connection between the architectural and construction activities of Tusi with his technical and mathematical knowledge.

Believing Nasir al-Din, Hulagu Khan invited specialists from China, who brought instruments with them. Also, Hulagu invited several scientists - specialists in the field of mathematics and astronomy – from different regions to help Nasir al-Din in the construction of the observatory (Razavi, 1994, pp. 40–41).

Thus, the first thing that is important to note here is the presence of a significant scientific potential of the era, concentrated within the walls of the observatory. Scientists of different nationalities worked under the leadership of Tusi. Most of them belonged to the number of major researchers who made an invaluable contribution to the development of science in their and subsequent eras.

Also, it should be emphasized: the observatory had a large number of instruments created here under the leadership of Tusi and distinguished by high quality. These instruments ensured greater accuracy in observations of the Sun, planets and various phenomena in the Universe. In total, 10 astronomical instruments were created here (Donirshoev, 1968). Among them were: 1. large wall quadrant; 2. armillary sphere; 3. as well as tools for determining the inclination of the ecliptic; 4. a tool for determining the moments of the equinox; 5. tool for determining the size of the eclipse; 6. Device for determining the horizontal coordinates of luminaries (rotating square); 7. Tool with two pillars; 8 sine-instrument I (sine-azimuth instrument); 9. Sinus instrument II; 10. The perfect tool.

At the Maragheh Observatory, you can find other instruments for measuring time. For example: hourglass, water, oil clock. Also, at the observatory, earth and celestial globes were made and displayed for all to see, one of which has survived to this day.

It was made by the son of Urdi Muhmammed and is today in the Mathematical-Physical Salon of Dresden State Art Collections. (Maksudov & Mammadbeyli, 1981, pp. 200–208). "Also, Nasir al-Din designed the astrolabe himself, having seen its image in any book" (Razavi, 1994, p. 45). With the passage of time, astronomical instruments in the Maragha observatory were used in various observatories of the world, among which the Tycho Brahe observatory, the Samarkand and Beijing observatories can be noted.

The third important factor that deserves attention is that a large team of researchers from Iran, Syria (Damascus) and the countries of the Caucasus and Central Asia, as well as from China and India, worked at the Maragheh Observatory. In total, more than 100 employees - prominent scientists and their students worked in the Maragheh Observatory and Library (Ibn al-Fuwati, 1962–1967, p. 19). The names of many of them have remained in history. These are: Muhammad Nasir al-Din al-Tusi, Qutb ad-Din Shirazi, Grigory Abul-Faraj (Bar-Ebrey – M. S.), Muayid-ad-din al-Urdi from Damascus, Najm ad-din Kazvini Dabirani al-Katib from Qazvin , Fakhr ad-din al-Akhlati from Tiflis, Fakhr ad-din al-Maragi from Mosul, Mohi ad-din Kamal Sheikh-Kamal, Najm ad-din Damgani Ustrlyabi, Husam ad-din Shami, Sadr ad-Din Nasir Tusi, Najm ad-din al-katib al-Baghdadi from Baghdad.

Many experts noted that the observatory will not be built earlier than in 30 years. Nasir al-Din al-Tusi built it much earlier (Razavi, 1994, p. 43). According to Rashid ad-din, its construction took 7 years (Rashid ad-Din, 1946, p. 48).

The result of 12-year (from 1259 to 1271) observations of the Maragha astronomers was the "Ilkhanic Tables (Zij Ilkhani)". This work contained tables for calculating the position of the sun and planets, as well as a star catalog. The tables contained a list of the geographical coordinates of 256 cities in the world. The uniqueness of the Maragheh Observatory lay in its location – an overview of all the stars opened from it. The library located at the Maragheh Observatory contained 400 thousand volumes of manuscripts in Arabic, Persian and Syriac in various fields of knowledge. To collect books, he sent people to different cities, and thus books were brought here from Baghdad, Damascus, Mosul, Khorasan, and other cities (Razavi, 1994, pp. 43–45).

The successor to the Maragha observatory was the observatory in Tabriz, founded by his student Qutb ad-din al-Shirazi (Rashid ad-Din, 1946, p. 48). Subsequently, the Maragheh Observatory had a huge scientific impact on the Beijing Observatory, built in the 13th century, as well as on the Ulugbek Observatory.

Thus, the Maragha Observatory, founded by Nasir al-Din al-Tusi, with its scientific potential, professional astronomical instruments, and the richest library, was the largest scientific center of the 13th century in the whole world. It was the "Academy of the Middle Ages".

Scientific activity.

As mentioned earlier, Nasir al-Din al-Tusi was a universal scholar and author of many essays.

In the book by Muhammad Tagi Mudarris Razivi "The Life and Works of Nasir ad-din at-Tusi", the author mainly examines the works of Nasir al-din and indicates the location of copies of his works. In particular, he notes the names of 190 works of Nasir al-Din (Razavi, 1994, pp. 446–449), which are especially famous as scientific works on economics, philosophy, medicine, geography, astronomy, mineralogy, ethics, logic.

A special place among his works in the field of mathematics and astronomy is occupied by such works as the astronomical treatise "Thirty chapters on the knowledge of the calendar" (in Arabic and Persian versions) and "On the knowledge of the astrolabe" ("Dar Marifati-i Asturlab"). Among the most valuable mathematical and astronomical manuscripts is the manuscript No. 8990, rewritten in 1424 from the autograph of An-Naysaburi and dated 1265. This tome contains the following works of Tusi: "A predetermined treatise on astronomy" ("Risala al-mu'ayaniyya fi'ilm al-hay'a") and an addition to it – "A collection of arithmetic with the help of a board and dust" ("Jami 'al-hisab bi-l takht wa at-turab"),"Thirty chapters on the knowledge of the calendar" ("Si fasl fi ma'rifat at-takvim"), as well as "commentary by al-Naisaburi to the last of the named treatises. This also includes an unknown in the literature essay "Treatise on the Calculus of Astronomers" ("Risala fi hisab al – munajimin") by Husayshah as Samnani (or al-Simnani, died in 1319), a poorly studied mathematician and astronomer of the Tusi circle, whose biography insufficiently studied. In history he is known, first of all, as the author of the commentary on the work "Zij Ilkhani" (Mammadbeyli, 1951, p. 37).

In the article by G. P. Matvievskaya and H. Tllashev, "New data on the scientific heritage of Nasir al-Din al-Tusi and his school", it is noted that "in the process of studying this manuscript, a list of Tusi's works was discovered, compiled, most likely, by his student An Naysaburi, and therefore which is of particular value for studying the scientific heritage of the great scientist". It lists 57 writings, many of which are not mentioned in the existing listings of Tusi's writings (Mammadbeyli, 1951, p. 37). Tusi's astronomical and mathematical works were very popular in the Near and Middle East, in China, India, and Western Europe.

His outstanding works such as "Zij Ilkhani" (Tables of Elkhani), "Tahriri Eglidis" ("Presentation of Euclid"), "Shaklul Gita" (Treatise on the Complete Quadripartite), "Usturiyat" (Astrolabe) are classic works in the history of astronomy and mathematics (Mammadbeyli, 1951, p. 37).

The treatise by Tusi "Benefits in Algebra and Almukabal" ("Fawayid – and Tusi dar jabr wa mukabala") has not yet been studied. It gives the solution of 20 arithmetic and geometric problems by methods of algebra. The authors of the study of the scientific heritage of Tusi, G. P. Matvievskaya and H. Tllashev, proved that this treatise is one of the sections of Tusi's work "Treatise on Algebra and Almukabal". The manuscript of this treatise is in Damascus. "Exposition of the "Beginnings" of Euclid", "Collection on arithmetic with the help of blackboard and dust", "Treatise on the figure of secants", "Treatise on squaring the circle", "Algebraic fragment", "Presentation of the Books of Assumptions of Sabit ibn-Korra", "Arrangements by Tusi medium

books", "Book of Euclid "Data", Book of Archimedes "Measurement of the circle", "Processing of the book of Archimedes "Lemma" (Rozhanskaya, Matvievskaya & Lyuter, 1999).

In his essay "Tahrir Eglidis" ("Presentation of Euclid") Nasir al-Din al-Tusi writes: "I wrote this book after editing "Majesti". Indeed, in the list of copies in Arabic held in the Paris National Library, there is a mention of the book of Euclid. This is the Introduction of the Arabic text of Euclid, printed in Rome. There are many handwritten copies of this book, and they are available in many libraries. During Tusya's lifetime, one old and exquisitely designed copy of this book was published in one journal. Another copy, written in 772 (1322), is in the Higher Madrasah, in the Sipakhsalar library (Razavi, 1994, pp. 446–449).

Among the mathematical works of Tusi, the "Treatise on the Complete Quadripartite" occupies a significant place. The treatise was written in Persian during his stay at Alamut, and also in Arabic, in abridged form, at Maragha (1260). In "Collection of arithmetic with the help of a board and dust" (1265) by Tusi describes in detail the method of extracting a root of any degree using the example 2441400626. Methods for extracting a root with an arbitrary exponent and decomposing a binomial degree are described.

Among Tusi's works in the field of astronomy, I would like to mention his famous book "Zij Ilkhani" ("Astronomical Table of Elkhani"), which contains a catalog of bright stars and an extensive presentation, including geographic tables. This book consists of 4 parts: 1 – about chronology, 2 – about the knowledge of the movements of the stars (and planets), 3 – about the knowledge of time and the fate of each time, 4 – about other astronomical sciences. From "Zij Ilkhani" we learn the updated value of the total annual precession (Maksudov & Mammadbeyli, 1981, p. 26). As already noted, the book is an astronomical catalog compiled as a result of 12 years of work by scientists at the Maragheh Observatory (from 1259 to 1271). It was the only astronomical catalog that existed for 200 years (up to the construction of the observatory by Ulug bek), from which scientists drew all the astronomical information necessary for compiling annual calendars and ephemeris (Abstracts of reports, 1951, p. 38).

In addition to issues of observational astronomy, Nasir al-Din al-Tusi was engaged in the theoretical side of the issue of planetary motion. One of his main works in this area, devoted to the theory of motion, is the book "A memo to astronomy". In addition to the above-mentioned works of Tusi, he also wrote the Treatise in "20 Chapters on the Knowledge of the Astrolabe" and "Treatise on the Sinus Quadrant".

The scientist also touched upon the problems of astronomy in a number of his treatises on physics. These are such works as "Processing", "Optics of Euclid", "Risola dar tahkiki kavsi kuzakh" ("Treatise on the study of the rainbow"), "Risola fil-kharorat wa-l Barudat" ("Treatise on heat and cold"), "Risola dar bayoni subhi kozib" ("Treatise on dawn twilight"), "Risola dar kaifiyati zarurati harakat" ("Treatise on the

circumstances of the necessity of movement"), Risola fi-l-hararat wa-l burudat (Reflection of the Light) (Dinorshoev, 1987, p. 34).

In addition to works related to mathematics and astronomy, Tusi's scientific heritage includes a large number of studies in the field of logic, philosophy and theology. I would like to note that Tusi knew Greek philosophy well. In his books, he has repeatedly given an objective assessment of the works of Aristotle, Plato, and also Porphyry – a famous Greek mathematician and logic of the Middle Ages (Seyidbeyli, 2015, p. 144).

Typically, medieval history is presented as the history of theology. Touching upon the religious and philosophical foundations of Tusi's evolutionary theory, I would like to note that the picture of the evolution of the world drawn by him corresponds to the ideology inherent in his time. On the one hand, the philosopher writes with admiration about the perfection of the surrounding world created by God, on the other, he recognizes the fact of self-development and self-improvement of matter. According to Tusi, nature as a whole and each creature individually are capable of developing and improving independently, but God inspires and directs this development. In other words, being once created by God, the world develops further by itself – according to the plan of the Creator (Seyidbeyli, 2015, p. 144).

In studying the issues of joint work in favor of society, N. Tusi paid great attention to the role of sociology. "The science of sociology is a theory about the real and general laws of the development of joint work aimed at the benefit of all. The object of this science is the system of human relations, people united by social labor, engaged in an improved form of production" (Tusi, 1989, pp. 228–229).

Among his other famous works are "Tazkira Nasir" ("Nasir's memory"), "Akhlaqi-Nasiri" (Nasirean ethics). The latter is still considered one of the best [in the spiritual heritage of the Middle Ages] as an example of fiction and philosophical literature. This treatise has been translated into many languages. It raises the problems of being, examines the philosophical aspects of the human character, examines the problems of good and evil.

In the book "Akhlaqi-Nasiri" ("Nasirean Ethics") Tusi outlined his ethical views, representing the new moral paradigms of his time. Here he raises the problem of being, the foundations of human behavior, but the main issue is the theme of human origin. According to Tusi, man is the highest product of evolution.

The work "Tajridul-etigad" ("On the proof of God and his attributes") is devoted to philosophy and the word. In the Introduction, Tusi says: "This book I have compiled in a good style and brought it into proper form. I have written in this book what I am convinced of. "Ultimately, this book can be used to judge the belief / attitude to the faith and religion of Tusi. "Tajridul-etigad" consists of 6 chapters. Chapter I deals with general issues, Chapter II is devoted to entities and their manifestations, Chapter III talks about the proof of the existence of God and his attributes, Chapter IV deals with the phenomenon of prophecy, and Chapter V deals with imams, finally, in the VI – about the Day of Judgment and its proof (Razavi, 1994, pp. 446–449).

In his work, N. Tusi attached great importance to science, scientific research, classification of sciences, the connection between science and life, as well as the role that science played in the development of mankind. All aspirations of scientific research, the scientist pointed out, should be aimed at the benefit of a person, at improving his well-being and achieving his well-being.

Nasir al-Din al-Tusi believed that each science has its own specific subject of study. This is what distinguishes various sciences from each other: according to the subject of study, they are classified as independent branches of knowledge. If some sciences have one common subject, then their classification as independent branches of knowledge depends on which side, which aspect of this subject they study

Nasir al-Din al-Tusi believed that each science has its own specific subject of study. This is what distinguishes various sciences from each other: according to the subject of study, they are classified as independent branches of knowledge. If some sciences have one common subject, then their classification as independent branches of knowledge depends on which side, which aspect of the given subject they study.

The scientist studied medical knowledge under Qutb ad-Din Misir. Having completed his studies in this area, he was well acquainted with the works of various doctors of that era. In particular, he wrote comments on the work of Ibn Sina “Medical Canon”. At the same time, it is interesting to note his answers to questions in the books “Laws of Medicine”, “Treatise on Medicine” (Risala at-Tibb). “Treatise on Medicine” consists of 2 parts.

Medical views of Tusi cover the issues of human hygiene and its relationship with purely medical problems, mainly in the field of the psyche. So, he divides human health into 4 groups, clearly defining the limits of each group. “Health is like moving in a straight line”, the scientist writes, “and illness is a deviation from this line”. N. Tusi distinguishes between physical and non-physical diseases. He classifies physical illnesses as follows: abnormality, stupidity, violence, fear, rabies, lethargy. The scientist gives a characteristic to each of these diseases. Along with physical illnesses, he considers the problem of moral health, which he subdivides into the following types and groups: mind, memory, resourcefulness.

Conclusions.

N. Tusi was a scientist-expert in many sciences of his time, especially such sciences as law, philosophy, kalam (scholasticism), logic, mathematical sciences, theology and astronomy, morality and ethics, etc., as well as some exact sciences. A large number of works were written by N. Tusi in the field of all the listed sciences. I would especially like to note the works written by him in the field of mathematics during his stay in Alamut (by the will of the Ismailis). After his release, he was engaged in very important state affairs in the palace of Hulagu Khan, and therefore he did not have the opportunity to translate and comment on his works.

Scientists and students from different parts of the world gathered around N. Tusi for the purpose of teaching. He perfectly knew the Arabic, Persian and Turkish

languages and wrote his works freely in these languages. The books written by N. Tusi in these languages are very commendable in terms of literary language and eloquence. He wrote his book on science "Ramal" (a poem in the style of eruz) in three languages – Arabic, Persian and Turkish. Some researchers claim that N. Tusi wrote the book on the science "Ramal" in Turkish, and in subsequent years a certain scholar translated it into Persian. N. Tusi's works are very valuable and significant. Most of the famous scientists took useful thoughts from them and wrote comments to them. Many of his works have been translated into the leading languages of the world, including German, French, English, Latin, and published in European countries. The scholarly historians composing the inventory of his works were his contemporaries.

In 672, Nasir al-Din al-Tusi went to Baghdad accompanied by his friends and mentors. In the same year, he fell ill in Baghdad and died of illness. When Nasir ad din Tusi became ill and he felt that he was leaving the world, he wrote: "Do not carry me out of the tomb of the 7th Imam and bury me next to the tomb of His Lordship. And after he bequeathed to bury him next to the grave of Imam Kazim and Imam Javad, he asked not to write on his grave about his scientific and other merits: "On my tombstone, write only my name". In the same year he bequeathed to be buried next to the grave of Imam Kazim. He died in AH 672.

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Життя і діяльність Насіра ад-Діна ат-Тусі

Анотація. *На початку VII століття в політичному житті Близького і Середнього Сходу відбулися кардинальні зміни. Араби захопили колосальну територію, до якої увійшли землі Ірану, Північної Африки, Північно-Західної Індії, азіатські провінції Візантії, велика частина колишньої Римської імперії. У завойованих містах халіфату будувалися обсерваторії, медресе, бібліотеки. В кінці VII століття в Багдаді був заснований перший науковий центр – академія – Будинок мудрості, в якому були зібрані вчені, які говорили на різних мовах. Тут була значно розвинена перекладацька і коментаторська діяльність. Протягом двох століть, з 750 по 950 роки, праці античних авторів з філософії, математики, медицини, алхімії і астрономії переводилися на арабську мову, що*

свідчить про високий науковий потенціал того часу на Сході. Зокрема, Аверроес, який працював в XII столітті склав 38 коментарів до праць Аристотеля, «Республіки» Платона, трактату «Про розум» Олександра Афродізіаса, які згодом дуже вплинули на творчість Насір ад-Діна аль -Тусі. Таким чином, основні праці античної думки, такі як праці Аристотеля, Птолемея, були опубліковані в 9 столітті в арабомовному світі. Таким чином, цей період в історії східної наукової думки відзначений високим інтелектуальним потенціалом. До цього дня історики середньовічної арабської наукової літератури стикаються з труднощами, пов'язаними з тим, що переважна більшість рукописів залишаються для них недоступними. Роботам багатьох відомих арабських авторів середньовіччя більше 1000 років, тому представляється очевидним, що рукописи переважної більшості авторів не збереглися до наших днів. Дослідники історії Азербайджану і сусідніх країн в середні століття, при всій різноманітності джерел, на які вони спираються, все ще залучають мало фактичного матеріалу, пов'язаного з арабомовними творами історичного і наукового характеру. Безсумнівно, велике значення має комплексне вивчення всього обсягу відомостей, наявних в працях Насір ад-Діна ат-Тусі, з історії науки в Азербайджані.

Ключові слова: *Насір ад-Дін ат-Тусі; історія науки; наукова діяльність; Мараге; астрономія*

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Жизнь и деятельность Насира ад-Дина ат-Туси

Аннотация. *В начале VII века в политической жизни Ближнего и Среднего Востока произошли кардинальные изменения. Арабы захватили колоссальную территорию, в которую вошли земли Ирана, Северной Африки, Северо-Западной Индии, азиатские провинции Византии, большая часть бывшей Римской империи. В завоеванных городах халифата строились обсерватории, медресе, библиотеки. В конце VII века в Багдаде был основан первый научный центр – академия – Дом мудрости, в котором были собраны ученые, говорившие на разных языках. Здесь была значительно развита переводческая и комментаторская деятельность. В течение двух столетий, с 750 по 950 годы, труды античных авторов по философии, математике, медицине, алхимии и астрономии переводились на арабский язык, что свидетельствует о высоком научном потенциале того времени на Востоке. В частности, работавший в XII веке Ибн Рушд составил 38 комментариев к трудам Аристотеля, «Республике» Платона, трактату «О разуме» Александра Афродизиаса, которые впоследствии оказали большое влияние на творчество Насир ад-Дина ат-Туси. Таким образом, основные труды античной мысли, такие как труды*

Аристотеля, Птолемея, были опубликованы в 9 веке в арабоязычном мире. Таким образом, этот период в истории восточной научной мысли отмечен высоким интеллектуальным потенциалом. По сей день историки средневековой арабской научной литературы сталкиваются с трудностями, связанными с тем, что подавляющее большинство рукописей остаются для них недоступными. Работам многих известных арабских авторов средневековья более 1000 лет, поэтому представляется очевидным, что рукописи подавляющего большинства авторов не сохранились до наших дней. Исследователи истории Азербайджана и соседних стран в средние века, при всем разнообразии источников, на которые они опираются, все еще привлекают мало фактического материала, связанного с арабоязычными произведениями исторического и научного характера. Несомненно, большое значение имеет комплексное изучение всего объема сведений, имеющихся в трудах Насир ад-Дина ат-Туси, по истории науки в Азербайджане.

Ключевые слова: *Насир ад-Дин ат-Туси; история науки; научная деятельность; Мараге; астрономия*

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Professor V. Ye. Timonov – the formation of the scientific worldview

Abstract. *The name of Vsevolod Timonov, an outstanding scientist-engineer, teacher, public figure, and popularizer of science, doctor of technical sciences, Honored worker of science and technology of the RSFSR, professor, is well known to a wide range of domestic and foreign scientists and technicians. Nowadays, the creative worky of the extraordinary personality of the scientist is particularly interesting to researchers for its inexhaustibility and versatility. In his activity, V. Ye. Timonov showed the features of a talented researcher, experimenter, organizer of science, an innovator in solving important theoretical and applied problems of hydraulic engineering. The article covers his early life and activities. This period of life of V. Ye. Timonov allows us to understand and reflect the conditions of the*

formation of the scientists' worldview, the factors that influenced the formation of his creative personality, and to analyze the main directions of his activity. And let us note that his 60 years of scientific, pedagogical, and social activity is characterized by exceptional versatility and depth. The outstanding scientist boundlessly devoted to science until the last day, V. Ye. Timonov is the author of more than 700 scientific papers. Among his works are a number of textbooks, manuals, and monographs, which have received wide recognition of scientists of our country and foreign researchers. Several finely written books showcase his multifaceted talent as a memoirist. For more than 50 years V. Ye. Timonov was engaged in pedagogical work at high school. His lectures (at institutes, universities, and in the general public) have always been a huge success. He brought up a whole galaxy of scientists. Vsevolod Yevhenovych devoted a lot of effort and time to the promotion of science, active, purposeful struggle with anti-scientific concepts in hydrobiology, hydrography, hydraulic engineering. Timonov's scientific and organizational activity was also fruitful. A man of great and versatile culture, an eager admirer, and a deep connoisseur of poetry and literature, V. Ye. Timonov himself was a gifted promoter of scientific knowledge.

Keywords: *V. Ye. Timonov; hydraulic engineering; water transport; engineer; water supply; water disposal*

Introduction.

M. M. Budtolaiev wrote about V. Ye. Timonov: «The graduate of the St. Petersburg State Transport University, Doctor of Technical Sciences, Honored worker of science and technology of the RSFSR Vsevolod Timonov is well known in the engineering world in our country and abroad as an outstanding scientist in the field of hydraulic engineering, an intrusive fighter for technological progress, an outstanding public figure, a talented organizer and tireless participant in domestic and foreign technical societies, a wonderful educator who has trained several generations of engineering and scientific personnel for our water transport» (Budtolaev, 1959, p. 3). And let us note that 60 years of his scientific, pedagogical, and social activity are characterized by exceptional versatility and depth. An outstanding scientist had been boundlessly devoted to science until the last day. V. Ye. Timonov is the author of more than 700 scientific papers. Among his works there is a number of textbooks, manuals, and monographs which have received a wide recognition both among the scientists of our country and foreign researchers. His multifaceted talent of a memorialist was vividly reflected in several finely written books. For more than 50 years V. Ye. Timonov was engaged in pedagogical work at high school. His lectures (at institutes, universities, and in the general public) have always been a huge success. He brought up a whole galaxy of scientists. Vsevolod Yevhenovych devoted a lot of effort and time to the promotion of science, active, purposeful struggle with anti-scientific concepts in hydrobiology, hydrography, hydraulic engineering. Timonov's scientific and organizational activity was also fruitful. A man of great and versatile culture, an

eager admirer, and a deep connoisseur of poetry and literature, V. Ye. Timonov himself was a gifted promoter of scientific knowledge.

Methods of the research.

Using the biographical and chronological research methods, the periodization of the main stages of Vsevolod Yevhenovych Timonov's formation as a hydrotechnical scientist and specialist in water transport has been developed. It includes two main periods: life and activity in St. Petersburg until 1917 and in the Soviet period 1917–1936. His first attempts to join science have been discussed in details (Soloviova, 2019). During the preparation of the article, chronological, comparative methods of historical knowledge, classification, and systematization of historical sources and bibliographic material were used (Fando, 2020; Krylov, 1976; Strelko, Pylypchuk, Berdnychenko, Hurinchuk, Korobchenko, & Martyian, 2019; Strelko, Pylypchuk, Berdnychenko, Hurinchuk, Gamaliia, & Sorochynska, 2019; Pylypchuk & Strelko, 2020). The use of these methods and approaches to scientific research allowed to retrace the way of life and professional activity of Vsevolod Yevhenovych Timonov's systematically and critically evaluate the sources used, highlight the main points in the current state of studying the subject and the results of predecessors, specify the most promising directions of research, give a description of the previous works on this issue and clearly distinguish issues that have not yet been resolved.

Results of the research.

V. Ye. Timonov was born on August 9, 1862, in Odessa, in the family of a magistrate judge. He got his secondary education at a private school in Vienna (1873–1874), then studied at a private real school in Sokolovsky in Odessa (enrolled in the second half of the third grade in 1874 and studied for six months), continued his studies at a public real school in Odessa (enrolled for the second half of the 3rd grade in 1875 and completed a full course with an additional class of mechanical department in the spring of 1879).There have been excellent conditions for the formation of his character traits since early childhood – a living example of his relatives, very educated people, and the environment in which he was brought up. Although the Timonov's family was financially well-off, parents taught the children to respect labor and people. This undoubtedly, to a certain extent, left a mark on the character of the young Vsevolod. From an early age he was distinguished by extraordinary diligence and devotion to work. The years spent in the Vienna school and in the real schools of Odessa also significantly influenced him to become a fan of machinery and water transport.

He received his higher education at the Paris School of Bridges and Highways (November 1879 to January 1883), a technical institution that trained specialists in the construction and operation of routes and seaports. (Karlov & Kudryavtsev, 2000). In the same 1883 year V. Ye. Timonov studied at the St. Petersburg State Transport University named after Emperor Alexander I in St. Petersburg (from August 1883 to May 1886). It was not easy to get there – it was possible to enter the University only

after completing two courses of a higher technical educational institution or mathematical faculty (Universitet do 1917 goda, 2010). V. Ye. Timonov graduated from both educational institutions as the best student. His name was written on the marble plank of the State Transport University of the Emperor Alexander I.

The brilliant abilities of V. Ye. Timonov appeared in his student years, when while studying in France, he explored the hydraulic structures of the Port of Sett. Later, his first scholarly work was honored with an honorable mention by the Conference of the State Transport University. In his student years in France, Vsevolod Yevhenovych Timonov also worked as a transport technician for the construction of railways, seaports, and some bridges, participated in the study of highways.

During his last training at the State Transport University, while serving apprenticeship in the port of Odesa, V. Timonov conducted a historical and technical study of the development of this port, which was also awarded and became the beginning of a series of similar studies and descriptions of other domestic commercial ports (Timonov, 1891a). During this studentship the great abilities of a young researcher were revealed, his active life position, erudition, free orientation in various fields of hydraulic engineering, which he has vividly demonstrated throughout his scientific career, were formed. It should be noted that the University in St. Petersburg had a team of highly qualified educators, who provided the educational process at a very high scientific and methodological levels. At the University Vsevolod Yevgenovich became closer to the leading part of the professorship and the student body. The outstanding educators who worked at that time at university were the professors, whom he mentioned with great respect later – M. A. Beleliubskyi, M. M. Hersevanov, D. I. Zhuravskyi, F. Ye. Maksymenko, L. F. Nikolai, and others. He has been studying at the University for four years, receiving not only important theoretical knowledge but also excellent practical experience. Captured by the lectures of these scientists, V. Ye. Timonov was formed as a hydraulic engineer, hydrologist, hydraulics specialist in water transport. Professors taught without tables and devices, using their own drawings on the board as illustrations. He reproduced these drawings skillfully and very quickly. Any phrase that didn't have a single redundant word in it could serve as a brilliant example of a well-constructed statement. At times, it seemed that his mentors did not speak but read through a book. Each lecture was strictly timed, and its content has been approved by many years their teaching experience.

His scientific and socio-civic outlook, his love and devotion to engineering science, his social and political views and principles, which he has never betrayed, were also shaped by his mentors at the Richelieu Lyceum in Odessa, with whom he had close ties: mathematicians V. P. Viardo, V. V. Petrovskyi, and professor Heinrich Brunn, an expert in Russian literature T. P. Zelenetskyi, a lawyer M. P. Solov'iov, professor of botany A.D. Baikov, professor of zoology O.D. Nordmann, trustee of the lyceum D. M. Kniazevych and many other colleagues and close friends. The sense and meaning of his life, like his great mentors, V. Ye. Timonov saw in the mental work for

self-improvement. Like the mentioned personalities, he continued to give his strength to social and educational work among the widest sections of hydraulic engineering.

Thus, we see that relationships and ties that were based on feelings of respect and sympathy were formed by Vsevolod Yevhenovych from communicating with the scientists whom the whole world is proud today. For example, prominent mathematicians of the Railway Engineers Department in St. Petersburg lectured: differential and integral calculus by Academician V. Ya. Buniakovskyi, the course of lectures in bridges was given by D. I. Zhuravskyi (wooden bridges) and M. A. Belelyubskyi (iron bridges). The latter loved and appreciated Vsevolod Yevhenovych – their rapprochement was facilitated by cooperative work in the Russian Technical Society, which was very popular in the scientific circles of the Russian Empire (Ivanov, 2006). The society solved the task: 1) to promote the development of technical sciences in general; 2) to spread natural science and technical knowledge in the Russian Empire; 3) to promote the study of technology in Russia.

V. Ye. Timonov did not write memoirs. But memories of how his youth passed, how the interest in hydraulic engineering and water transport technology woke up, have been with him all the time. He felt the need to share them in his works. In his remarkable factual book books (for example, «From the International Congress to the German military captivity» (1917 autobiographical facts covering his surroundings at a certain period of life are intertwined (Timonov, 1917). A considerable amount of information is contained in archival documents, the information from which, as it turned out, has not yet been fully introduced into scientific circulation. Many important facts related to the scientific work of V. Ye. Timonov, his public, and organizational activities are contained in letters, diaries, notes of prominent engineers. For example, in the literature of M. O. Belelyubskyi, D. I. Zhuravskyi, Ye. O. Paton and others.

After graduating from higher educational institutions, V. Ye. Timonov received such titles: civil engineer (with a diploma from the Paris School of Bridges and Highways in 1883), railroad engineer (with a diploma from the State Transport University of Emperor Alexander I in 1886) a railway engineer (according to the rules of service in the Department of Railways in 1886). He was elected a member of the Society of American Civil Engineers (in 1886), a Privy councillor (in 1909).

After several years of practical activity, V. Ye. Timonov defended his dissertation in 1891 and received the degree of adjunct professor at the State Transport University of Emperor Alexander I in two specialties: waterways (inland waterways and ports) and sanitary and agricultural hydraulic engineering. On the basis of a serious experience gained during the construction of the port of Libava and the comparison of the existence of structures in similar conditions in other places in Russia and abroad, V. Ye. Timonov wrote his great work «Study on the construction and maintenance of the port on the sandy coast in application to the conditions of Libava» (Timonov, 1891b). V. Ye. Timonov submitted this work as a dissertation for the degree of adjunct (candidate of science) and successfully defended it at the Academic Council of the St. Petersburg Transport University on May 19, 1891.

The topic of the dissertation was very relevant. The port of Libava was the only non-freezing port in Russia on the Baltic Sea. But bed load material made shipping difficult, as a result, maritime trade suffered significant damage. That is why the question arose about the construction of external (restrictive structures). V. Ye. Timonov analyzed in detail the local conditions and results of the development of buildings in Libava and other ports of the country in relation to the marine environment. Taking all this into account V. Ye. Timonov developed a project for the placement of external structures of the port and established a number of convincing provisions on the interaction of port structures and sea drifts on the sloping sandy shore. Subsequently, Timonov's proposals were taken into account in the construction of the Libava military port.

In 1895, Timonov was elected the professor. For the first time in Russia he created the Department of «Water Supply and Water Disposal» (sanitary hydraulic engineering) at the State University of Transport. Since 1902 he has managed the Department of Port Facilities. In general, during his life, Timonov held the following positions: Professor of the State Transport University of Emperor Alexander I, member of the Engineering Council and Head of the Department of Statistics and Cartography of the Ministry of Railways of the Russian Empire, Chairman of the Hydrological Committee of the Main Department of Land Management and Agriculture, member of the Technical Council of the Ministry of Industry and Trade, member of the Medical Council of the Ministry of Internal Affairs, Honorary magistrate of Odessa a member of the St. Petersburg City Duma. Led of the Interdepartmental Commission for drawing up a plan of works on improving and developing water communications of the Empire (Smirnov, 1997). And this is not a complete list of his positions and membership in various esteemed organizations. But especially noteworthy are the honorary titles of Timonov received in the early life and work of a scientist and engineer: Honorary Member of the General Association of Engineers, Architects, and Hygienists of France, Belgium, Luxembourg, Switzerland, and Algeria (since 1904). A lifetime member of the Standing International Commission of the International Association of Navigating Congresses (since 1900), honorary member of the Society of Civil Engineers of France (since 1909) (Timonov,1911).

V. Ye. Timonov also received a number of important awards. They are divided into native and foreign. Native: St. Stanislaus 3rd and 1st class; St. Anne 3rd and 2nd class; St. Vladimir – 3rd class; medals of Emperor Alexander III and in memory of the Holy Coronation of His Majesty Emperor Nicholas II and Empress Alexandra Feodorovna; sign of the Red Cross. Foreign orders: Austrian – Franz Joseph 1st class, Serbian – St. Sava 2nd degree with a star, Bulgarian – for civil service 2nd class, Belgian – Commander's Cross of Leopold, French – Cavalry and Officer's Cross of the Legion of Honor – 33rd class, Prussianorder of the Crown of 3rd class.

V. Ye. Timonov was a lifelong member of various scientific societies: Russian Geographical Society, Society for the Promotion of Russian Industry and Trade (committee member), Shipping Society (Council member), Russian Public Health

Society (chairman of the public hygiene section and member of the journal's editorial board), Russian Red Cross Society and Water Rescue Society (a member of the Main Directorate).

V. Ye. Timonov was a full member of various Russian public organizations: St. Petersburg Group of the All-Russian Water Congress (Assistant Chairman), a member of the All-Russian Aeroclub, a member of the Assembly of Railway Engineers (a member of the Board of the Technical Department and the Editorial Board of the journal «Izvestiya Sobraniya inzhenerov putei soobscheniya») and a member of the Maritime Union.

Slightly larger is the list of Timonov's actual membership in various foreign and international organizations: Society of Civil Engineers of France, General Association of Engineers, Architects and Hygienists of France, Belgium, Luxembourg, Switzerland, and Algeria; Society of Civil Engineers of America; Institute of Civil Engineers of England; Concrete Institute of England; Permanent International Association of Navigation Congresses (life member of the Standing Committee and member of the Bureau from Russia (Bekiashev, & Serebriakov, 1981, p. 217) and Permanent International Association of Road Congresses (member of the Standing Commission and Bureau from Russia) (Timonov, 1915; Belyakov, 1993; Makkaveev, 1930).

V. Ye. Timonov was also a full member of the St. Petersbur English Assembly and the St. Petersburg Club of Public Figures.

In general, it is very difficult to periodize the life and creative path of V. Ye Timonov.The scientist-engineer has lived all his life in St. Petersburg, from this city he went on various business trips, both within his country and abroad. Sometimes these trips lasted for months. Therefore it will be more correct in this section to characterize his engineering and research, pedagogical and public activity.

Extremely interesting is the period of V. Ye. Timonov engineering, administrative and public service over the years, in chronological order. The first years of Timonov's engineering activities coincided with a period of the rapid economic and technical rise of tsarist Russia. External and domestic trade relations have intensified in the process of creating a domestic market for large-scale industry, and exports of agricultural products have increased. Railways were built, which cut the territory of the European part of Russia in many directions and created huge opportunities for trade. New branches of the Russian Empire were drawn into the capitalist market. River shipping and external maritime relations developed, as well as trade – across the land borders of the empire. Let's follow the course of Timonov's engineering activity.

This description should be begun with his activities in France. Thus, in 1881 V. Ye. Timonov became an acting conductor of railways in France in the Loir-et-Cher department (when he was a student at the Paris School of Bridges and Highways). Technical service during the construction of the railway from Romorantin to Blois with an iron bridge over the Loire River and stone bridges in its valley, and the construction of stone spillways in the protective embankments against the floods of the Loire River.

The following year, in 1882 V. Ye. Timonov was already an acting conductor of railways in France in the Department of Morbigam (at that time he was a student at the Paris School of Bridges and Highways). He carried out searches on the department's roads, excavations at the seaport of Vannes, technical service in the construction of fishing ports on the ocean coast of Brittany, and the pier at the commercial port of Lorient – this is a non-exhaustive list of Timonov's technical preferences. In the same year, according to a special business trip of the Chief Engineer of the Morbitan Department, V. Ye. Timonov is studying the construction of a dry dock in Bordeaux, breakwaters, piers, and embankments in Seth (a study of the port of Seth was published in 1887 by engineer V. Ye. Timonov in the «Journal of the Ministry of Railways») (Timonov, 1887a). He also studied hydraulic structures on the South French Canal.

Timonov spent the third year of his work in France as a railway engineer, assigned to work in special branches of the railway: to the traction service of the Paris-Lyon-Mediterranean Railway and to the construction of new state railways (after graduating from the Paris School of Bridges and Highways). He actively worked in railway workshops, even drove locomotives. He participated in the construction of a high arched viaduct Garabi with a span of 166 m (description of this structure and work on its construction was the first scientific work of a young 23-year-old engineer V. Ye. Timonov in 1884) (Timonov, 1884).

From his youth V. Ye. Timonov has witnessed active development of maritime trade and the growth of the port of Odesa – the source of prosperity of the city of Odessa. We believe that this circumstance probably played an important role in the fact that in Timonov's technical activity the issues of development of domestic water transport and, first of all, sea transport was of the greatest importance (Timonov, 1886a). Our conclusion is based on the fact that in 1884 V. Ye. Timonov, after returning home from France, worked as a technician in the port of Odesa (after graduating from the Paris School of Bridges and Highways and while still being a student at the Transport University of Emperor Alexander I). He carried out a number of repairs in the port. Timonov's historical and technical study on the development of the port of Odesa published in the Journal of the Ministry of Railways in 1886 was of particular importance. It was awarded the Prize of the Conference of the Transport University and marked the beginning of a series of descriptions of Russian commercial ports) (Timonov, 1886b).

In 1885, V. Ye. Timonov was an acting assistant of a chief of the tracking service of the South-Western Railways and an engineer for special assignments under the head of the Odessa branch of the service of the track and facilities of the South-Western Railways. He took an active part in repair work on the railway line and stations. He carried out local research. He studied the causes of erosion of bridges and pipes on the Bessarabian railway line. He designed new bridge structures. Already at this time, his imagination was filled with hydraulic engineering.

Since 1886 V. Ye. Timonov has been an assistant of the inspector of works in the port of Libava (Liepaja) (order of the Ministry of Railways №50 of June 25, 1886 –

the beginning of civil service) (Timonov, 1887b). Here he received a good practice during production and design work. As a senior work performer at the port of Libava (from 1886 to 1889), he worked on the research, design, and construction of this port. In addition to dredging, the young engineer was engaged in the construction of port facilities, repair of piers, and embankments. He spent a lot of time extending the South Pier from concrete massifs (for the first time in the Baltic Sea). And this led to his special interest in such a design. He was also involved in the construction of excavations at the bar and inside the port. He carried out maritime surveys and projects for the development of the port of Libava. Thus, in the first years of his engineering activity V. Ye. Timonov participated in the full cycle of work on the creation of seaports: in exploration work, their design and construction.

At the same time, V. Ye. Timonov made a number of business trips to the ports of Western Europe. He visited Rotterdam, Eymenden, Dunkirchen, Boulogne, and Calais, excavating and developing the foundations for the construction and commission of Russia's first offshore marine pump for Libava, which also transported depleted sand. V. Ye. Timonov became the initiator of the first in Russia marine dredging works at the bar of the port of Libava with a reduction in the cost of work by several times. A historical and technical study on the development of the port of Libava (published in the journal «Journal of the Ministry of Railways» in 1888) he was awarded the first prize. As we have already noted, this study became the basis of the dissertation, for which the Council of the Institute in 1891 awarded the engineer Timonov the academic title of the adjunct of the Institute (Timonov, 1891c).

V. Ye. Timonov made an important report on the port of Libava even earlier, at the First Congress of Coastal Structures, which took place in Paris in 1889, where he participated in the work of this Congress (Timonov, 1890). A clear clarification in this report of the stages of construction of port facilities on the sandy coast allowed domestic port builders to assess accurately the impact of these important factors in the construction of other port facilities. That is why V. Ye. Timonov published a short article «External structures of the port of Seth» (1887), in which he briefly described the history of the construction of the French port enclosures in the Mediterranean for 220 years (Timonov, 1897). He found a great similarity in the hydrological and geological conditions of existence of the ports of Sett and Libava. The researcher pointed out that in the port of Seth, fencing structures, although they do not guarantee the port area from the depositing of significant sediments, but allow using this area with relatively low operating costs. The experience of the builders of the Port of Seth in combating sediments, described by V. Ye. Timonov, enriched the knowledge of domestic port builders and to some extent was taken into account in the design and construction of ports in similar conditions. Timonov spent a lot of time studying the site of the mouths of the Garonne, Seine, Elbe, Weser and the ports of Royan, Rofshof, La Rochelle, Le Havre, Rouen, Hamburg, Bremen, and others.

Since 1889, V. Ye. Timonov has been a junior engineer of the Commission for the Arrangement of Commercial Ports in the Ministry of Railways (until 1893). For 4

years he performed a variety of work – reviewing projects, estimates, contracts, and reports on port operations in the Black, Azov, White, Caspian, and Baltic Seas. He draws up programs of port researches and works concerning the creation of projects of ports, for example in Vladivostok (Valliant, 1974, p. 29). He elaborated on the issue of correction of the paragraphs of the Building Regulations relating to the use of Portland cement in hydraulic and other structures, with the publication of his scientific work (Timonov, 1888). It discusses the application of Portland cement port works. The activity of V. Ye. Timonov in the Commission for the arrangement of commercial ports and the study of port business abroad enriched the knowledge of Vsevolod Yevhenovych in the field of domestic and foreign port construction. The development of industrial cement production in Western European countries in the early XX century created favorable conditions for the widespread use of concrete in the practice of port construction.

Conclusions.

The main factors having contributed to the formation of V. Ye. Timonov's personality and the formation of his scientific worldview were: his family (his father, who was a prominent magistrate in Odessa, and the family environment, which became the place where the personality of the future scientist was formed); cultural and educational (studies at the Vienna Gymnasium, Odessa Real School, Paris School of Highways and Bridges, St. Petersburg Transport University); scientific and pedagogical (influence and authority of highly qualified specialists, scientists, professors, among which it is worth noting the following: M. A. Beleliubskyi, K. A. Buniakovskyi, M. M. Hersevanov, D. I. Zhuravskyi, F. Ye. Maksymenko, L. F. Nikolai, and others who contributed to Timonov's choice of the hydraulic scientist profession) as well as engineering activities on the railways of France and ports (Libava and Odessa).

It has been shown that Timonov's scientific research was carried out in the context of the tasks of hydraulic engineering and transport science. The creative work of the scientist can be divided into three main areas: a) work in the field of hydraulic engineering and hydraulic structures; b) scientific achievements in the field of water transport; c) scientific and historical direction and promotion of scientific and technical knowledge. It has been established that V. Ye. Timonov's works are a significant contribution to the development of science and technology, thanks to which he became one of the world's leading hydraulic engineers. Professor V. Ye. Timonov is a scientist-innovator in the field of dredging works on large rivers and coasts. He was the first in Ukraine to take the initiative to improve the navigability of the Dnipro, the Dniester, and Ukrainian parts of the Danube. His research has now made it possible to address properly the issues of port construction, port management, and port operation.

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Професор В. Є. Тімонов – формування наукового світогляду

Анотація. *Ім'я Всеволода Євгеновича Тімонова, видатного вченого-інженера, педагога, громадського діяча і популяризатора науки, доктора технічних наук, Заслуженого діяча науки і техніки РРФСР, професора добре відоме широким колам вітчизняних і зарубіжних вчених, що працюють в різних галузях науки і техніки. Сьогодні творчість непересічної особистості вченого особливо цікавить дослідників своєю невичерпністю і багатогранністю. В діяльності В. Є. Тімонова яскраво проявилися риси талановитого дослідника, експериментатора, організатора науки, новатора у вирішенні важливих теоретичних і прикладних проблем гідротехніки. У статті висвітлюється його*

ранній період життя та діяльності. Цей період життєвого шляху В. Є. Тімонова дозволяє нам зрозуміти і відобразити умови формування світогляду вченого, фактори, що вплинули на становлення його творчої особистості і проаналізувати основні напрями його діяльності. А від себе зауважимо, що його 60-річна наукова, педагогічна і громадська діяльність характеризується винятковою багатогранністю і глибиною. Видатний вчений, до останнього дня безмежно відданий науці, В. Є. Тімонов – є автором понад 700 наукових праць. Серед його праць – ряд підручників, навчальних посібників і монографій, які отримали широке визнання вчених нашої країни і зарубіжних дослідників. В декількох талановито написаних книгах яскраво відобразився його багатогранний талант мемуариста. Понад 50 років В. Є. Тімонов вів педагогічну роботу у вищій школі. Його лекції (в інститутах, університетах і на масовій аудиторії) завжди мали величезний успіх. Він виховав цілу плеяду вчених. Багато сил і часу Всеволод Євгенович віддавав справі популяризації науки, активній, цілеспрямованій боротьбі з антинауковими концепціями в гідробіології, гідрографії, гідротехніці. Плідною була і науково-організаційна діяльність Тімонова. Людина великої і різнобічної культури, палкий шанувальник і глибокий знавець поезії та літератури, В. Є. Тімонов і сам був обдарованим популяризатором наукових знань.

Ключові слова: *В. Є. Тімонов; гідротехніка; водний транспорт; інженер; водопостачання; водовідведення*

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Профессор В. Е. Тимонов – формирование научного мировоззрения

Аннотация. *Имя Всеволода Евгеньевича Тимонова, выдающегося ученого-инженера, педагога, общественного деятеля и популяризатора науки, доктора технических наук, Заслуженного деятеля науки и техники РСФСР, профессора хорошо известно широким кругам отечественных и зарубежных ученых, работающих в различных областях науки и техники. Сегодня творчество незаурядной личности ученого особенно интересует исследователей своей*

неисчерпаемостью и многогранностью. В деятельности В. Е. Тимонова ярко проявились черты талантливого исследователя, экспериментатора, организатора науки, новатора в решении важных теоретических и прикладных проблем гидротехники. В статье освещается его ранний период жизни и деятельности. Этот период жизненного пути В. Е. Тимонова позволяет нам понять и отразить условия формирования мировоззрения ученого, факторы, повлиявшие на становление его личности и проанализировать основные направления его деятельности. От себя заметим, что его 60-летняя научная, педагогическая и общественная деятельность характеризуется исключительной многогранностью и глубиной. Выдающийся ученый, до последнего дня беззаветно преданный науке, В. Е. Тимонов - является автором более 700 научных работ. Среди его работ - ряд учебников, учебных пособий и монографий, получивших широкое признание ученых нашей страны и зарубежных исследователей. В нескольких талантливо написанных книгах ярко отразился его многогранный талант мемуариста. 50 лет В. Е. Тимонов вел педагогическую работу в высшей школе. Его лекции (в институтах, университетах и на массовой аудитории) всегда имели огромный успех. Он воспитал целую плеяду ученых. Много сил и времени Всеволод Евгеньевич отдавал делу популяризации науки, активной, целенаправленной борьбе с антинаучными концепциями в гидробиологии, гидрографии, гидротехнике. Плодотворной была и научно-организационная деятельность В. Е. Тимонова. Человек большой и разносторонней культуры, страстный поклонник и глубокий знаток поэзии и литературы, В. Е. Тимонов и сам был одаренным популяризатором научных знаний.

Ключевые слова: *В. Е. Тимонов; гидротехника; водный транспорт; инженер; водоснабжение; водоотведение*

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Professors of the Kharkiv Technological Institute: unknown pages of biography

Abstract. *The purpose of the study is to conduct a comprehensive historical and scientific analysis of the life and scientific and organizational activities of professors of the Kharkiv Technological Institute Oleksii Khinkulov and Pavlo Dedusenko, using the study of scientific literature and involved archival materials. On the basis of the involvement of unknown and little-known archival documents, a historical reconstruction of the creative activity of scientists was conducted; in particular, the little-known period of their life in 1940–1946 was studied in detail. A comprehensive analysis of the scientific activities of Oleksii Khinkulov was carried out, his contribution to the formation of the electrical industry was determined. His role in the development of scientific research in the field of radio engineering in Ukraine was emphasized. He headed one of the largest radio engineering club in Ukraine. The social activities of Oleksii Khinkulov were investigated, it was found that for a long time he worked as deputy chairman, and then as chairman of the All-Ukrainian Association of Engineers, which united the teams of research departments of technical institutions of Ukraine. The scientific and organizational activities of Professor Oleksii Khinkulov certainly contributed to the development of electrical engineering science and education both in Kharkov and in Ukraine. He was one of the organizers and*

promoters of the radio engineering direction in Ukraine, participated in the work of public organizations and electrical congresses. His colleague at KhTI, Professor of chemistry Pavlo Dedusenko, is undoubtedly an outstanding person. As an active member of various charities, he worked hard for the public. These are both scientific societies and various social projects. A supporter of Ukrainian nationalism, he strove for the Independence of Ukraine, the development of Ukrainian culture. Repressed in 1945, the scientist died in the concentration camp in 1946. In 1991, due to the lack of evidence confirming the guilt of Pavlo Dedusenko, the professor was rehabilitated.

Keywords: *Oleksii Khinkulov; Pavlo Dedusenko; Kharkiv Technological Institute; higher technical education; Ukraine*

Introduction.

The system of higher technical educational institutions began to be created in Ukraine at the end of the XIX century. In order to improve the training of engineers for the industrial complex in 1885 in Kharkov was opened the first higher technical institution of Sloboda Ukraine – the Kharkiv Practical Technological Institute (KhPTI, since 1898 – Kharkiv Technological Institute, KhTI, since 2000 – National technical University "Kharkiv polytechnic institute"), which became a center for technical sciences and a base for the emergence of research collectives.

The history of NTU "KhPI" from its beginning has become an integral part of scientific, technical, intellectual and cultural history of Ukraine. During the long history of the University many scientific directions have been formed. NTU "KhPI" played an important role in the creation and development of leading technical universities in Kharkiv and Ukraine, in particular the National Aerospace University M.Ye. Zhukovsky "Kharkiv Aviation Institute", Kharkiv National University of Radio Electronics, Kharkiv National University of Civil Engineering and Architecture, Ukrainian Engineering Pedagogics Academy, Volodymyr Dahl East Ukrainian National University, Central Ukrainian National Technical University (Kropyvnytskyi), Sumy and Kremenchuk institutions of higher technical education, which had long been branches of Kharkiv Polytechnic. The formation of scientific research in the field of electrical engineering and chemistry at NTU "KhPI" took place in the late XIX century – at the first half of the XX century during socio-political and economic transformations, revolutions, wars. The names of Mykola Pylchykov, Oleksiy Pogorelko, Mykola Klobukov, Pavlo Kopniaev, Valerii Hiemilian, Ivan Adadurov, Oleksandr Lidov, Yevhen Orlov and others were associated with this period.

Among the representatives of the scientific community of Kharkiv Technological Institute cannot miss the figures of Oleksii Khinkulov and Pavlo Dedusenko, who were engaged in teaching and research activities at the KhTI in the first half of the XX century and were members of the same family (O. Khinkulov got married to P. Dedusenko's sister).

The fate of these scientists remained unknown for a long time. The last information about Oleksii Khinkulov's life dates back to 1938 when he was a professor at the Department of General Electrical Engineering of the Civil Engineering Institute. His joint activities with P. Dedusenko in public associations during the pre-war period and at the beginning of the World War II remain completely unexplored. Meanwhile, a number of declassified documents emerged in the State Archives of Kharkiv Region, which allowed fill in gaps in the biographies of KhTI professors.

Scientific and organizational activity of Professor Oleksii Khinkulov and Professor Pavlo Dedusenko was not the subject of a separate study. Some information about the life and professional activities of the scientists can be found in the anniversary publications on the history of NTU "KhPI" (Kirkach (Ed.), 1985; Tovazhnianskyi, 2000). Brief biographical data are presented on the website of NTU "KhPI' in the section "History of the Kharkiv Technological Institute in persons". Information about the work of Oleksii Khinkulov in Kharkiv is presented in a monograph about the activities of Professor Pavlo Kopniaev' scientific school (Tverytnykova, 2009), monograph on the history of technical sciences in Ukraine (Tverytnykova, Posvyatenko, & Melnyk, 2015), and article (Klepikov, 2010).

There are even fewer publications about the activities of Professor Pavlo Dedusenko. Some information about the life of the scientist is in the work of D. Zhurylo (Zhurylo, 2016). However, the name of the scientist is not at all mentioned in the publications on the history of NTU "KhPI" (Baranov, 2016; Zynchenko & Krotenko, 2017; Kamchatnyi, 2017; Minakova et al, 2018).

Today scientific biography has become an important component of modern historical research. One of the current areas of the system of scientific knowledge development of modern Ukrainian studies about Ukraine is the study of the scientific achievements of the technical Ukrainian community as a social phenomenon, their role and contribution to world and Ukrainian science. Therefore, the systematization of biographies of scientists of NTU "KhPI" as a form of preservation of cultural memory and popularization of science is relevant.

The purpose of the article – to reconstruct the little-known pages of life and creative activity of scientists associated with the Kharkiv Technological Institute, in particular one of the organizers of electrical and radio engineering education in Ukraine – Oleksii Khinkulov and Professor of chemistry, public figure – Pavlo Dedusenko.

The source base of this study was the documents of the archives of the Dedusenko's family, the funds of the State Archives of Kharkiv region and the archive of NTU "KhPI".

Research methods.

The methodology of research is a system of principles and basic approaches to cognition and dialectics, which together allow for a comprehensive analysis. Methods such as content analysis, historiographic analysis, historical-genetic, historical-

chronological, historical-comparative, biographical methods, and the method of critical analysis based on the principles of objectivity and historicism have been used (Pylypchuk & Strelko, 2020).

Results and discussion.

Oleksii Khinkulov was born on March 17, 1885 near Chisinau in a family of Bessarabia nobles (father – Kharyton Vasylovych Khinkulov). In 1836, this Bessarabian family was added to the city nobility at the petition of Constantine and Khariton Khinkulov.

In 1903, Oleksii graduated from the Chisinau Real School, where he received his first technical knowledge and skills. The curriculum of the real school was quite varied, in addition to lectures on literature, history, geography, mathematics, physics, foreign languages, chemistry, drawing, mechanics, chemical technology, etc., the practical classes were held in laboratories.

Oleksii Khinkulov decided to continue his studies at KhTI. However, as early as 1907, he was expelled and banned from living in large and medium-sized cities in Russia due to active revolutionary activities. In 1911, attempts were made to restore. His father, Khariton Khinkulov, filed a petition to the Director of the KhTI, but it was denied. Only in 1914 Oleksii Khinkulov was admitted to study (Bondarenko, 2009).

In 1914 with the beginning of the World War I Oleksii Khinkulov (Fig. 1) went to the front as volunteer, took part in hostilities, and received the rank of ensign. According to the "Russian word" newspaper, he was wounded in 1915. On October 8, 1919, he was sent to Odessa, then served in the Armed Forces of the South, Staff Captain and was captured. After the end of the Civil War, he continued his studies at KhTI, despite the fact that he was under the constant supervision of the State Political Department (Volkov, 2015).

Figure 1. Oleksii Khinkulov, 1914 (photo from NTU «KhPI»'s library Website).

After graduating in 1921 from accelerated course of the Faculty of Mechanical Engineering, he was enrolled in the staff of the Faculty of Electrical Engineering as an engineer. But he was involved in teaching lectures on general electrical engineering. Then Oleksii Khinkulov studied in graduate school under the guidance of Professor Pavlo Kopniaev (SAKhR, f. R-1682, op. 1, c. 120, p. 46).

Scientific and pedagogical activity of Pavlo Kopniaev began in the KhTI in 1899, when the situation with the electrical engineering was unresolved. Electrical engineering disciplines were not included in the curriculum, and no scientific research was conducted. The activity of Pavlo Kopniaev was aimed at expanding the teaching of electrical engineering and the creation of an Electrical Engineering Faculty at the KhTI, the organization of scientific laboratories. Professor P. Kopniaev conducted theoretical research in the field of AC and DC machines, electrical measurements, electrical traction, and electrification of production (Gutnyk, Tverytnykova, & Sklyar, 2019).

In the early 1920's Pavlo Kopniaev headed the Research Department of Electrical Engineering and the Department of Postgraduate Studies. Great merit of Pavlo Kopniaev was in that he gathered a forceful teaching staff of the Faculty of Electrical Engineering, which created favorable conditions for the development of scientific school. To increase the level of teaching and research work strengthen Pavlo Kopniaev invited a specialist in the field of high voltage technology Vasyl Khrushchev, a specialist in electric traction Oleksander Potebnya, a specialist in the field of electric drive Tyhon Hubenko. As part of the research Department of Electrical Engineering of KhTI professors M. Perevozsky and S. Theis, researchers Oleksii Khinkulov, Oleh Bron, Leonid Hayler, Oleksander Berher, Hryhorii Sturman were worked. In addition, the staff of the Faculty was carefully selected among the most talented students (SAKhR, f. R-1682, op. 1, c. 107, pp. 22–23).

After graduating from postgraduate courses Oleksii Khinkulov worked as an assistant at the Department of Electrical Equipment. There he taught courses in telegraphy, telephony, radiotelegraphy, and electrical measurement. At the proposal of Professor Pavlo Kopniaev the assistant Oleksii Khinkulov began promising research in a new direction – radio engineering (SAKhR, f. R-1682, op. 1, c. 233, p. 18).

In 1922 Oleksii Khinkulov went on a business trip to Moscow, where he visited a radiotelephone station, the Shabolovka arc radio station, the laboratories of the Institute of Communications, and the electrical laboratories of the Moscow Higher Technical School. During 1922–1923 he studied the methods of radio measurements, got acquainted with the equipment of the Nizhny Novgorod laboratory, under the direction of Dmytro Rozhansky. In 1926 he was sent to Germany, where he got acquainted with the methods of teaching radio engineering and laboratory equipment (Klepikov & Tverytnykova, 2017).

Gained experience he used for the development of a new specialization and the establishment of a new faculty at KhTI. According to the results of the business trip Oleksii Khinkulov made the reports at the electrical department of the Faculty on the

main details of radio technology, the work of radio stations, prepared an educational program on radio technology, which was included in the curriculum of the Electrical Engineering Faculty in 1927. A separate course of lectures for the Aviation Department was also prepared. Taking into account the new direction of development of electrical engineering in KhTI, he started six new laboratory works in the electrical measuring laboratory, developed a lecture course – radiotelegraphy and initiated the construction of a radio laboratory. Later, the radio laboratory became the basis for the organization of the Radio Engineering Department at the Kharkiv Electrotechnical Institute (SAKhR, f. R-1682, op. 1, c. 151, p. 12).

In KhTI Oleksii Khinkulov created a radio engineering club, which in addition to scientific work was also engaged in promotional activities. At that time there were more than 100 such clubs and Kharkiv club was one of the largest. The first information about the scale of the Kharkiv radio engineering club can be taken from the article by M. Vladimirova. However, only a few words were given in the materials of the publication about the role of O. Khinkulov in the formation of the radio club. Students and teachers gave lectures and made reports on topical issues of radio engineering at enterprises and other educational institutions. Lectures were accompanied by demonstration materials. A large loudspeaker was installed in the physical auditorium of the KhTI, where lectures were regularly held for those who were interested in radio engineering (Vladimirova, 1967, p. 5).

During 1925–1930, Oleksii Khinkulov worked as deputy chairman and later he became a chairman of the All-Ukrainian Association of Engineers. The association united more than 1600 people and had nine branches: Kharkiv (610 members), Dnipropetrovsk (360 members), Kyiv (183 members), Zaporizhzhia (42 members), Odessa (260 members), Kherson (22 members), Mykolaiv (32 members), Berdiansk (17 members) Lysychansk (28 members) (Zhelekhivsky, (Ed.) 1930, pp. 11–12).

The All-Ukrainian Association of Engineers was established in 1921 at the proposition of Professor Ivan Krasuskyi. In the report by I. Krasuskyi the creation of new forms of science organization – Research Institutes or public associations of research departments was discussed. This allowed more effective communication among the scientific communities. The Association offered the publication of scientific periodicals, holding annual congresses, conferences, international exchange of specialists. As a result, the All-Ukrainian Association of Engineers was created, which united the staff of research departments of Ukrainian technical institutions (SAKhR, f. R-1682, op. 1, c. 155, pp. 16–18).

It should be added that Oleksii Khinkulov organized electrotechnical courses within the Association, founded a scientific journal “Electrotechnical Bulletin”, carried out active promotional activities of the achievements of electrical and radio engineering science. He also took part as secretary of the Presidium of the Congress in the organization and holding of the All-Ukrainian Energy Congress in April, 1924 (Fig. 2).

Figure 2. Presidium of the All-Ukrainian Energy Congress, in the center P. Kopniaev & O. Khinkulov, 1924 (Funds of the museum of NTU "KhPI").

In 1931 Oleksii Khinkulov was invited to the Kharkiv Aviation Institute (KhAI), where he organized the workshop of Electrical Engineering, on the basis of which in 1934 the Electrical Engineering Department was established. In 1936 he was fired from the KhAI as a «*class-hostile element». «… ..Khinkulov O. Kh., Professor, non-party. – Former White Army staff-captain. He was arrested by the GPU) in Rostov. Son of a rich Bessarabian kulak. He was associated with prominent figures of the Central Committee of the Cadet Party. As an expert is not of special value…»* (Baluta (Ed.), 2014, p. 54).

However, Oleksii Khinkulov began to work at the Kharkiv Technological Institute, headed the General Electrical Engineering Department until 1942 and he headed the school of craftsmen at the Kharkiv Tractor Plant. At that time, Professor Pavlo Kopniaev died and his student headed the Electrical Engineering area at the KhTI.

In addition, as a leading electrician Oleksii Khinkulov was invited to organize electrical engineering research in other institutes of the city. Thus, he worked until 1938 at the Kharkiv Civil Engineering Institute as acting Head of the Department of General Electrical Engineering (Pavlova, 2016).

With the beginning of World War II at the territory of Ukraine Oleksii Khinkulov was not evacuated and stayed in Kharkiv during the occupation. By this time he got married for the second time to Oleksandra Oleksandrivna Khinkulova (surname before marriage is unknown), born in 1898. Oleksandra worked as the secretary of Main

Department of Nonmetallic Industry (SAKhR, f. 901c/Г3744, op. 2, c. 2, p. 10).

The first wife of Oleksii Khinkulov was Kateryna Tymofiivna Dedusenko (Fig.3), sister of Professor of the Department of Analytical Chemistry of KhTI Pavlo Dedusenko. Actually, thanks to the archives of the Dedusenko's family, some information about the further life of Oleksii Khinkulov was kept.

Figure 3. Oleksii Khinkulov with his first wife – Kateryna Dedusenko (photo from Bondarenko V. K., 2009).

Short information about Oleksii Khinkulov can be found in the materials of the State Archives of Kharkiv region. According to the list of people who were living in the building of KhTI № 16, at Kaplunivska Street – on February 15, 1942, Professor Oleksii Kharytonovych Khinkulov and his wife Oleksandra Oleksandrivna left to Poltava for temporary residence according to the order of the German authorities. His first wife Kateryna Dedusenko, who lived in the same house, stayed in Kharkiv (SAKhR, f. 901c/Г3744, op. 2, c. 28, p. 18).

Further information on Oleksii Khinkulov and his second wife wasn't found by authors of the article. So, the further fate of this electrical engineer is unknown.

From the archive of the Dedusenko' family it is known that Oleksii Khinkulov could have been repressed after the World War II, but documents proving this have not been found yet.

Pavlo Dedusenko was born in 1872 in the village Yelizavetivka (Azov district, Rostov region), in a large Cossack family. Pavlo had three brothers and five sisters. He studied at the Kharkiv University at the Department of Natural Sciences of the Faculty of Physics and Mathematics, and graduated it in 1897 with a diploma of the 1st degree (Fig. 4).

Figure 4. Pavlo Dedusenko, 1902 (photo from NTU «KhPI»'s library Website).

After graduation, he worked for two years as a non-staff laboratory assistant in the chemical laboratory of the University, then as a laboratory assistant in the Analytical Department of the chemical laboratory of KhTI. In addition, he was invited as an assistant during the lectures of Professor Volodymyr Timofeev in organic chemistry and Professor Ivan Osipov in inorganic chemistry. During this period, the young scientist worked hard, engaged in both teaching and research. He taught various disciplines at the Kharkiv Institute of Noble Girls, Mariinsky Women's Gymnasium (girl's high school), Kharkiv Real School, Kharkiv School of Dentists, gave practical classes for students of medical and chemical faculties. He studied samples of iron and manganese ore, coal from the mines of Ukraine. He also participated in naturalist congresses. In 1904, Pavlo Dedusenko passed the exams at the Chemical Department of the KhTI for receiving a degree in engineering technology. Pavlo Dedusenko's career was quickly progressed at this time. Having received in 1901 the rank of titular counselor, in 1908 Pavlo Dedusenko received the councilor-in-arms rank, that is, he became a nobleman.

The initial period of Pavlo Dedusenko's scientific activity in the chemical department of KhTI is highlighted by D. Zhurylo (Zhurylo 2016, pp. 220–221). In the biographical data of the scientist given by D. Zhurylo there is information that raises questions, so it needs appropriate explanations or clarifications. In addition, the further fate of the scientist has not been studied at all, and especially during the World War II.

Since 1917, Pavlo Dedusenko was an assistant at KhTI, taught chemistry and worked as the Head of the laboratory of qualitative analysis (Fig. 5) (SAKhR, f. R-1682, op. 2, c. 89, pp. 3–7).

To providing the taught courses with the scientific literature, the scientist in 1919 prepared a publication "Introduction to the study of qualitative analysis". In September 1925, P. Dedusenko took part in the IV Mendeleev Congress, which was held in Moscow. A total of 432 reports were discussed in the field of chemistry, including colloid and agronomic ones (Proceedings of the IV Mendeleev Congress, 1926). An invitation to the event of such a high level confirms that by the middle of 1920s Pavlo Dedusenko had already been a well-known chemist.

On March 3, 1928, Pavlo Dedusenko was arrested for his nationalist views and imprisoned for three years in the Solovetskyi special purpose camp (forced labour camp), where he was recruited to work in chemical laboratories. After his return, he was exiled to northern Russia. For some time he was an associate professor at the Vologda Dairy Institute. Pavlo Dedusenko's second wife, Hanna (his first wife Kseniia Semenova has died), and their youngest daughter, Nataliia, were also in exile. From 1933 he worked as a Professor of chemistry at the Kharkiv Mechanical Engineering Institute. In addition, he got a job at the Cement Research Institute and at the Central Materials Testing Laboratory. He tried to made scientific experiments, but soon in 1934 he was fired «*for lack of workload»*. This was written in the order No. 107 from October 20, 1933, the approval of the teaching staff for 1933/1934 educational year.

Later Pavlo Dedusenko was forced to leave Kharkiv. First he got a job at the Institute of Chemical Technology in Berezniki (Russia), then at the Advanced Training Institute for Agriculture in Moscow (SAKhR, f. 30530, c. 4797, p. 57).

In 1937, Pavlo Dedusenko took academic degree – Associate Professor and from 1937 to 1941 he headed the Department of Inorganic Chemistry at Samarkand University. In September 1941 he returned to Kharkiv, where his big family lived: his wife, daughter and son, grandchildren, sister and old father.

In 1941, during the German occupation, an attempt to organize the educational and scientific process in KhTI was made. The professors of the Institute who stayed in Kharkiv continued to work at the Institute. They were engaged in the equipment inventory, preservation of facilities and library funds from theft. At the chemical department, some production was developed and Pavlo Dedusenko worked there as a consultant.

In addition, to support the starving KhTI teachers, the "Academpensioner" society was established to support the KhTI faculty and their families. At the initiative of the Society a canteen was opened at the Institute. At the end of 1941 and the beginning of

1942, Pavlo Dedusenko headed this Society and O. Khinkulov was a secretary. In addition, Pavlo Dedusenko headed the cultural and educational society «Prosvita» (USBU, f. 30530, c. 4797, pp. 22–24).

In August, 1943, Pavlo Dedusenko and his family moved to Lviv, where he worked as the head of the analytical department of the created Chemical Research Institute. The Chemical Institute had six departments: organic chemistry; study of the coal properties; organic technology; biochemistry; inorganic and analytical chemistry; physical chemistry. In 1944, together with the staff of the institute Pavlo Dedusenko was evacuated first to Krakow and then to Berlin.

In the archival file of Pavlo Dedusenko there is a certificate in which is stating that from May to September 1945 repressed P. Dedusenko had been working in the group of Major General P. N. Skorodumov in Berlin. In 1945 he was arrested for the second time. On March 27, 1946, a military tribunal sentenced him to 10 years in prison. He died in the camp in 1946. In 1991, due to the lack of evidence confirming P.T. Dedusenko's guilt, the professor was rehabilitated (USBU, f. 30530, c. 4797, pp. 5–6).

Conclusions.

Summarizing, it should be noted that the educational and organizational activities of Professor Oleksii Khinkulov certainly contributed to the development of electrical science and education both in Kharkiv and in Ukraine. The significance of the scientist's activity as the Head of the General Electrical Engineering Department at the Kharkiv Technological Institute, General Electrical Engineering Department at the Kharkiv Engineering Civil Construction Institute, Electrical Engineering Department at the Kharkiv Aviation Institute for the revival of the educational process, organization of electrical engineering disciplines. Several his main achievements of this period were: the teaching an unique discipline "Radio engineering" in Kharkiv, building a radio laboratory and creation a radio club at the KhTI, which became a stimulus to the organization of the Radio Engineering Faculty at the Institute.

In addition, unknown and little-known facts from the biography of the scientist were summarized and introduced into scientific circulation, in particular concerning with his personal participation in scientific forums, congresses, meetings and conferences, where he made reports and in this way his popularization activity was characterized. In particular, as the chairman of the All-Ukrainian Association of Engineers O. Khinkulov initiated the publication of scientific journal "Electrotechnical Bulletin", organized electrotechnical courses. It is determined, that during the World War II he was one of the initiators of the creation of the "Academpensioner" company, which aimed to support the teaching staff of KhTI and their families.

Based on the analysis of the Professor P. Dedusenko's archival investigation file, adjustments were made to his official biography. It is obvious that he was groundlessly accused because of his public activity during the World War II in the cultural and educational society 'Prosvita" ("Enlightenment"). The life and activity of the scientist

in the late 1930s – 1946 were studied in detail. Professor of Chemistry P. T. Dedusenko is definitely an extraordinary person. An active member of various charitable societies, he worked hard for the public. These were both scientific societies and various social projects. A supporter of Ukrainian nationalism, he sought the independence of Ukraine, the development of Ukrainian culture.

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Професори Харківського технологічного інституту: невідомі сторінки біографії

Анотація. *Мета дослідження – на основі опрацювання наукової літератури та архівних матеріалів провести комплексний історико-науковий аналіз життєвого шляху та науково-організаційної діяльності професорів Харківського технологічного інституту Олексія Хінкулова та Павла Дедусенка. На основі залучення невідомих та маловідомих архівних документів здійснено історичну реконструкцію творчої діяльності вчених, зокрема ретельно досліджено маловідомий період їхнього життя впродовж 1940–1946 рр. Проведено комплексний аналіз наукової діяльності Олексія Хінкулова, окреслено*

його внесок у становлення електротехнічної галузі. Підкреслено його роль у розгортанні в Україні наукових досліджень в галузі радіотехніки. Вчений очолював один з найбільших радіотехнічних гуртків України. Досліджено громадську діяльність Олексія Хінкулова, встановлено, що тривалий час він працював заступником голови, а далі головою Всеукраїнської асоціації інженерів, яка об'єднувала колективи науково-дослідних кафедр технічних закладів України. Наукова та організаційна діяльність професора Олексія Хінкулова безумовно сприяла розвитку електротехнічної науки й освіти як в Харкові так і в Україні. Він був одним з організаторів та популяризаторів радіотехнічного напряму в Україні, брав участь у роботі громадських організацій та електротехнічних з'їздів. Його колега по ХТІ професор хімії Павло Дедусенко безумовно непересічна особистість. Активний учасник різних благодійних товариств, він багато працював для громадськості. Це як наукові товариства так і різні проекти соціального спрямування. Прихильник українського націоналізму він прагнув незалежності України, розвитку української культури. Репресований повторно 1945 р. вчений помер у таборі у 1946 р. У 1991 р. з огляду на відсутність доказів, що підтверджували провину Павла Дедусенка, науковця було реабілітовано.

Ключові слова: *Олексій Хінкулов; Павло Дедусенко; Харківський технологічний інститут; вища технічна освіта; Україна*

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Аннотация. *Цель исследования – на основе обработки научной литературы и архивных материалов провести комплексный историко-научный анализ жизненного пути и научно-организационной деятельности профессоров Харьковского технологического института Алексея Хинкулова и Павла Дедусенка. На основе привлечения неизвестных и малоизвестных архивных документов осуществлено историческую реконструкцию творческой деятельности ученых, в частности детально исследован малоизвестный период*

их жизни в 1940–1946 гг. Проведен комплексный анализ научной деятельности Алексея Хинкулова, определен его вклад в становление электротехнической отрасли. Подчеркнуто его роль в развертывании в Украине научных исследований в области радиотехники. Он возглавлял один из крупнейших радиотехнических кружков Украины. Исследовано общественную деятельность Алексея Хинкулова, установлено, что длительное время он работал заместителем председателя, а дальше председателем Всеукраинской ассоциации инженеров, которая объединила коллективы научно-исследовательских кафедр технических заведений Украины. Научная и организационная деятельность профессора Алексея Хинкулова безусловно способствовала развитию электротехнической науки и образования как в Харькове так и в Украине. Он был одним из организаторов и популяризаторов радиотехнического направления в Украине, участвовал в работе общественных организаций и электротехнических съездов. Его коллега по ХТИ профессор химии Павел Дедусенко бесспорно незаурядная личность. Активный участник различных благотворительных обществ, он много работал для общественности. Это как научные общества так и различные проекты социальной направленности. Сторонник украинского национализма он стремился к независимости Украины, развитию украинской культуры. Репрессирован повторно в 1945 г., умер ученый в лагере 1946 г. Ввиду отсутствия доказательств, подтверждающих вину Павла Дедусенка в 1991 г. профессор был реабилитирован.

***Ключевые слова**: Алексей Хинкулов; Павел Дедусенко; Харьковский технологический институт; высшее техническое образование; Украина*

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