

Technical Characteristics of Incunabulum in Europe

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Abstract: Incunabula are printed materials created in Europe from the time of Johann Gutenberg's invention until 1500. Incunabula originate from the Latin language (lat. Incunabulum) and mean cradle or the beginning of something. In this paper, the representation of individual states and cities in the creation of incunabula is investigated and presented. The persons responsible for such development are also listed. Special attention is given to the presentation of Croatian incunabula. The mentioned works describe the characteristic features. Incunabula testify to a high level of culture, standards, and technological development of a particular area. The studied works reveal and confirm, as confirmed in this paper, the attitude of society towards literacy, education, and the national culture of each nation. This paper aims to comprehensively present the importance of incunabula for the development of European and Croatian culture, technological and comprehensive progress.

Keywords: Glagolitic alphabet; incunabulum; Latin alphabet; printing press

1 INTRODUCTION

The turning point in the rapid development of European civilization, science, and culture, occurred in the middle or second half of the 15th century. The introduction of metal-based movable-type enabled the replacement of handwritten copying with machine multiplication of the original. The inventor of the technology of moving letters, inks, and presses for machine printing of graphic templates was Johann Gutenberg, an inventor from Mainz, Germany (Fig. 1). Gutenberg was trended as a goldsmith, a worker in metals which enabled him to make metal letters [1]. The Gutenberg press was probably derived presses from agriculture or industry presses for grapes, olives, herbs, or papyrus. The wooden press had a large screw attached to a flat platen [2].

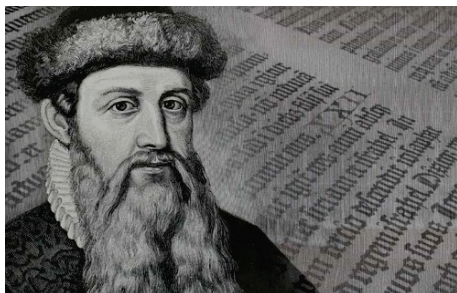


Figure 1 The inventor of movable type and the printing press Johann Gutenberg [5]

To reproduce the original in a lot of copies, the material of the letter had to have certain durability. Gutenberg found an alloy that was easy to pour, cooled quickly, and gave letters of such hardness that they could be used for printing several different editions (Fig. 2a). In doing so, the material of the letter had to accept the ink well and then release it onto the printing substrate [3]. Therefore, the printing substrate, the paper had to be adapted to the printing process. Gutenberg also made an oil-based ink that easily transferred on the printing form and then easily transferred to a printing substrate on which it dried relatively quickly [4].

In 1450, Johann Gutenberg tested his machine by printing a Latin book on speech (Fig. 2b) [6]. This is followed

by the printing of small dictionaries, short grammars, farewell letters, and calendars [5].

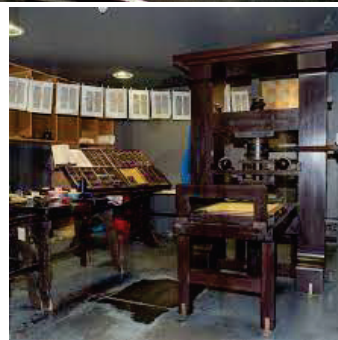
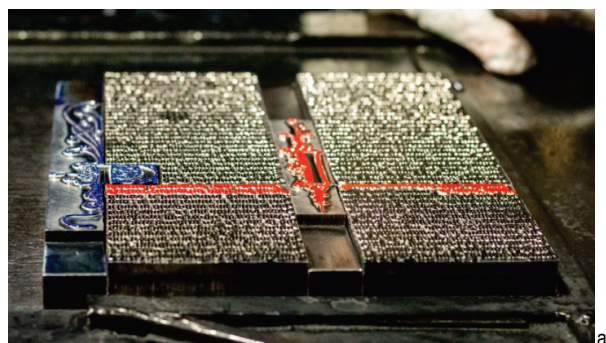


Figure 2 a) Bible printing form, Johann Gutenberg museum in Mainz [7], b) Reconstructed Gutenberg print shop with the printing press and movable types [8]

Gutenberg started printing the Bible around 1452. and completed it in late 1455. or perhaps early 1456 [7]. Some authors cite 1454. as the year of completion of the printing of the first Latin Gutenberg Bible. [9] Those years are considered the birth of printing [10].

Johann Gutenberg's most famous publication is the 42-line Bible (Fig. 3). The work was printed in two volumes with a total of 1282 pages [11, 12]. About twenty employees of the print shop worked on the production of this work. 290 different decorative figures were printed in the work. It is estimated that 180 copies were printed. About 150 of them on paper and about 30 on parchment. About 49 specimens have been preserved [13, 14].



Figure 3 a) The first page of the Gutenberg Bible [8], b) Gutenberg Bible [13, 15]

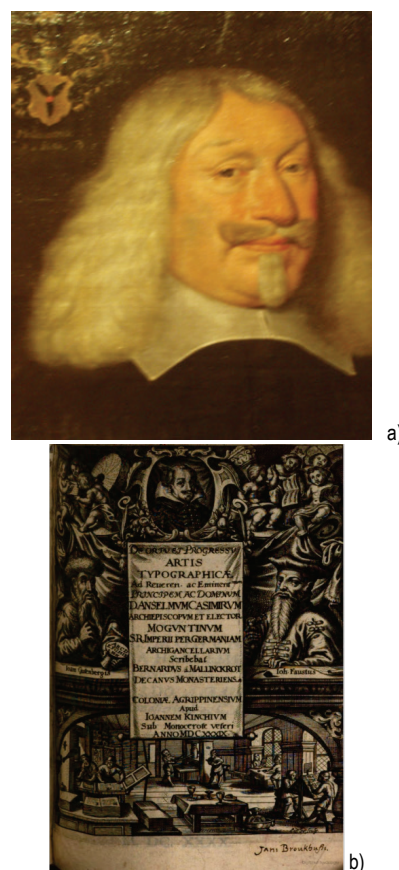


Figure 4 a) Bernhard von Mallinckrodt, b) Pamphlet mentioning the term "Incunabula" [7, 19]

The Psalter was finished in 1457. and is considered a second masterpiece by some authors [16]. The names of Faust and Schifer are mentioned for the first time as the followers of Johann Guttenberg in the Psalter. It is considered the most beautiful printed work by some authors. The decorations were so beautifully printed that some authors think they were printed in the technique of intaglio printing [17].

Books printed by Gutenberg did not have a special name until the celebration of the 200th anniversary of Gutenberg's invention, in 1639 when the dean of Münster Cathedral and the famous book collector Bernhard von Mallinckrodt published the pamphlet "On the Rise and Advancement of Graphic Art" (Fig. 4). He called the works printed between the time of Gutenberg's invention and the year 1500 "prima typographical incunabula - the first cradle of the press". With that, he defended the primacy of Johann Gutenberg as the inventor of book printing. Since then, the name incunabula has been used for works printed at that [7, 18].

Johann Gutenberg's invention caused a rise in print shop numbers and printed works in Europe. The greatest development was recorded in the area of today's Germany and Italy. It is believed that in each of those areas existed over 40 print shops around the 1480s [20]. The estimates are of 30000 to 40000 printed incunabula printed by the year 1500 [21]. The number of preserved editions is around 22000 copies. The main theme of published works was religion.

2 METHODOLOGY

Research methods that include deductive and inductive methods were used in the research work [22]. A list of research frameworks was compiled by deductive methods, which was processed through a review of previous research with similar topics. The published data are carefully examined, which is the area of this research by reviewing and studying all the literature found based on scientific papers, impartially taking into account all the obtained search results. The applied inductive approach reduces the possibility of overlooking the given search frameworks, which contributes to optimization in expanding or creating new frameworks, which contributes to deepening the research topic and including all relevant data in the research [22]. The mentioned approach can contribute by grouping previously published data and recognizing the omitted data. This can simplify the approach to important facts in this scientific field.

All the above-mentioned literature quotations collected in the described manner have been read several times and provided. The results are presented depending on the geographical area (Europe or Croatia) within a specific period of fifty years (1450 to 1500). All technical characteristics are presented in turn, with additional emphasis on the comparison of different sources cited in the manuscript, to elaborate specific functional features of the framework and contribute to the inconsistency of the source

of information. Articles containing information on similar data were grouped and provided together to better identify the technical characteristics of printed books in the mentioned period.

3 RESULTS

3.1 Print Shop Development in Europe

Although some people opposed the machine replication of printed materials, the majority were supporters of this technological novelty allowing the easier distribution of knowledge [23]. Having a print shop also gave the ruler and the inhabitants of each country prestige (Fig. 5).



Figure 5 Prevalence of print shops in Europe during the 15th century [24]

The placement of print shops and their equipment in letterpress begins in the German city of Mainz around the year 1440. In Mainz Johann Fust and Peter Schöffer printed *Psalterium Moguntium* – A double sheet on 14 August 1457. Book was printed in black, red, and blue on vellum. Initials were printed in two- to three-line alternatively in red and blue color (Fig. 6).

Letterpress print shops appear in Köln 1465., Eltvillen 1467., Augsburg 68. – 72., Nürnberg 1470. and Ulm 1472. It is estimated that around 60 print shops existed around 1472. on the territory of today's Germany. In Augsburg, Günther Zainer printed *Biblia Germanica* between 1474 -1476 and Jodocus Pflanzmann in 1475. Zainer's third edition of the Bible in German has 533 leaves (Fig. 6.). Chapter headings and three-line initials are printed in red while rubricated, versals touched are printed in yellow. Bible has several woodcut *Maiblumen* initials, and 73 large woodcut initials in contemporary coloring. Pflanzmann printed the fourth German Bible in 456 leaves. Pflanzmann used several colors, rubricated and simple initials he printed in red, and *Maiblumen* initials in red, blue, green, and liquid gold. The Bible contained an abundance of 57 woodcut illustrations printed from 21 blocks colored by a contemporary hand (Fig. 6) [25].

Hanza built print shops in Lübeck, Rostok, Denmark, Sweeden, and at the beginning of the 16th century even in Russia. In meantime, a large number of letterpress specialized print shops appeared in Germany [26-28].

The first print shop appeared in Italy around the year 1462. or 1463. in the Subiaco Benedictine Abbey near Rome. The print shop was established by clergymen Conrad Sweynheim and Arnold Pannartz [29, 30]. The print shop relocated to Rome around the year 1467. The number of print shops grew continuously reaching around 40 print shops around the year 1500, with around 4500 printed titles. One of the reasons for such a development is due to the largest paper producer in Europe was in northern Italy.



Figure 6 a) Page in *Psalterium Moguntium*, b) Page in the third edition of *Biblia Germanica*, c) Page in the fourth edition of *Biblia Germanica* [25]

It is believed that the press was brought to Venice by Johannes de Spiro in 1469 [31]. Before that, he worked in a print shop in Mainz (1460/1461)[32]. Venice, a large commercial and cultural center, accepted a novelty, letterpress. As early as 1470, Nicholas Jensen perfected the letter by using fewer varieties and sizes of lettering. Then have been introduced major changes in the appearance of printed pages such as smaller, plainer, simpler, and more regular pages, fewer columns and blocks, less ornament, and less color: black and white, regularly spaced, and justified lines, a rectangular block [33, 34]. In 1495, the top graphic artist Aldus Manutius printed a book of supreme artistic value, *Hypnerotomachia Poliphili*, in 500 copies which was at that time a large edition [35]. In addition to the aforementioned book, the printer introduced innovations

such as the octave format for his books, while the manuscripts and incunabula had the (larger) quarto or folio format, replacing the wooden inlays in the book covers with cardboard, italics typefaces [36, 37] and other. The explosion of printing in Venice can also be seen in the fact that in 1500 it had about 150 printing presses for letterpress printing [26]. In this period are produced over four thousand editions, twice more than Paris and about one-seventh of the entire European production [38].

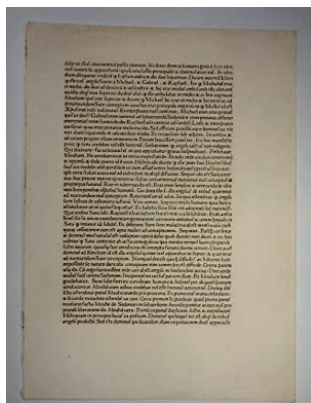


Figure 7 a) Incunabula, Rome ZVAB, b) Printing revolution in renaissance [26]

The first letterpress print shop appeared in England in 1476. The first printer in England was English William Caxton [39]. By occupation, William Caxton was a trader, diplomat, translator, and writer. This brought him to Köln where he learned the printing trade. Afterward, he started his first print shop in Bruges in Belgium, and gains the support of Burgandy ditches [40].

William Caxton returned to England in 1474 and started a print shop in Westminster (Fig. 8a). There he printed the first letterpress work in Great Britain (Fig. 8b) [27, 28]. He immediately expanded the number of titles and personally translated, typesetted, printed, and sold the editions. Of the 90 titles, he published and printed 74 were in the English language [26-28]. Unlike most print shops in Europe, he printed knightly secular novels, historical works, fables, and poems. William Caxton printed his translation of *The Recuyell of the Histories of Troye* a work by Raoul Le Fevre, and the first book printed in English in 1475 [41].

The first copies of Gutenberg's Bible were sold as manuscripts with aesthetically perfect black letters. Many

people at the time viewed the press as black magic, and as a cheap, disgusting medium that could devalue the aesthetics of the beauty of handmade objects. All that led the printers to write elaborate prologues, advertising and describing the book. Caxton's prologues convey his personal credentials and efforts in the production [41, 42]. It should also be noted that Caxton was the first in England to use woodcarving to print ornaments and paintings in some of his works [39].

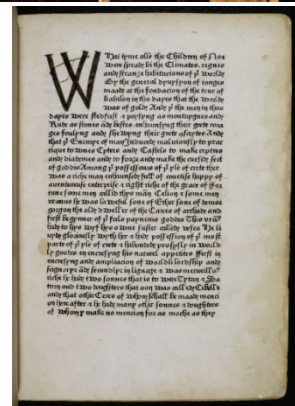


Figure 8 a) William Caxton in his print shop, b) the First book published in England [27, 28]

The laws in England did not support the rapid development of print shops. Thus, according to some sources at the end of the 15th century in England were only 5 print shops [26].

France as well as Italy had a well-developed intaglio printing at the time. However, letterpress and book printing came to France from Germany, via the city of Strasbourg, where it appeared in 1458. Guillaume Fichet [43] came to the Sorbonne and in the 1470s he founded a print shop at the Sorbonne University with his colleague Jean Heyulin. It was the first printing press in France, and it was primarily focused on the printing of humanitarian texts (Fig. 9). The first book was a collection of letters [44, 45]. In three years, the Paris print shop produced twenty-two books in Latin. It is believed that Fichet directed the press activities and Heyulin supervised production [46].



a)



b)

Figure 9 a) First print in Sorbonne in 1470. b) Drawing of the print shop from 1480 [44, 45].

Expensive books were printed in the beginning and after that, the production of cheap books began. This placed France at the top of book publishers of that time [26, 28]. Both founders left the Sorbonne in 1473, which was a blow to the increase in the number of books of this content [43]. It was not until ten years later that the printing of books continued in Paris, but then a nationally oriented humanism was established. In the meantime, printing expanded not only in France but throughout Europe and even a little wider [44].

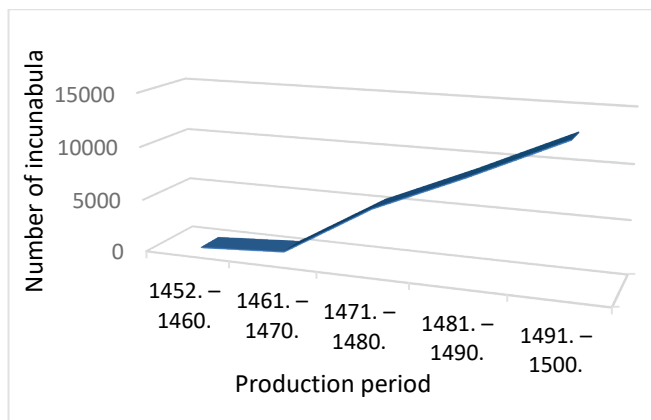


Figure 10 The rise of incunabula in comparison to the production period

The rest of Europe also held on to its reputation and wanted progress in its region [47]. Thus, print shops were opened in many countries, such as Utrecht (1470), Budapest (1473), Valencia (1473), and Krakow (1474). The print shops also appeared in other countries and cities as well (Fig. 10)

[13]. In the cities of Germany and Europe, there has been an increase in book printing. It is interesting to see that the growth is not related to the distance from the place of the first print shop (Fig. 11) [23]. When print shops opened in individual cities, the increase in the number of printed books is related to the number of available works in Latin, the ability to write and translate into the language of a particular country, and the degree of civilization.

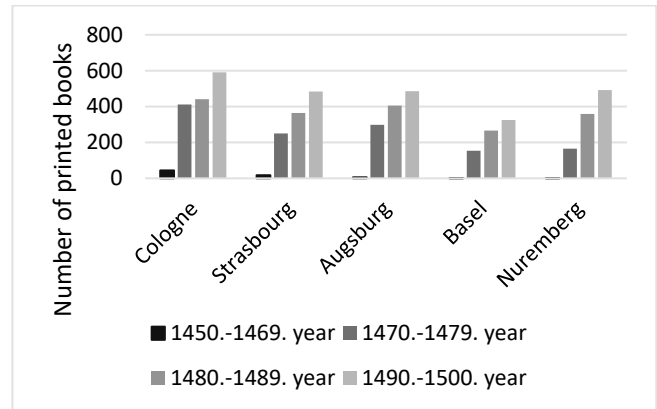


Figure 11 The number of printed books in German cities in the period from to [23]

Incunabula are preserved as cultural treasures all over the world. According to some sources, for example, there are about 19,700 copies in Munich, 12,500 in London, 12,000 in Paris, 8,600 in the Vatican, 8,000 in Vienna, 7,300 in St. Petersburg, and about 1,000 in Zagreb.

3.2 Incunabula in Croatia

The area inhabited by Slavic nations also prints its incunabula. The Check republic has the most published incunabula titles, around 60, then Croatia with 9, Ukraine with 5, and Montenegro with 5 titles. The peculiarity of Croatian incunabula is in the fact that they were mostly printed in Glagolitic, and a smaller number in Latin. Of all the mentioned nations, the Croats, with their diversity in writing, developed a special form of the Glagolitic alphabet, the so-called Croatian angular form. The mentioned alphabet is used both in writing and in the press [48].

The oldest Croatian incunabula is named Missal according to the law of the Roman court, printed in 1483 in Glagolitic script (Fig. 12). This work is the first incunabula printed by all South Slavic peoples and the first missal in Europe not printed in Latin letters and language [40]. No record has been found of where the work was printed, but some authors assume it was printed in Venice [49]. There are scientific discussions about the place of printing that have not yet been harmonized. The Missal is printed on 438 pages, arranged in two columns with 36 works. It is printed in two colors, red and black. 201 typographic characters (uppercase or lowercase letters, initials, ie initials, ligatures, abbreviations, etc.) were used in printing [50]. Most of it is printed on white cotton fiber paper, and a smaller is printed on parchment. The book is printed in two colors, red and black. In terms of typographic, esthetic, and artistic features,

this work is not surpassed by any later Glagolitic edition. 11 specimens have been preserved and none are complete [51]. Only 6 of them are kept in Croatia.

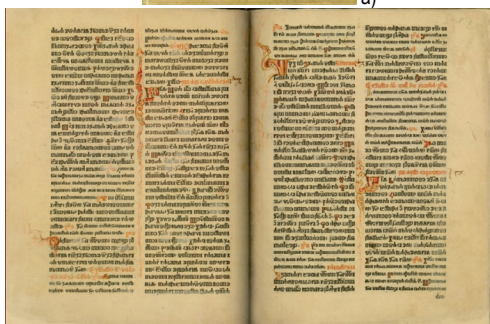
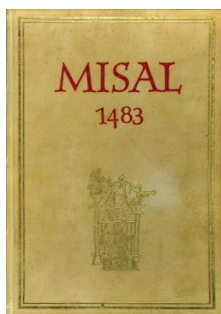


Figure 12 Missal according to the law of the Roman court a) first page, b) inner pages, c) tome

Thanks to the good connection with the Venetians, the first Latin breviary in Zagreb was printed in the print shop of Erhard Radtolt in Venice in 1484 (Fig. 13) [39]. This printed breviary of the Zagreb church was ordered by the Zagreb Bishop Oswald [52]. The typography breviary is unpretentious, containing only two small woodcuts and one decorated woodcut initial letter at the colophon. Two known preserved copies are kept in the Vatican library and the National Library in Budapest [53]. Missals have a few small and several big calligraphic initials in red, blue, or black ink with gilt layer and a printed Crucifixion miniature in front of the mass canon text [52].

The prayer book from 1490 was printed in Latin. The book contains an office in honor of the Virgin Mary and seven obedient psalms. In the same year was printed Office in Latin. The Office consists of two parts, the Office of the Holy Cross, and the Office of the Holy Spirit. The printing place for both books is unknown, and one copy has been preserved. Preserved specimens are bound together and kept in the Vatican libraries.

According to Z. Kulundžić and other scientists, the Glagolitic Breviary According to the law of the Roman court

was printed in Kolin in 1491. The year of printing the Breviary was determined based on a calendar because the only surviving copy is missing the last quaternion with the colophon where the data on the print shop, the date of printing, and other information would be found [55-57]. The copy is kept outside Croatia, in the Vatican. The preserved copy has VIII + 380 sheets, while the text is printed in two columns of 38 lines in two colors: black and red. A copy is printed on paper and a fragment of the calendar is on parchment [54].

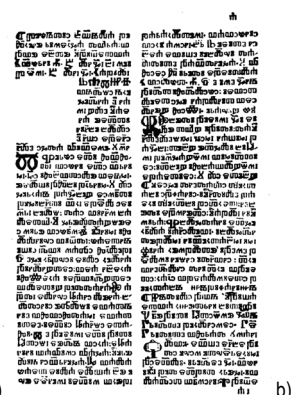
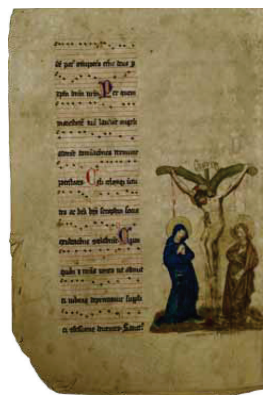


Figure 13 a) Zagreb Missal a Crucifixion miniature [52] b) The Glagolitic Breviary, printed in 1491 [54].

The Italian Peregrinus de Pasqualibus printed the Glagolitic incunabula, the Confession (*Ispovid*) or Treatise on Confession (*Ispovid ku e vsaki krstjanin drtan imiti i umiti i naučiti*). It was compiled by Matej Bošnjak from Zadar. The Incunabula was printed on June 16, 1492, in Venice. Not a single copy has been preserved, evidenced of the existence is evidenced by a manuscript in the Tkon's proceeding (*Tkonskom zborniku*) [58, 59].

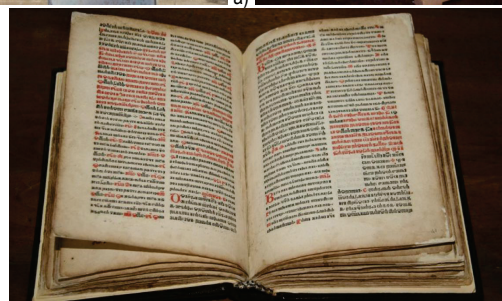


Figure 14 a) a bust of Blaž Baromić, b) Reconstruction of the printing press in Senj c) Senj Glagolitic Missal from 1494 [64]

In 1493, Blaž Baromić printed the Breviary in Venice in the print shop of Andreas Torresani. The breviary is a small format and consists of 544 leaves [60, 61]. The typographic peculiarity of this breviary was ligatures, especially the ones "broken". They were made in the so-called Baromić technique of broken ligatures or Baromić's technique of stacking ligatures [62, 63]. Five copies were saved of which only two are in Croatia.

Blaž Baromić, Silvestar Bedričić, and Gašpar Turčić printed the Senj Missal in Glagolitic script in Senj in 1494 (Fig. 14) [64]. One complete and two incomplete copies have been preserved, of which only one incomplete copy is kept in Croatia. Preserved fragment of the Missal consists of three leaves and has a woodcut with a crucifix (canonical image), which makes the Missal the first Glagolitic book with a woodcut [65, 66]. The missal consists of 216 leaves with two columns of 37 rows each. It is printed in two colors. Frane Paro emphasizes the original technique of casting half-letters, which enables the arrangement of ligature letter groups, further analyzes the details of the typographic process of printing the book, and finds that Baromić's typographic set created for the print shop in Senj is the best of Croatian Glagolitic printing [67].

Bernad Spličanin's Lektioner was printed in Latin script in Venice in 1495. The book was printed in the print shop of master Damian of Milan (Damianus de Gorgonzola). The Lektioner has eight volumes and 208 pages, it is printed in two colors. Two complete copies and one fragment have been preserved. One copy is in Odessa, in the Maksim Gorki Library, and the other in Zagreb in the Juraj Habdelić Library in the library of the Zagreb Jesuit College. The fragment is in Zagreb with the Franciscans at the Zagreb Kaptol [68, 69].



Figure 15 Colophon from Spovid općina printed in 1496 [60].

Spovid općina was printed in Glagolitic in Senj in 1496. It was a translation of manual Confessionale generale (Fig. 15) [70]. Confessionale generale was a popular work of the period and was written by Michael Carcano [71]. Blaž Baromić was mentioned as a printer and referred to as priest Blaž. Spovid općina was printed on 40 sheets, in one column with 25 lines. It is printed in one color, black. One specimen has been preserved in Zagreb in Croatia [24].

The development of print shops in northern parts of Croatia is related to the period after 1500, i.e., to the time after the printing of the incunabula.

4 TECHNICAL CHARACTERISTICS OF EUROPEAN INCUNABULUM

The design of the matrix enabled the technology for making type or individual pieces of metal tiles of alloy lead and tin in large series. The matrix was formed by engraving letters in harder metal and fastening them in softer metal. Large batches of type have contributed to a sufficient inventory to stack one page, which contributes even out the print. In this way, it was possible to make the desired number of copies in a short time, after which the types could be used to compose a new page.

According to all the above write out, it can be concluded that technical characteristics of the printing materials in 15 centuries, such as paper or ink, are similar in all incunabula. Inks were prepared for each edition, which could cause small variations in composition, but were not significant. Inks are made from raw materials available in nature or the environment, such as mineral, plant, or animal origin. The mineral used in red inks at the time is mercury vermilion. The white (hydro cerussite), yellow (massicot and lead-tin oxide), and orange (lead tetroxide) inks were based on lead. Blue could have been produced from raw materials from the plant origin as indigo, but from the mineral azure. The earliest recipes are designed specifically for printing and are similar in composition to carbon-based printing ink. Another source is dyes of animal origin such as carbon black obtained from raw materials of animal origin. Soot or lampblack pigments were commonly added to iron gall, which contributed to the good coating properties of the dye, but also its durability [72]. The good durability of natural pigments contributed to the preservation of books of that time, which testify to the level of technological development of that time and the inventiveness of the first printers.

Paper was known in the world and Europe before the invention of printing, but paper production grew rapidly with the invention of the printing press. The main raw material for making paper was used fabrics, especially tulip cloth. The good preservation of paper used in the research period is influenced by the optimal ratio of calcium and potassium. The high calcium content of the papermaking recipe is related to the use of gelatin, while the low amount of potassium binds to the amounts used by Alum [73].

The paper used by Guttenberg for the printing of the Bible was made at Caselle in Piedmont. That is visible from the watermark embedded in the used paper. Watermarks had the symbol of an ox's head (70%), a bunch of grapes (20%), and a walking ox (10%). The sheet format common to all printed matter is called the royal foil, which is about 430 × 620 mm.

5 CONCLUSION

One of the greatest inventions of mankind is the invention of the movable type and printing by Johann Gutenberg. This technology has enabled the rapid development of science, culture, and the economy.

Collecting and compiling religious texts, and translations into national languages contributed to greater accessibility and increased the use of printed books. In this way, all the most important literary works of human civilization become available to the public. Books greatly contribute to getting to know the world and people, which causes the start of a great wave of civilization. In addition to all the above, books are a source of information about the way of life at that time.

In the beginning, there was resistance to the new way of publishing, but soon the number of editions was taken as an unwritten parameter of the development and civilization of a country. In particular, politics in the late 15th century recognized the marketability of language in the press. The measure, the right measure, and the currency fit into it. That is why kings Louis XI (1461-1483) and Charles VIII (1490) strengthened printing by special decrees.

Croatian printers were the first to participate in the printing of books abroad. They brought the acquired knowledge and skills to Croatia, where they expanded their knowledge and introduced innovations. Blaž Baromić published the first book in Croatia and encouraged the reading of technological achievements in that area. From all the above, it is evident that Croatia actively participated in this early civilization process and thus actively contributed to the spread of new knowledge both in Croatia and in the world.

Despite the great distances from the place where the first print was created in Guttenberg's printing house and the poor traffic connection in the 15th century, the new technology spread rapidly throughout Europe. This is reflected in the similarity of technological processes related to the production of paints, paper and printing. Regardless of the above, creative individuals bring their innovative ideas and improve the development of technology, so Caxton, for example, printed ornaments and pictures with woodcarving, and Baromić was the only printer who made "broken" ligatures.

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