Chapter 2
Historical Overview

"He who cannot account for 3,000 years of history remains in the dark, living from one day to the next."
– Johann Wolfgang von Goethe (1749–1832)

Probably nothing has impacted the advance of humankind more significantly than its ability to communicate and exchange information with one another. The knowledge of how to retain the contents of communication and to pass it on – also over great distances – has given communities a significant advantage, assured them of survival and cemented their position of supremacy. The development of writing and paper, as a transportable communication medium, soon led to the establishment of regular messenger services and the first postal system. Already in ancient civilizations optical telegraphic media, such as smoke or torch signals, were used. These enabled the fast transport of messages over large distances with the help of relay stations. The Industrial Revolution, and the heightened need for information and communication accompanying it, accelerated the development of the optical and electrical telegraph, both of which appeared at the same time. Initially available only to the military, government and business, this long-distance communication media gained increasing importance in private communication. The development of the telephone started a huge demand for private communication, also to far-off locations, and led to rapid growth. Development surged in the 19th and 20th centuries thanks to the invention of the phonograph, gramophone, photography, film, radio and television. Mass media was born and continues to shape our society. On the road to total networking the world has became a global village with Europe, America and Asia only a mouse click from each other in the WWW.

2.1 The Development of Writing

To truly be able to understand the spectacular nature of digital communication and the possibilities it offers, it is worthwhile to take a brief look back at the history of communication and its media forms, or in other words *from Homo sapiens to Homo surfiens*. Testimonies to the medium of communica-

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tion can be found dating back 30,000 years, for example the **cave paintings** from the prehistorical time. With language as the innate means of direct and indirect communication between people (more about that in Excursus 1), the human memory was initially the only aid in keeping and fixing communicated information. However, just as today, the human memory was far from being a reliable or permanent means of storage. Early humans first leave the dark pages of history when they begin recording their sensory impressions in pictorial form. If they were protected from the elements, these rock carvings and paintings, as well as stone engravings and reliefs, remain with us until today. Besides the ritual and religious significance of these prehistoric drawings, they had a communicative purpose above all – namely to preserve messages in a visually. These pictorial representations of our ancestors' lives, were however not intended purely as depictions of reality, but, more importantly, memory aids in supporting the oral tradition. According to the beliefs of Aboriginal Australians, who have preserved their ancient culture up to today, rock paintings retain the souls of the painted image. Through the act of painting itself, the act of touching the depiction, or through rituals performed in the caves, the souls are inspired to a new incarnation and fertility. Additionally, cave paintings provided the people valuable information. They warned about dangerous animals living in the area, gave information about hunting or even hunting instructions. These testimonies to the life of prehistoric, nomadic hunters are called petroglyphs. The actual meaning of these pictures still often remains hidden from the modern viewer. The cultural background in which these depictions were created is simply not known.

Cave paintings are found on all continents. The greatest number of sites in Europe are in France, Spain and Italy. Everyone who looks at these pictures gets the same message, even if they express it in different words. To refresh the viewer's memory about the content, the image only needs to be seen again. Communities who recorded information in the form of drawings were more competitive than those who didn't. But pictures can only express information related to appearance. Sensory impression cannot be shown, for example the scent of a flower, or even abstract qualities such as the content of a law. The development of **language** was a necessary prerequisite to storing this kind of information. It allowed people independence from the here now of a situation as well as the ability to talk about the past and the future or what happens somewhere else. This basic power of human language was perfected with the development of **writing**.

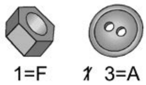
The decisive step leading from the pictograph of the **icon** to the phonetic characters we know today can first be carried out when the information to be transmitted is recorded with the help of visual script characters. The nature of these characters is no longer purely pictorial but directly related to the language of the script user. The characters should thus not only indicate meaning, but also the articulation of the object they describe, such as words, syllables or individual sounds (see Fig. 2.1).

From Pictograms to Phonograms – The Formal Development of Written Characters

- **Pictograms**:
  Pictorial signs used to represent objects, people or animals. Pictograms are often used today to give general information and on traffic signs. For example, the stylized image of a man designates the men's restroom or a knife and fork a restaurant. Simple pictograms are the starting point for the next level of the development of writing.

- **Ideograms**:
  Pictorial signs or a combinations of pictorial signs used to identify intangible expressions. Among other things, these can be activities, abstract terms or feelings. In contrast to pictograms, the meaning of ideograms cannot be construed by the image alone but must be learned. Ideograms are always used within a cultural group and in the framework of a strict formal system. Today ideograms are used, for example, in cartography to show streets or points of interest.

- **Rebus**:
  Rebus spelling is based on the existence of **homonyms**. These are words that sound the same or are linguistically identical to the characters for which they can be replaced. Today rebus spelling can be found, for example, in puzzles. The use of phonetic symbols evolved directly from a rebus type of spelling.



- **Phonograms**:
  Phonograms do not stand for concepts but represent only a specific articulation. Until the development of a complete **alphabet**, phonograms were often used together with the older pictograms, as in the case of Egyptian hieroglyphics.

Fig. 2.1 From pictograms to phonograms.

Excursus 1: The Development of Language

The pictorial representation is older than language, which is on a higher level of abstraction. In the evolutionary process intuition and imagination come before understanding and reporting. People can communicate with each other through language, unlike other creatures. Culturally speaking, it is in fact **language** that has an exceptional meaning for human communication. Language is not only a means of mutual understanding, but also promotes the development of standards and the handing down of values and culture. Language is therefore seen as a prerequisite for any kind of cultural development. The formation of communities and the emergence of a network of cultural relationships within these communities is based on the verbal communication of its members. Since ancient times language has been considered the ultimate "conditio humana" – the thing that distinguishes humans from animals.

As to the origins of language, we have to rely largely on guesswork. Even languages that might be seen as primitive from a linguistic point of view possess a complex set of rules based on syntax and semantics. They have already reached an advanced stage of development considering the huge span of human evolution. Our whole thought process and every thought transfer uses the tool of language. The human, according to *Johann Gottfried Herder* (1744–1803), is a "Sprachgeschöpf"(product of language). Language serves as a means of opening up the world. A person expresses the objects he or she perceives in concepts and signs and in this way is able to explain the world.

The origins of language remain hidden in the darkness of early human history. Only since the invention of writing (see Chap. 2.1) is it possible at all to conserve language and thus to obtain insight into its evolution. But precisely for this reason there is no lack of hypotheses about the history of language.

Anatomists attempt to determine the existence of the speech center in the brain using casts of the fossilized remains of the inside of the skull with its impression of the long decayed cerebral cortex. By comparing the different areas of the brain in humans and in primates, neurobiologists seek to discover clues to the language ability of our ancestors, while linguists attempt to reconstruct a "protolanguage" of all languages and language families known today.

Paleoanthropologists are split on the issue of the **origin of language**. One faction views language as a very old feature of the history of human evolution, believing it to have been developed over a million years ago. The second group holds that language is a young phenomenon that came into existence about 100,000 years ago in a sudden "creative explosion." Based on anatomic prerequisites necessary for the development of a phonetic language, many scientists see a parallel between language evolution, early technological developments (the use of tools) and human social development. The production of complex tools involves the planning and organization of work processes as well as a visualization of the finished product. The transfer of such techniques, with their increasing complexity, requires verbal instruction – for planning the production processes – besides simply imitating (see also Fig. 2.2). Language demands the highest effort from the brain and vocal apparatus. Variation-rich combinations of basic sounds must be created and understood in milliseconds. The exact wording of what has been said generally remains in our memory for only for a short time.

The search for the origins of language begs the question of the first, commonly spoken protolanguage. Through a linguistic comparison of living languages based on similar grammatical characteristics and constructions, it is possible to recognize similarities suggesting a common historical origin. Step by step it has been possible to develop a kind of tree model. Just as with the genealogical tree model, it is possible to draw conclusions about migration and propagation patterns.

Today there are more than 6000 different living languages worldwide, which can be assigned to the approximately 20 largest language families. Their distribution throughout the individual continents is however quite heterogeneous. This means that, in the meantime, about 12% of the 6 billion people who live in Europe speak only 3% of all languages. Sixty percent of the world's population lives in Asia, with about a third of all languages spoken there. In contrast, only about 1% of the world's inhabitants live on the Pacific Islands, but almost 20% of all languages are spoken there. Mandarin Chinese is spoken by nearly a billion people. In Europe a single language is spoken by about three million people, whereas the 850 languages in New Guinea are spoken by an average of only 4,000 people. Half of all languages today have little more than 50 speakers and are therefore threatened with extinction. The majority of linguists now believe that the human ability to speak in any form is not really learned but acquired instinctively. Every healthy child has the ability to learn his native language perfectly at a breathtakingly fast pace – regardless of social environment or intelligence. As an adult, a comparable performance in learning a foreign language is impossible in terms of speed, perfection and apparent ease.

Further reading:

Crystal, D.: Dictionary of Linguistics and Phonetics, John Wiley & Sons, Hoboken, NJ, USA (2011).

Cavalli-Sforza, L., Menozzi, P., Piazza, A.: History And Geography Of Human Genes, Princeton University Press, Princeton, NJ, USA (1994).

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Theories About the Origin of language

Miracle theory: God created language and gave it to humankind. This occurred either instantaneously at the moment of creation or afterwards following a certain period without language. Evaluating this theory is a religious issue.

Invention theory: Humans invented language. Language proved to necessary at some point in time and consequently the first language was devised. The problem with this theory is its self-reference: the essential condition for the invention of language is that a person can already speak.

Imitation theory: Humans imitated noises in their environment (e.g., the barking of a dog, the sound of the wind, etc.) in naming the object connected with the sound. This type of linguistic rendition of sounds has been retained in our vocabulary up to today. These constructions are called **onomatopoeia**. Yet onomatopoeia differs considerably from language to language even when referring to the same object. Moreover, it does not explain the phonetic inventory of our vocabulary.

Natural sound theory: Humans produced spontaneous exclamations or **interjections**. These formed the starting point for the meaningful creations of sound. An argument against this theory – just as with the onomatopoetic imitation theory – is that interjections differ greatly from language to language.

Reaction theory: An imitative reaction expressed as an utterance in response to environmental stimuli. In this way the word "mama," for example, could be traced back to the movement of an infant's lips prior to nursing. The argument against this theory is the same as in the natural sound theory.

Contact theory: Language is based on the general need for reassurance. The need for contact automatically led to voiced declarations of affection or common song.

Work and tool-making theory: Language arose from rhythmic vocalizations during the course of collective labor (common folk variation). Tool-making and tool use require a division of labor and a transfer of skills and, consequently, language as well. The development of tools cannot be separated from the development of language.

None of the above-named theories has succeeded in convincing linguists and anthropologists completely. However, when the reaction, contact and tool-making theories are combined it is possible to create a coherent, overall picture to some degree. From this, a possible scenario for the evolution of language may be derived.

Further reading:

Deutscher, G.: The Unfolding of Language: The Evolution of Mankind‘s greatest Invention, Henry Holt and Company, New York (NY), USA (2006).

Fig. 2.2 Theories about the origin of language.

The divergent development of symbols and characters can be understood as an increasingly linear arrangement in accordance with the drawing materials implemented. The reason for this evolution stems from the necessity of carrying out and retaining mathematical calculations that were crucial for the administration of developing societies. While the icon could generally be read by everyone, the written character was separate from the collective memory and could only be understood by those who had mastered the art of reading and writing.
The birthplace of the culture of writing is considered to be the ancient Near East in Mesopotamia, the land between the Euphrates and Tigris rivers. While recent discoveries indicate the existence of even older testimonies of writing, such as from the ancient European Danube culture in the 6th millennium BC, the invention of the **cuneiform** in Mesopotamia around 3500 BC is considered the most important breakthrough in the development of writing. The cuneiform is thought to be the earliest complete writing system, developed by the Sumerian people who had lived in Southern Mesopotamia since the beginning of the 4th millennium BC. At first they used a purely pictographic script (pictogram), but by 3000 BC it had already been transformed into completely abstract forms through extensive phonetization. In the 4th millennium BC, the first city-states appeared in Mesopotamia. With its sacral monarchy and tightly organized and hierarchical temple bureaucracy, the Mesopotamian culture was strictly separated from others. Writing, which was initially implemented in temple administration, quickly became popular as an effective instrument in the area of taxation. It would however be a mistake to assume that in ancient cultures the knowledge and practice of writing was open to the masses as it is today. In all archaic cultures, writing was initially only available to the elite and used exclusively for special purposes, such as in rituals and the sphere of religion (see Fig. 2.3) [37].

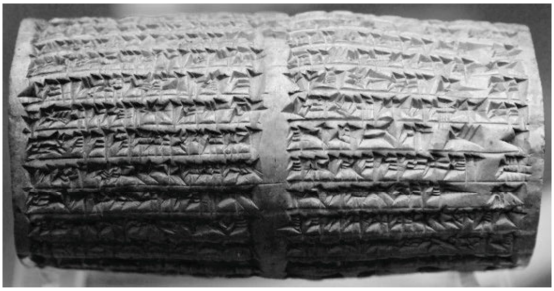


Fig. 2.3 Sumerian cuneiform cylinder with an inscription of King Nabonidus from Ur, 555 – 539 BC.

Around 2700 BC, the Akkadians penetrated the territory of the Sumerians, subsequently adopting the word and syllabic writing into their own semitic language. The wedge-shaped characters grouped vertically, horizontally and diagonally resulted in a new script. The cuneiform script, further developed and transformed by the Assyrians and Babylonians, quickly spread and became the writing for traffic in the entire ancient Orient. Just as quickly, the functional spectrum of writing developed. Writing now became focused on practical purposes. These included purchasing contracts and certificates as well as literary and scientific works. Starting in the eighth century BC, cuneiform writing was gradually replaced by other systems of writing such as the Greek or Phoenician phonetic spelling.Serving as writing material for the cuneiform were clay and stone tablets and, from 1000 BC on, wax tablets. Knowledge of the cuneiform writing system was later lost and it was not until 1802 that the German philologist *Georg Friedrich Grotefend* (1775–1853) took the first successful steps toward deciphering it.

Through a combination of pictures and characters it now became possible to fix other sensory impressions besides visual information. But even with the the introduction of phonetic writing, symbols hardly became superfluous. With their inherent powerful expression, they continue to also be used today whether in pictograms or advertising. The most remarkable feature of writing, however, lies in its ability to save and transfer language in uncorrupted form. The ancient Egyptian **hieroglyphics** (*hieros*=[Gk.]holy, *glyphein*=[Gk.]inscribe) passed through a similar development as the cuneiform. This pictographic writing consisting of syllables and single consonants can be traced back to 3000 BC. The script received its commonly known name "hieroglyphics" in ancient times from Greek visitors.

In their native language, the Egyptians called their script "*medu netjer*, "which translates roughly as "the words of God." Carved with a chisel in stone, the script initially adorned monuments, grave chambers and other mostly religious places of worship (see Fig. 2.4). Hieroglyphics were written on vessels or on the surfaces of walls with a brush and with a reed pen on trade documents composed of papyrus rolls. From the characters first used for purely ritualistic purposes developed a simplified, easier to write script that was independently used in profane writing from about 2500 BC. The hieroglyphics themselves were not subject to any kind of changes over the millennia because the Egyptians considered them sacred. They remained in use up to the fourth century AD until Greek writing, which had already been introduced in Egypt in the second century BC, evolved into Demotic and Coptic writing. In the Roman empire, knowledge of the hieroglyphics was lost. First

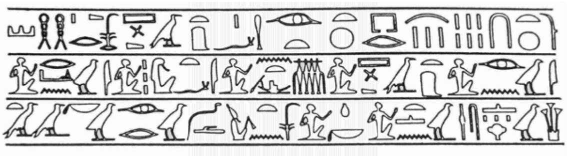


Fig. 2.4 Ancient Egyptian hieroglyphic writing.

with the discovery of the famous Rosetta Stone (1799) in Egypt by *Napoleon Bonaparte's* (1769–1821) expeditionary forces did it became possible for the

French Egyptologist, *Jean Francois Champolion* (1790–1832) to decipher the hieroglyphics in 1822.

It was mainly the **Greek alphabet**, whose original form dates back to the Phoenicians, that decisively shaped our western intellectual culture. The **Latin alphabet** succeeded it and continues to be used today, albeit in a slightly expanded and modified form. The first evidence of this phonetic alphabet can be found in inscriptions on clay pottery fragments and bronze statuettes from the eighth century BC. The addition of vowels to the Phoenician characters, which consisted of 22 consonants, was the decisive step in the development of the Greek script. Vowels already existed in the Mesopotamian cuneiform script, or in the Mycenaean-Minoan "Linear B" script , but the Greeks were the first to make a clear distinction between vowels and "pure" consonants. This meant that reading – which amounts to decoding the written message – was made dramatically easier. The reader can rely on a strictly linear sequence of characters and this allows an unambiguous reproduction of the vocalizations. A rich literary culture flourished with the Greek script from the fifth century BC on. It was inherited by the West and has survived to a large degree until today (see Fig. 2.5).

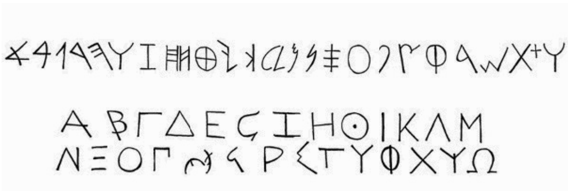


Fig. 2.5 Phoenician and ancient Greek script.

Beyond the European cultural heritage, and independent of it, an early writing culture also developed in Asia. The earliest evidence of Chinese script appears around the time of 1400 BC. This script of the Shang Dynasty has mainly been found carved on so-called **oracle bones** and served primarily in rituals and ceremonies. Both tortoise plastrons and the flat side of an ox scapula served as oracle bones. Used for predicting the future, they were heated with a red hot bronze pin until cracks appeared in the bone material. These cracks were then read by a diviner. In addition to questions and answers, an interpretation of the cracks and fissures was written on the oracle bones.

A great obstacle along the evolutionary path of writing was the much later development and structural design of **grammar**. Grammar as the rules and science of language originated in about the sixth century BC in the Indo-European areas of India and in Greece. Both developments were independent of each other.The first scientific study of language and therefore the oldest surviving grammar can be traced back to the Indian grammarian *Panini*. His work of grammar, the "*Ashtadhyayi*" (=[Sanskrit] eight books of grammatical rules), was composed in the fifth century BC. It contains more than 4000 rules about word formation in Sanskrit in addition to exact phonetic descriptions.

In the Greek culture it was *Plato* (427–348 BC) who was the first to report on the origin of language in his dialogue, "*Cratylus, or On the Correctness of Words.*" The focus of his discussion was on the essence of words themselves and their meaning.Since the Middle Ages grammar has numbered among the seven liberal arts (grammar, rhetoric, dialectic, arithmetic, geometry, astronomy and music). This late development of grammar, as a structural regulator of language, in contrast to the historical darkness shrouding the origin of speech can be viewed with an analogy from technology. A great void stretches between the creation of modern technology at the time of the Industrial Revolution, in the eighteenth and nineteenth centuries, and the emergence of an internationally regulated norm. This time period extends up to the middle of the twentieth century. It was then that a suitable standardization committee was formed in 1946: the ISO (International Standardization Organization).
As only a few people could read and write initially, books and scrolls were available to just a limited group of people for more than a thousand years. In Christian cultures this was the clergy and later the higher nobility. The act of spontaneously capturing one's thoughts in writing or looking something up in a book on the spur of the moment was strictly reserved for a select few. Writing was a long way from being a mass medium. The development of writing as a new medium had a huge effect society and was accordingly also the subject of criticism. For example, in the following story from his dialogue with *Socrates* (470 – 399 BC), "*The Phaedrus*," the Greek philosopher *Plato*, who himself left no written records behind, gives a vehement critique of writing.

> *Thamus, the king of Egypt, had been imparted by the god Thoth with all the scientific disciples, including the art of writing. This made it possible for people to preserve their thoughts, which they would otherwise have quickly forgotten. But the pharaoh (alias Socrates) was anything but happy. Memory, said the pharaoh, is a wonderful gift, but it can only can survive when it is constantly exercised. With the new invention, people no longer need to use their memory. From now on instead of exerting themselves they only serve the new invention. Writing is therefore very dangerous for it exchanges a memory carved in stone with a weakening of the mind's strength* [185].

Therefore, according to Plato, those who make a written notation are simply too lazy to use their own memory. This complaint against writing, which ironically is only known to us today because it was written down by Plato's pupil Socrates, reminds us in an amazingly similar way of the complaints by modern media critics about television causing human talents to atrophy.
Of course we know today that books don't think independently nor do they make decisions without us. On the contrary, rather then dulling the human spirit books challenge it to strive toward ever greater perfection.But the Socratic warning of not placing too much trust in the written word seemed to ring true all too soon in 48 BC. It was at this time that the library of Alexandria (see also Fig. 2.6), was destroyed in a devastating fire during the wars led by *Gaius Julius Caesar* (100 – 44 BC). The library's size was estimated

at 700,000 scrolls, making it the largest library in the ancient world. When these works were lost a large part of the collected knowledge of that time was gone forever. The little that remained was destroyed by Christian zealots in the early days of Christianity. Practically the entire cumulative knowledge of antiquity vanished and the long period of the “Dark Ages“ began.

2.2 First Communication Network

The variety of materials used to pass on information in written form seems unlimited in the course of nearly 70,000 years of writing history. Besides inorganic materials, such as stone, clay, metal or even plastic, a large number of organic materials have also been put to use. These include bone, shell, wood, leather, palm leaves, papyrus, paper or textiles. Witnesses of the oldest traces of human culture are found on stone, whether carved, chiseled, or painted. The first evidence of written characters also appears in fired **clay tablets** and in tiles of fired clay. Once fired, the clay tablets were also protected from forgery to a large degree. Unlike the early writing materials of papyrus or parchment, such tablets were resistant to destruction by fire. In fact, some archaeologists even believe that the majority of preserved clay tablets were burned unintentionally in a fire rather than being fired in a kiln. An added benefit of such material was its exceedingly cheap production .
As the preservation of writing evolved into a more permanent state, so did the difficulties of sharing and transporting this information across great distances. Despite the durable nature of rock drawings, cave paintings and rock carvings, their messages could only be transferred indirectly via the often unreliable memory of the viewer. The transport of inscribed stone, clay or later wax tablets turned out to be easier, but also in this case the size of the transferred message was strictly limited. The first step toward a flexible and easy to transport information carrier was made by the Egyptians with the development of **papyrus**. This writing material was made out of the pith of marsh grass plant *Cyperus papyrus* and its production method was a long held secret.The Egyptians developed a black ink for writing that was composed of soot and a gum arabic solution and applied with a brush made of rushes.
In about the third century BC, **parchment** is mentioned as a writing material for the first time in ancient Greece. The raw material used for parchment was hides cured in a lye solution. The hides were cleaned by scraping off any remnants of flesh and hair and finally stretched on frames to dry. In contrast to papyrus, parchment could be written on from both sides and mistakes corrected by rescraping. While expensive to produce, unlike papyrus, parchment was especially durable and resistant in hot, humid climates. It consequently developed into the most important writing material in the ancient world.

The Library – Its Mission and History

The concept of the "**library**" was mentioned for the first time by the Greek comic poet *Cratinus* (520 – 423 BC) and refers to a collection of writings. The Middles Ages refined the the concept to mean a collection of books and furthermore as the building housing the collection. In contrast to an "archive,"whose main focus is the documentation of writings of a political and economic nature, the task of libraries today can be divided into three areas: acquiring books and written documents, archiving and cataloging book collections (whose verification proceeds via a bibliography) as well as facilitating accessibility to the book collection for the purpose of education and information dissemination.

In Egypt, Pharaoh *Ramses II* (approx. 1290 – 1224 BC) had one of the first libraries set up as part of his tomb in around 1250 BC. Allegedly, it contained about 20,000 scrolls. The library of the Assyrian king *Assurbanipal* (approx. 669 – 627 BC), which was started in around 650 BC, is considered the oldest library in world history. Located in Nineveh, it contained over 20,000 clay tablets. Each clay tablet from the library bore the king's insignia of ownership and an army of scribes was hired by the king to make copies of Assyrian, Sumerian and Akkadian texts.

The most important book collection of antiquity is considered to the **Great Library of Alexandria**. Various sources estimate the collected inventory at between 400,000 and 700,000 scrolls. Given the task of collecting all of the writings of the world at that time, it was a central meeting place for researchers and scholars. Affiliated with the great library was the "museion,", a unique research institute dedicated to the muses, where scientists and their students found an ideal place to discuss and immerse themselves in the knowledge of the time. It is all the more tragic for us today that the library was destroyed and its vast collection of writings lost. The actual events of the destruction remain a source of argument up to today. Ancient sources speak about a fire during Caesar's conquest of Alexandria in 48 BC. Further Roman attacks on Alexandria followed in the third century under Emperor *Aurelian* (214 – 275 AD). In the course of these attacks the buildings of the library were gradually destroyed.

Afterwards, a branch of the library, was relocated further inside the city in the so-called "Serapeum." Approximately 40,000 scrolls were stored in this temple. On orders of the Christian emperor *Theodosius I* (346 – 395 AD), *Theophilus* (†412), the patriarch of Alexandria had all pagan temples destroyed, including the Serapeum. And thus an almost 700 year period of library history came to an end. When Alexandria was conquered by the Arabs under Caliph *Omar of Damascus* (592 – 644) the library no longer existed. Widespread versions of Arab destruction were propagated during the medieval crusades.

The Great Library of Alexandria is thought to be the precursor of the modern **National Library**, which had its beginnings in 1536 with the "Bibliothèque du Roi." This library was established by the French king *Francis I* (1494 – 1547). All booksellers were ordered by decree to deliver a mandatory copy of each work published in France to the library of the king. Even today national libraries, in their function as a central state library, have the right to a mandatory copy of each book published in order to archive and catalog all the books of a country.

Further reading:

Michael H. Harris: History of Libraries of the Western World, Scarecrow Press, Lanham, MD (1991).

Fig. 2.6 A brief history of the library.

The decisive step in the evolution of writing materials – up to the point where they became a cheap, simple medium that could be produced in large quantities – was bridged by the Chinese with the invention of **paper.** This event occurred in about 105 AD at the time of the eastern Han Dynasty. In the year 794 the first paper mill in the Arabic world began its operation Thus paper reached Egypt at the end of the eighth century and quickly pushed out papyrus, which had been used for thousands of years. The Arabs carefully guarded the secret of paper production for almost five centuries. They carried on a busy paper trade and via Spain, which was under Arab occupation, western Europeans were soon introduced to paper. The key role of the Islamic culture in the production and distribution of paper can for example still be seen in the Arabic word derivation "ream." A ream of paper means a quantity of 500 identical sheets of paper. The first paper mills in Europe were founded 1144 in Valencia, Spain and 1276 in the city of Fabriano, Italy. In Germany a water-powered mill began operation at a rail mill on the Pegnitz River in 1390. Just 200 years later there were 190 paper mills operating in Germany alone. They were usually located near a flowing water source as paper production required enormous amounts of water. Water power also served as an ideal source of energy.

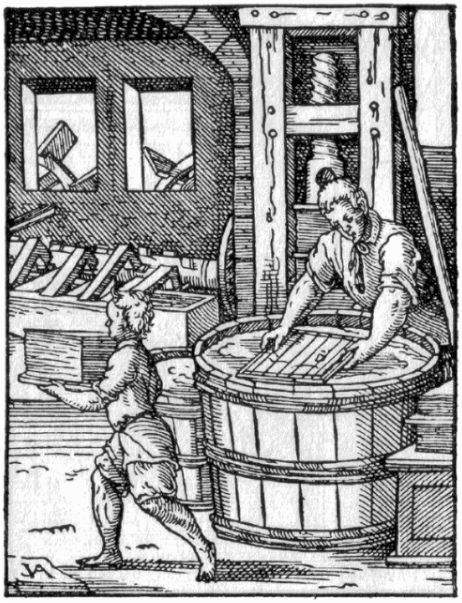


Fig. 2.7 "The Papermaker,"(woodcut by Jost Amman, 1568). [6]

Easily transportable information carriers were indispensable for reliable communication across great distances. The disadvantages of a memorized oral message carried by a messenger are obvious: slow transmission speed, short range and a lack of reliability concerning the message transmitted. Additionally, it took a long time for the answer to a message to return – if one ever came back at all. Misunderstandings and mistakes in interpreting the message, such as we know ourselves, were the order of the day.

The history of message transmission is a long and rich one. Already the Egyptians had used the Nile as the main channel of communication sending messages via boat passengers. The Egyptian pharaohs also used numerous foot messengers to keep in touch with their far-flung provinces. They had to be able to cover large distances in as short a time as possible. However nothing existed in the way of a functioning postal system as we know it today. First in the New Kingdom, from approx. 1500 BC onwards, were there official postal messengers in Egypt along with foot messengers and mounted postal messengers.

Besides acoustic telecommunications, for example in the form of relay chains of oral messengers such as in ancient Greece and Persia, drum telegraphy was also used. It remains today a form of communication among indigenous peoples. Having originated foremost in Africa, drum languages soon became widespread. The transmitted message is based on the rhythm and pitch of natural language syllables and "copied" in drum beats.

There is evidence of well-organized **relay messengers** as early as the fifth century BC in the Persian Empire and later also in the Roman Empire. Greek historian *Herodotus* (approx. 484 – 424 BC) reported that King *Cyrus II* (550 – 529 BC Chr.) had his own postal stations set up at regular intervals along the most important traffic routes of the Persian Empire. They were each located about a day's journey from one another by horse, and also served as intermediate rest stations for the messengers. In ancient Greece itself, there were initially no postal system due to the many and often warring city-states. However, foot messengers did exist; the so-called *hemerodrom*. Because of the terrain in Greece they often proved to be even faster than mounted messengers. The most famous of these messengers is *Pheidippides.* In 490 BC, he is said to have traveled the distance from Athens to Sparta (about 240 km) in two days to deliver news of the Battle of Marathon.

The Roman Empire used the *cursus publicus.* This messenger service, operated by means of mounted relay, stretched along the roads of the Roman Empire from Britain to North Africa and from Spain to Arabia and the Black Sea. It is often regarded as the prototype of today's postal service. At the time of its greatest expansion the cursus publicus had a road network of over 90,000 km. On these roads there were stations set at intervals of between 7 and 14 kilometers where mounted messengers could change horses,. This institutionalized messenger service, established under Emperor *Augustus* (31 BC – 14 AD) in the year 15 BC, offered a communication infrastructure only for the ruling elite in the service of public administration and the military.When the Roman Empire declined in the turmoil of the period of migration, this precursor to the postal system gradually fell apart until it came to a complete standstill in the sixth century. For private mail it was necessary to choose another means of transport in the Roman Empire. One way was transporting

mail via traveling friends or acquaintances. If only short distances had to be bridged, Romans sent slaves who were especially assigned to this duty and could cover distances of up to 75 km per day.
The regular conveyance of messages was inseparable with the expanding traffic and transport systems. Without traffic there was no flow of messages and with traffic there was not only the need to exchange goods over great distances but also the latest news. Even before the Roman Empire's massive road network system in the European Bronze Age, the so-called Amber Road existed between Italy and Denmark via Austria. In China caravans transported precious goods along the route of the Silk Road, from China's Middle Kingdom to the West.
During the Middle Ages a number of different, and often socially anchored **courier systems** existed: monastery couriers, couriers of the Teutonic Order, merchants, city and university messengers and, unique to the area of southern Germany, the so-called butcher couriers. The butcher's trade made it necessary to travel across the country from cattle market to cattle market. Therefore, transporting letters on the journey was not only natural but also a brilliant business idea. These more or less organized courier services existed either as a one-man operation or as a relay system conveying letters as well as memorized messages. The postal route led through already existing commercial and and political paths of connection. Monastery messengers maintained a communication link between individual abbeys and Rome. The couriers were usually monks who took messages along with them on their travels.
Homing pigeons, which had already been domesticated by the Egyptians five thousand years ago, must also be mentioned here. Their airworthiness (average flight speed of around sixty kmph, with a top speed of up to 120 kmph and a range of up to one thousand km) and excellent sense of direction were responsible for ensuring their place early in the transportation of messages. Because of the iron minerals in their beak, pigeons can orient themselves using the earth's magnetic field and therefore determine their geographical position. In Egypt and other Middle Eastern countries they were introduced as early as 1000 BC, and the Greeks and Romans also kept pigeons for information delivery. *Nur-Ed Din* (1118–1174), emir of Damascus, was the first to establish and develop a carrier pigeon messenger service for state purposes. This means of communication helped him to administer the long embattled empire of Egypt and further to the Iranian highlands.Carrier pigeons were first used in Europe starting in the sixteenth century. They had a fixed place as an important communication medium until the advent of the telegraph. According to one legend, the London banker *Nathan Mayer Rothschild* (1777 – 1836) is said to have received the news of Napoleon's defeat at Waterloo via a carrier pigeon. Aided by this message, it was possible for Rothschild to make a considerable profit at the London Stock Exchange and to thus lay the cornerstone for his fortune.The news agency Reuters used carrier pigeons to communicate stock market quotes between Brussels, Aachen and Cologne

until 1851. The Swiss Army also maintained their own carrier pigeon service until 1997.
The first **modern postal service** was established in 1490 by King *Maximilian I* (1459 -1519) between his court in Innsbruck and the Burgundian Netherlands in Mechelen. It was administered by the Thurn and Taxis (formerly spelled Thassis) family. Maximilian was motivated by the need to manage his widely scattered dominions in Tyrol and Styria. He also sought to manage the territory in modern-day Belgium gained through his 1477 marriage to Maria, the daughter and heiress of Charles the Bold of Burgundy. Already in the 15th century numerous members of the Lombard lineage, from Bergamo in Upper Italy, there had been occupied in the papal courier service. As early as 1451, Roger de Thassis was commissioned by Friedrich III to set up a postal service via intermediate stations in Tyrol and Styria for the army and administration.
When Maximilian's son Philip became the king of Castile in 1504, the postal route, installed under *Francis of Taxis* (1459 – 1517) extended to Spain. In the postal contract between Maximilian I and Francis of Taxis the transport times were laid down for the first time with variation depending on the season. Thus, the conveyance of a letter between Brussels and Toledo took 12 days in the summer and 14 days in the winter. A European-wide, fee-based message transport system quickly developed offering a regular and reliable service. It became available for private mail as early as the beginning of the sixteenth century. The tightly organized changing of rider and horse at specially set up stations made it possible to have a daily postal route averaging around 166 km. From the travel report of the Venetian merchant's son *Marco Polo* (1254 – 1324) it is known that China had an excellently structured postal system as early as the thirteenth century. A well-organized system of hostels and stables was maintained for mounted couriers along the main roads of the Chinese Dynasty. It is said to have been comprised of nearly 1, .000 stations. Emperor *Rudolf II of Habsburg* (1552–1612) placed the German postal system under a status of imperial sovereignty in 1597. Its exclusive use was based on the hereditary vassal relationship transferred to the Taxis family. The family was elevated to the status of count of the imperial state in 1615. The post virtually became nationalized and this ultimately meant that the general conveyance of mail was open to everyone. Over time, thanks to special inherited rights – the so-called privilege – the Thurn and Taxis postal service quickly developed into a kind of European state-wide service. By the end of the sixteenth century it already employed an army of around 20,000 couriers.The Thurn and Taxis family achieved a position of indispensability throughout the course of centuries. It was not until 1867 that they were forced to turn over their postal system to Prussia because of the fragmentation of the German Empire into many small states. Article 10 of the constitution of the North German Confederation, the basis for the German Empire, then ended the Thurn and Taxi postal service. Another form of mail transportation was carried out via waterways. The first postal service by ship in Europe

was established in England in 1633 for the carriage of mail between Dover and Calais, as well as to Dublin.

2.3 The Development of the Printing Press

While the establishment of modern postal systems enabled the transfer of messages over large distances, this was limited to individual messages between (one) sender and (one) receiver. In order to spread messages quickly and in large number a simpler way of duplication had to be found. Copying longer messages manually was bound by quantity and time limits. This changed dramatically with the development of the printing press. The history of printing can be traced back to ninth century China, with the oldest surviving print discovered in the Buddhist monk caves of Dunhuang, in western Chinese Turkestan. The print was made in 868, 100 years after books (now lost) had already been printed in Japan.
Wooden printing blocks exist dating back to sixth century China. These blocks were made by Buddhist priests who carved religious images in wood, colored them and used them to print on silk or rag paper. Wooden blocks or tablets served as stamps. This technique of the **woodcut** (xylography) is just one relief printing processes and is thought to be the oldest form of graphic printing. Hallmarks, stamps and seals are also considered to be much older predecessors of printing. Stamped impressions have been found on Mesopotamian clay tiles that date back to the third millennium BC. During the Chinese Tang Dynasty (615 – 906), the idea of printing entire books first came to fruition in the ninth century. Printing with movable clay letters can be traced back to the Chinese alchemist and printer *Bi Sheng* (†1052) who practiced his art in the years between 1041 and 1049. He came up with the idea of developing a set of standard font letters that could be produced in a series.
In the western world, the development of the **printing press** is often regarded as the crucial event leading people into a period of generally accessible information that could be distributed in mass quantities. The impact of this event cannot be underestimated. For people living then, particularly ecclesiastical and secular leaders, it was a great sensation to be able to duplicate information thousands of times over at lightning speed. The son of a merchant, *Johannes Gensfleisch zum Gutenberg* (1397 – 1468), was an ingenious goldsmith who lived at the court “zum Gutenberg“, in Mainz, Germany. With his invention of a casting method for movable type he succeeded in creating the required norm for a script. Gutenberg became familiar with so-called **block books** during his time as a book-copying scribe. These books were printed using the woodcut technique: both the text and illustration were cut into wooden blocks. The production of every single page required tremendous effort and for this reason was not superior to the traditional calligraphy

carried out by hundreds of writers. Gutenberg approached the problem of mechanically duplicating written works via printing techniques analytically. He realized that if a block could be broken down into into sufficiently small, individual elements, it would be possible to express what the human spirit could put into words using the 24 known Latin letters and a few punctuation marks. Gutenberg's revolutionary solution to the printing problem involved making a large number of the same stamps for each character, with the necessary low error tolerance. After one printing they could then repeatedly be used for other printings in a different order. Gutenberg succeeded in mechanically producing texts in identical form and – in comparison with the number of handwritten copies – in huge numbers. The first mass medium was born.

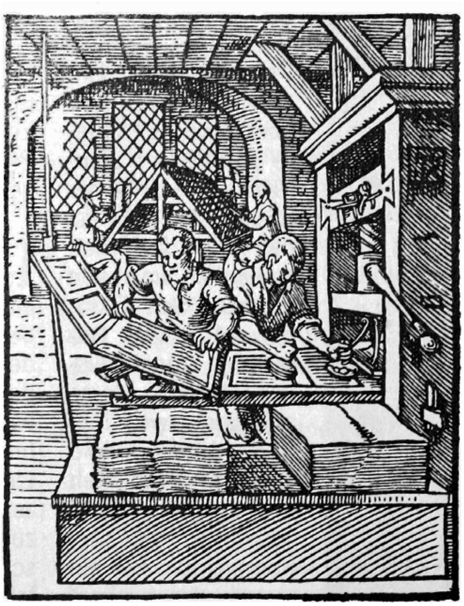


Fig. 2.8 "The Printer,"(woodcut by Jost Amman, 1568), [6]

Gutenberg succeeded in casting his first printing type in 1445. It was made of an alloy of lead, antimony and tin, with the addition of bismuth for pouring. As no type from Gutenberg's time has survived, the exact mixture remains unknown. The target mixture distinguishes itself through its fast hardening properties. This made the rapid production of uniform type possible. Gutenburg's casting instrument was able to produce up to 100 letters of uniform type in one hour. The first printed document attributed to him was produced at the same time: a poem about the Last Judgement, written in German in 1360 and based on a Sibylline Book from Thuringia. Only a small fragment of it still survives. His first prestigious printed work – the one that has made him famous until today – is the forty-two line Latin Bible. It was produced in the years 1452 – 1456 in a print run of 185 copies. Of these, 49 copies still exist today, when also only as fragments[1]. Although the Gutenberg Bible can be considered the first mass-produced item of printing technology, it was anything but a cheaply produced and mass-distributed print product. With the production of his superbly printed Bible, Gutenberg's aim was to outdo the craftsmanship skills of calligraphers and copyists. He not only wanted to produce first-rate books but also to deliver them in a consistent quality. Every one of his Bibles consisted of two volumes, each with 648 and 643 pages. Approximately, thirty of the copies were printed on parchment.If Gutenberg had decided to print the entire circulation on parchment, the skins of up to 50,000 calves would have been necessary. In 1450, German paper mills were still not capable of producing the amount of paper needed, therefore the lion's share was imported from Italy. While Gutenberg did not invent the art of printing – and for the present-day viewer his Bible can barely be distinguished from other manuscripts of the time – through a combination of the then known techniques and the masterful engineering of his innovative casting method, he became the founder of a new industry.

Before the invention of printing, text duplication meant tedious manual labor. For the most part it was performed by monks in monasteries. Their painstaking work in the preservation and reverse translation of antique manuscripts should not be underestimated. Students and teachers needed enormous amounts of time to transcribe texts – undoubtedly a reason why the progress of science was very slow during this period. In cities with universities, a regular writing industry developed. At the University of Angers, scribes in the fifteenth century were capable of making copies of lectures in a month's time at relatively low prices. Sometimes it was even possible to complete these manuscripts before the start of the next lectures. At the time Gutenberg was attempting to produce his first typographical work, there were forty professional scribes in his hometown of Mainz alone and additionally those transcribers who were monks or students. While medieval monks needed at least a year for the handwritten copy of a book, Gutenberg could print up to 300 pages per day with his innovative technology .

Even if Gutenberg's role could be better described as a skilled technician than a creative genius, his invention of the movable-type printing press heralded a new age in the entire Western world. Whereas before 1456 there had been approximately 5000 handwritten books on the worldwide market, fifty years later there were nearly 10 million printed copies. Although only a minority of the population could read, the more books entered the market the more the interest in reading grew. The use of writing became part of the public domain thanks to Gutenberg's printing press. Gutenberg himself was however unable to capitalize on his development. He died in 1468, blind and bankrupted by a lawsuit against his financier Mainz banker, *Johannes Fust* (1400–1466). Furst demanded return of the money he had lent the inventor, which finally led to

[1] In 1987 one of these books sold for the price of 9.75 million German marks (approx. five million euros), the highest price ever paid for a printed work.

the confiscation of Gutenberg's printing house including the rights to all of his works.

The newly-developed printing technology was being used for political purposes early on. In 1455 the so-called Turkish Calendar ("*A Warning to Christendom Against the Turks*") appeared in which a crusade was called against the Turks who had conquered Constantinople a short time before. The Catholic Church used the new technology for the high-volume publication of **indulgences**. The sale of these documents improved the finances of the Church in the 15th century. In exchange for a fee an indulgence (forgiveness) was granted for a sin committed and verified with an official seal. This practice was one of the main points of criticism of the reformers – especially *Martin Luther* (1483–1546). The indulgence itself was printed in advance. Later, the sinner's name, the date and the signature of the indulgence seller were added by hand. This document was well-suited for mass distribution and reached a circulation of several thousand to over one hundred thousand.

The books printed in the 15th century – at the time the printing process was still in its infancy – are called **incunabula** (early printed works). The year 1500 is documented as the end of the incunabula for purely bibliographic reasons. It is assumed that at this time approximately 30,000 titles with a total publication of 9-10 million books were printed. Of these books about 500,000 survive until today. Because of the predominant use of Latin as the print language, this printed matter was accessible to a Europe-wide market, notwithstanding regional language borders. Besides pamphlets, also street ballads, church and secular calenders, political and inflammatory speeches as well as theological manuscripts were include among the first printed works.

The **Frankfurt Fair** developed as a hub for the new, printed products from Germany, France, Italy and the Netherlands. Mainly raw prints were sold, i.e., unbound, printed sheets of paper. These were transported and distributed by print workshops in barrels. The bookbinding and artistic design of the prints, including section headings and illumination, were dictated by the buyer. Initially, almost exclusively large-format folios were printed, intended for use in the Church liturgy or universities. A significant reduction in the size of the print format could first be seen at the beginning of 1480. Until this time it had been usual practice to add a colophon in hand-written manuscripts and printed works with the details of the scribe or printer as well as the place of printing. For practical reasons, this information and the book's title were moved to the front of the book, appearing there on a separate **title page**. The use of page numbers (**pagination**) also originated at this time as did the first printed advertising posters for the sale of books.

As a mass-produced media, the book had a tremendous influence on modernization in all areas of science, administration, education, religion and art. "Social knowledge" was put on paper, recorded and published to an extent that had never been witnessed before that time. In the beginning the new media was slow to catch on and it was only in the 16th century that the printing press fully emancipated itself from the prevailing culture of handwritten manuscripts. The technology then spread quickly and was known by some as the “black art“– a name that stemmed from the printer’s ink but also alluded to an underlying secret knowledge behind the method. As a new craft, the art of printing was not subject to the same limitations that traditional guilds were forced to comply with. Wandering journeyman printers could establish themselves wherever they desired. By the year 1500 there were already 300 printeries in 60 German cities and in Italy there were 150.

The printed book had just begun to inspire the mass spread of ideas when the fear arose of the widespread dissemination of unwelcome or even dangerous thoughts via the printed word. *Berthold von Henneberg* (1441–1504), archbishop and elector of Mainz, was the first German prince to impose a **censor**, with his edict of March 22, 1485, on all “books translated into Greek, Latin or another language“ into German. The aim was to prevent certain knowledge and opinions, until that time only discussed among scholars, from gaining a popular audience.

In addition, the bishop ordered the Frankfurt city council, together with church officials, to inspect all of the printed books at the spring fair and to prohibit works, if necessary. A translation of the Bible from Latin into the vernacular was also suppressed. Henneberg believed that the “the Order of the Holy Mass“ would be desecrated by its translation into the German vernacular. Pope *Leo X* (1475–1521) strengthened this ban in 1515 for fear of a rampant “spread of falsehoods about the faith.“ The fear that the Bible would be desecrated if it were available to the general public was coupled with apprehension of a threat to the sole supremacy of clerics to interpret the scriptures.

Because both church and state recognized the consequences of the fast and large-scale dissemination of printed matter, censorship soon became a commonplace practice. On one hand, **preventative censorship** called for a close examination of documents by censorship authorities prior to printing. On the other hand, **repressive censorship** focused on already printed documents, whose further dissemination was regulated by ban or confiscation. These practices were institutionalized in papal bulls by Pope *Innocent VIII* (1432–1492) and Pope *Alexander VI* (1430–1503). It was necessary that every book approved by the Catholic Church be given an **imprimatur** (=[Lat.] it may be printed) by church authorities. Violators were threatened with severe punishments including excommunication, extreme fines and even professional disbarment. The famous **Index librorum prohibitorum** – the blacklist of banned books – first appeared In 1559. It remained in existence until being officially lifted by the Second Vatican Council in 1967.

In the wake of the book’s development into a mass medium, cultural criticism was expressed early. The French poet *Victor Hugo* (1802–1885) called the art of printing “the greatest event in human history.“ Yet a scene in his novel “Notre Dame de Paris“ (or “The Hunchback of Notre-Dame“) describes the priest, Claude Frollo, as he points his finger at a book and then at the towers and paintings of his beloved cathedral and says: „Ceci tuera cela“, – the book

Table 2.1 Milestones in the History of Communication Media

30,000 BC	Cave paintings, first pictographs and proto-writing
3500 BC	Ancient Sumerian inscriptions on unfired clay tablets in Uruk
3200 BC	Cuneiform writing in Mesopotamia
3000 BC	Egyptians develop hieroglyphic writing
3000 BC	The abacus used as a calculating device in Babylon
3000 BC	Papyrus invented as a writing material in Egypt, becomes the forerunner of paper
1500 BC	Ugaritic (Phoenician) cuneiform writing with 27 main characters
1400 BC	Oracle bones provide first evidence of Chinese writing
1000 BC	Carrier pigeons used in Egypt and in the Middle East for message transport
9th c. BC	First record of Greek writing
ca. 650 BC	Assurbanipal founds the first large library in Ninive
6th c. BC	First recorded grammar in India and Greece
6th c. BC	Persian courier postal system established under King Cyrus II
6th c. BC	Darius I, king of Persia, sets up courier relay systems
5th c. BC	Telegraphy with arranged fire signals used in the Peloponnesian War
450 BC	Torch telegraphy used for message communication in Greece
3rd c. BC	Parchment invented as a writing material
288 BC	The Library of Alexandria established by Ptolemy II
1st c. BC	"Cursus publicus", relay courier service set up in the Roman Empire
63 BC	"Acta diurna", first newspaper in the Western World founded in Rome
105 AD	Paper invented by the Chinese
8th c.	Woodcut invented as the first printing method in China
794	First paper mill in Bagdad
1041	First print made with movable clay letters in China
12th c.	Nur-Ed-Din, emir of Damascus, sets up state postal service via carrier pigeon transport
ca. 1440	Johannes Gensfleisch zum Gutenberg develops the printing press with movable type
1455	First printed pamphlet for political propaganda
1485	First state-ordered book censorship enacted by Berthold von Henneberg, archbishop and elector of Mainz
1490	Maximilian I establishes the first modern postal service, administered by the Thurn and Taxis family
1502	The "Newe Zeitung", an early form of the present-day daily newspaper, is published
1536	Francis I founds the "Bibliotèque du Roi", predecessor of the modern national library
1571	First newspaper correspondent agency set up in Augsburg – the "Nouvellanten"
1633	First postal service by ship between Dover and Calais
1647	First European coffee house opens in Venice
1650	First regularly published daily newspaper in Leipzig
1710	Jakob Christof Le Blon develops four color printing
1764	Pierre Simon Fournier standardizes typography
1796	Aloys Sennefelder invents lithography, creating the foundation for modern offset printing

means the end of the cathedrals. The story takes place in the 15th century shortly after the invention of book printing. The ability to read manuscripts was the privilege of a small elite ruling class. The broad population only had the possibility to gain information and knowledge about Bible stories from the paintings and reliefs in churches and cathedrals, the so-called "pauper's Bible" (Biblia pauperum). In this way it was possible to learn about moral principles as well as history and geography.
Pope *Gregory II* (669–731), who settled the dispute about veneration of sacred images in the Catholic church on the basis of the quote from the Bible „Thou shalt not make unto thee any graven image" forbade Eastern Roman Emperor *Leo III* (685–741) in the year 726 any type of image-worship in his empire. He invented the ingenious compromise formulation: „The pictures are for the laity what the written word is for the literate". In contrast, the book would incite the masses to turn away from their most important virtues and possibly to interpret the Bible freely or to even develop more unhealthy curiosity.

2.4 The Birth of the Newspaper Industry

A prototype of the newspaper can be considered the ancient Roman annuals or yearbooks. The most important events to receive the publics' attention were recorded here by the head of the priest quorum – the pontifiex maximus. Before the time of Julius Caesar, the pontifex maximus was also responsible for the **calendar**. The calendar date, which today still remains the "first news" every newspaper presents, was relatively complicated to calculate at the time of the Julian calender. Because the lunar year shifted constantly according to to the season, the high priest needed to establish a certain number of additional so-called intercalary days. Upon the inauguration of Julius Caesar, in 63 BC in Rome, the so-called "*acta diurna*" or "*acta urbis*"– the first public gazettes – were created.
These forerunners of our modern newspaper were carved in stone or on metal plates long before the invention of paper. Caesar had the minutes of the Roman senate sessions taken in shorthand. Directly afterwards they were edited and then published on the same day. Originally, there were three such official journals: the senate acts (*acta senatus*), which were not available to the public prior to the time Caesar took office, the people's acts (*acta populi*) and the state acts (*acta urbana*). The acta urbana often had the additional designation *diurna* (daily), although its publication did not yet strictly occur on a daily basis. The official version of the news in the Roman Forum was presented to the public on a white message board and circulated throughout the whole of Rome and the provinces. This forerunner of the newspaper was published until the year 235 AD, although a strict periodicity was not maintained during this time.

The **newspaper industry** with its previously described beginnings in antiquity, had already established a niche in the sixteenth century even before the printing press came on the scene. Written newspapers existed in the form of hand-written notes containing the latest news added as an attachments to commercial and private letters. An example of these were the so-called "Fuggerzeitungen" (Fugger newspapers), established between 1568 and 1605 as a collection of hand-written news items. The Augsburg trading house Fugger had these news pieces compiled from their correspondences and other sources. Since the Fugger business had an extensive network throughout Europe and the world, it organized the first news service and were thus able to stay on top of political events. Jeremias Crasser and Jeremias Schiffle were professional news dealers, whose services were gladly used by the Fugger trading house. Together they founded the first newspaper correspondence office in Augsburg in 1571 and called themselves the "Nouvellanten". The trade with news as a commodity had already begun in the 14th century between Italian cities with Venice as the hub of news transmission. Correspondents and news dealers were mainly representatives in the areas of diplomacy/politics and business. In their reports they inserted special news letters containing general information. Event-focused, one page broadsheets called **leaflets**, which were politically or commercially motivated, appeared with the invention of the printing press. These leaflets usually served less the purpose of political agitation – in the sense of the modern-day protest leaflet – and more the announcement of merchandise offered by barkers and traveling merchants at fairs and outside church doors.

The leaflet authors remained anonymous most of the time. Large illustrations, usually produced as woodcuts, had a dominant place in leaflets. They were intended to motivate purchase as well as to make the content accessible to those who were not able to read. Besides political, religious or military news there were also stories that were pure sensationalism. These topics included exorcisms, comets, people with birth defects or heretics. The leaflet is considered the first means of mass communication. The irregularly published **pamphlet** is the direct predecessor of our daily newspaper. In contrast to a leaflet, a pamphlets consists of several printed pages.

The German word for newspaper, **Zeitung**, appeared at the beginning of the fourteenth century as "*zidunge*" and meant "customer" or "news." Used in the vicinity of Cologne, it describe oral and written messages. On December 4, 1501, the so-called "Newe Zeitung" appeared as the title of a transcribed and Germanized report from Doge *Leonhard Lauredan* (1459–1516). It quickly became the generic name for irregularly appearing published pamphlets and journals in the sixteenth and seventeenth centuries. The newspaper as a printed periodical containing the latest news first came into fashion at the beginning of the seventeenth century. One of these was the first German-language weekly newspaper called "Avisa, Relation oder Zeitung." It was printed in Wolfenbüttel in 1609. Since newspaper distribution was initially dependent on the available messenger and transportation services, it was

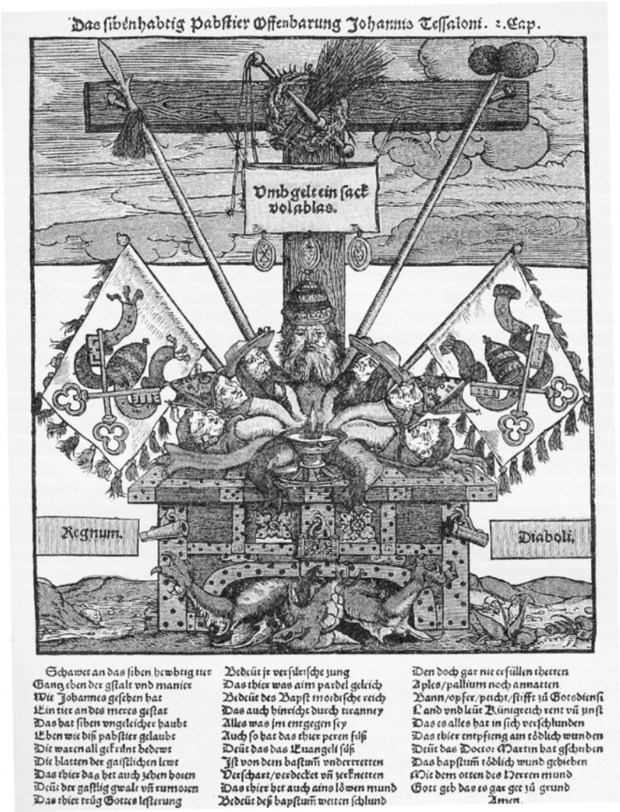
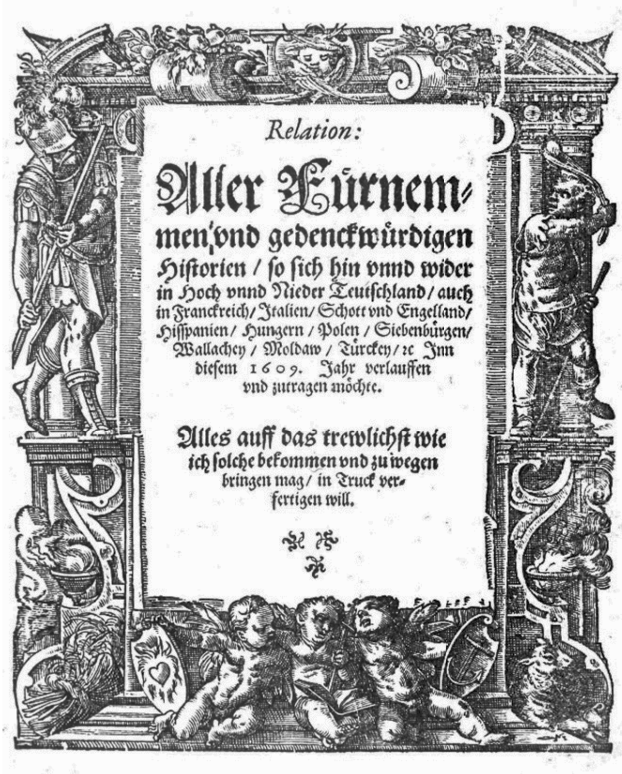


Fig. 2.9 Leaflet protesting the sale of indulgences (16th c.), from [194].

only available weekly. It is important to note that the beginnings of many newspapers ran parallel to the coffee house culture starting up at that time. This culture was rooted in the first European coffee house in 1847 Venice. Not only were coffee houses places where a cup of coffee could be enjoyed, but they were also havens for reading and discussion. Merchants did their business here, while intellectuals gathered to question old structures and superstitions For the just emerging editorial staff, coffee houses served as places to meet and exchange news.

On July 1, 1650, the first German-language daily newspaper was published and, simultaneously, the first daily newspaper worldwide in Leipzig. The six issues per week were edited by *Timotheus Ritzsch* (1614–1678) and the newspaper was entitled "*Neu-einlauffende Nachricht von Kriegs- und Welt-Händeln,*"(the latest news on actions in the world and in warfare). By the end of the seventeenth century there were already 170 daily newspapers in Germany alone. At first the daily newspaper was a marginal phenomenon. Before the nineteenth century its most interesting function was to provide the


Relation:
Aller Fürnem-
men/ vnd gedenckwürdigen
Historien / so sich hin vnnd wider
in Hoch vnnd Nieder Teutschland / auch
in Franckreich / Italien / Schott vnd Engelland /
Hispanien / Hungern / Polen / Siebenbürgen /
Wallachey / Moldaw / Türckey / ꝛc Inn
diesem 1609. Jahr verlauffen
vnd zutragen möchte.

Alles auff das trewlichst wie
ich solche bekommen vnd zu wegen
bringen mag / in Truck ver-
fertigen will.

Fig. 2.10 The title page of one of the first newspapers (*Relation aller Fürnemmen und gedenckwürdigen Historien*), 1609.

city's calender of events, as in the "*Daily Courant,*" which began its London publication in 1702.
The Thirty Years' War (1618–1648) threw Germany back economically and led England and France to establish themselves as pioneer countries of the press. The first magazines originated there. Initially, they were only targeted at scholars but later concentrated on specific subject areas and topics, such as those of interest to women. Huge print runs (up to 300,000) were reached with calendars, which remain up to today an important and low-risk source of income for many printing houses. The publication of the printed book reached ever-greater proportions. At the end of the sixteenth century, books in print had reached over 200 million copies.The mass press was born in the nineteenth century, buoyed by the further technical development of the printing press. The so-called rapid press was invented in 1812, the rotary press in 1845 and the modern Linotype typesetting machine in 1884. At the same time, the general public became more and more interested in getting information from the realms of politics and society. The state advertising mo-

nopoly was abolished and the sale of advertising provided a new, important source of income. As a consequence, the newspaper itself could be sold more cheaply, which in turn expanded distribution. The rate of literacy in Germany experienced parallel growth. At only 10%, in 1750, literacy rose to over 88% in 1871, and consequently the newspaper became interesting for a much larger audience. Press censorship relaxed in Germany and in 1848 the Paulskirchenverfassung (Paulskirche Constitution) legally established freedom of the press. There were approximately 3,500 newspapers in Germany at the end of the nineteenth century. Considered the oldest public mass medium, the press was the subject of intense cultural-critical debate, just as every new mass medium initially. The first criticism to be leveled in book form was not long in coming. In "Diskurs über den Gebrauch und Missbrauch von Nachrichten, die man Newe Zeitung nennt" (Discourse about the Use and Abuse of News that is Named the New Newspaper), published in Jena in 1679, a campaign was leveled against the "newspaper reading addiction." The pastime was characterized as a "vain, unnecessary, untimely and work disruptive" pursuit.

2.5 Telecommunication Systems and Electricity

2.5.1 Optical Telegraphy

Smoke and fire signals are considered the beginning of optical telecommunication. Used in antiquity, they could bridge a greater distance more easily than was possible with relay messengers. The technology of optical signal transmission by means of relay stations had already found widespread use in ancient Greece. In his tragedy "Agamemnon", the poet *Aeschylus* (525–456 BC) reported that the Greek commander sent news of the fall of Troy (1184 BC) to his wife by way of a fire signal message. The relay spanned 9 stations on the way to the 555 km distant Argos. From Greek historian *Thucydides* (460–399 BC) comes the first description detailing the use of previously arranged fire signals in the Peloponnesian War 431–404 BC. Whereas smoke signals do not allow freely formulated messages another type of messaging that did was described by the Greek historian *Polybius* (200–120 BC). He reported about the invention of torch telegraphy in 450 BC, which allowed messages to be formed using individual letters of the alphabet. Two telegraphers stood behind a large plate and positioned the torches corresponding to letters at specific places right or left next to the plate. The Romans set up signal towers and watch towers along their empire's border (e.g., along the Limes Germanicus from the Rhine to the Danube). From these points they could communicate with each other via fire signals. The Roman writer *Vegetius Renatus* (400 AD) described how movable beams were set on high towers to signal previously arranged messages based on the varying position of the beams. As the Roman Empire declined, optical telegraphy initially lost its importance, but, especially during the times of war in the Middle Ages, it was later rediscovered in all its variations. Optical telegraphy first achieved dramatic improvement in modern history.

Prompted by the beginning Industrial Revolution as well as the profound social changes taking place in Europe in the wake of the French Revolution, the heyday of optical telegraphy broke out at the end of the eighteenth century. The **telescope**, invented in 1608 by Dutch eyeglass maker *Jan Lipperhey* (ca. 1570–1618) played a decisive role in multiplying the optical range of human perception. Englishman *Robert Hooke* (1635–1703) presented his ideas for the transmission of “thoughts over great distances“ to the Royal Society in London in 1684. Hooke is also considered the inventor of the “string telephone,“ which however is purported to go back to the tenth century to Chinese philosopher *Kung-Foo Whing*. Hooke’s telecommunication idea involved transferring individual letters, by way of rope hoists, onto large engraved boards that were to be set up on a mast system near London. Using a relay chain of similar installations it was then planned to “telegraph“ all the way to Paris. The technical implementation of Hooke’s idea however proved ahead of its time.

French physicist *Claude Chappe* (1763–1805) was the first to succeed in inventing a practical application – amidst the turmoil of the French Revolution. Chappe’s invention was a signal transmission system with swiveling signal arms called a **semaphore** or an optical shutter telegraph and telescopes. The invention was based on the idea of deaf physicist *Guillaume Amontons* (1663–1705). In 1695, Amontons fastened and successively exchanged large pieces of cloth adorned with huge letters onto the ends of the long circular blades of a windmill in Belleville. Those in distant Meudon near Paris were able to read the letters with a telescope. British politician, inventor and writer, *Richard Lovell Edgeworth* (1744–1817) had already developed an optical telegraph in 1767 that was operated “privately“ between New Market and London. It was not until 30 years later, after Claude Chappe had already successfully presented and introduced his telegraph system in France, that Edgeworth offered his telegraph to the British Admiralty.

Claude Chappe presented his telegraph for the first time to the Legislative Assembly in March 1792. The invention consisted of a five meter high mast with a two-arm cross beam and swiveling beams fastened on both its ends. The Assembly immediately decided to build one of the first 70 km long test lines between Pelletier St. Fargau and St. Martin de Thetre. After a series of successful trials, in which Chappe could prove that his apparatus was sufficiently robust and simple to operate, the first regular telegraph line could be set up in 1794 between Paris and Lille. One letter of the alphabet could be sent the length of the test line – which was 270 km long and with 22 station houses – within 2 minutes. Impressed by this speed, and the potential for military utilization, it was quickly decided to expand the telegraph system throughout France. Chappe was given permission to use any tower or church steeple desired for his telegraph line and granted the authority to remove any obstacle in the way. *Napoleon Bonaparte* (1769–1821) used the system and transported a mobile version of it with him on his campaigns. In this way he was able to coordinate troop formation and logistics over greater distances more successfully than any other army.

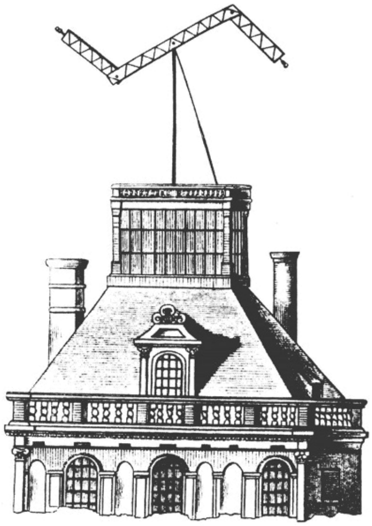


Fig. 2.11 A Chappe semaphore telegraph at the Louvre in Paris.

A disadvantage of the semaphore was that the signal poles could be seen by everyone and unauthorized people and spies could also read the military messages. This problem was resolved using encryption techniques. A country-wide star-formed network emanating from Paris existed until 1845. It connected the capital city with all other important cities in France. Depending on the terrain and visibility, the semaphores were located at intervals of nine to twelve kilometers so that the signals from the neighboring station could be unmistakably recognized. The two "telegraphists", who worked at each station, read the signals of one of the two neighboring stations and passed it on to the next station. Despite its advantages, the implementation possibilities of the optical telegraph were very limited. While one signal could be transmitted over a great distance very quickly – in 1834 a signal needed only 15 minutes for the 600 km long stretch between Berlin and Koblenz – the transmission of a complete text took a long time. The capacity of the described telegraph line was limited to two telegrams per day. On top of that, poor weather conditions were responsible for irregular and unreliable operations. These shortcomings, as well as the advent of the electric telegraph, led to giving up the last optical telegraph line in France in 1853.

2.5.2 Electric Telegraphy

The research and exploitation of electricity at the beginning of the eighteenth century had far-reaching consequences for the further development of telecommunications. Until that time the phenomenon of electricity was often viewed as a curiosity or discounted as a parlor trick. The Greek philosopher *Thales von Milet* (ca. 640–546 BC) had already recognized the magnetic effect of static electricity. He observed how a piece of amber attracted feathers when it was rubbed with a cloth. The Greek word for amber, *electron,* has been used since this time to describe the effects of electricity. Archaeological findings indicate that electricity was already being used to galvanize gilded metals in antiquity. But there was still a long way to go before electricity could be practically utilized.

Only in 1730 was the British physicist *Stephen Gray* (1666–1736) able to prove that electricity could propagate along a wire. The vision of electrical message transmission was born. With the help of conductive materials, greater distances were soon being bridged. An early form of the modern battery, the 1745 Leyden jar, was developed by Dutch physicist *Petrus van Musschenbroek* (1692–1761) Musschenbroek's invention allowed the possibility of storing electricity. In a letter published in Scots Magazine in 1753 and signed "C. M.", the writer proposed for the first time an apparatus for the electrical transmission of messages consisting of wires that corresponded to the twenty six of the letters of the alphabet[2]

However, a truly reliable and continuous supply of electricity was still missing for a practical implementation of this new means of electric communication. First in 1800 the Italian physicist *Alessandro Volta* (1745–1827), developed the first constant source of electricity, which was named the voltaic pile in his honor. Even with this source of electricity it took another twenty years before the Danish chemist *Christian Oerstedt* (1777–1851) discovered the effects of electromagnetism. This led to the development of the first **electromagnetic needle telegraph** by French scientist *André Marie Ampère* (1775–1836) in 1820. Yet even before this time in 1804 (some sources say it was already in 1795) Spanish physician and natural scientist *Francisco Salva y Campillo* (1751–1828) had constructed an **electrolyte telegraph** that used twenty-six separate transmission lines. At the end of each line was a glass tube in which a surge of power caused the fluid inside to form gas bubbles that rose to the surface. German anatomist and physiologist *Samuel Thomas von Sömmering* (1755–1830) was successful in improving the range of this technique in 1809. Nevertheless this type of electric telegraphy proved of little interest as recognition of the transmitted sign was a tedious and unreliable process.

The first truly significant practical device was invented by *Carl Friedrich Gauss* (1777–1855) and *Willhelm Weber* (1804–1891) in 1833. This was the

[2] The true identity of the author could never be conclusively discovered. There is evidence it was the Scotch surgeon Charles Morrison who lived in Greenock.

pointer telegraph, based on the use of just two wires and introducing a binary code system for the letters of the alphabet. In that same year they succeeded in carrying out the first telegraphic message transmission: from the physics building near St. Paul's church in the town center of Göttingen to the observatory. The inventive spirit of the times was reflected in the novel array of possibilities following in the wake of the pointer telegraph. But it was only the **writing telegraph,** presented in 1837 by *Samuel Morse,* (1791–1872), which achieved the breakthrough that led to worldwide dissemination. With his assistant *Alfred Vail* (1807–1859), Morse developed a successful alphabet code in 1840. The power of Morse's invention lay in its ingenious simplicity. It was improved even further in 1845 with the introduction of the Morse keys, which were named after the inventor, who was also an accomplished portrait painter. According to legend, just at the time Morse was working on a portrait of Portrait General Lafayette in Washington his wife became seriously ill and died. The news of her illness took seven days to reach him and as a result he never saw her alive again. In his time of mourning it was said that the idea first occurred to him of trying to break the time barrier by means of modern technology – in other words transporting messages using electricity. This would ensure that a person would never again be unable to contact a loved one in an emergency. It is, however, more probable that the idea took root when he was studying in Paris in 1829. At that time Morse became fascinated with Claude Chappe's optical telegraph, which he had seen often on his frequent trips to the Louvre. Twenty years before that time, Chappe had ordered his semaphore be placed on the Louvre's roof (see Fig. 2.11).
Besides the captivating simplicity of his invention, Morse's telegraph was impressive due to its high transmission power and weather-independent reliability.
The first 64 km long experimental line between Baltimore and Washington became the starting point for the soon rampant "telegraph fever." On May 1844 it was ceremoniously opened with the transmission of the Biblical quote: "*What Hath God Wrought!*" By 1845 there were already more than 1400 telegraph lines spanning the U.S. Because the U.S. government rejected the purchase of Morse' patent – it was of the opinion that such an undertaking could not earn a profit – the expansion of the telegraph network in the United States was financed by private operators. The first telegraph line in Europe began operation between Bremen and Bremerhaven on January 1, 1847. Quickly, telegraph networks spread out along the new railway lines.
The lion's share of the telegraphed news was initially related to the trading, shipping, stock market and the newspaper industries. The advantages it offered to these sectors soon became indispensable. Messages became commodities with an extremely short shelf life. The first news agencies that opened, e.g., the Associated Press in New York (1848) or Reuters in London (1851), owe their existence to the success of telegraphy. Morse's system was continually being improved upon and was soon passed up by a directly readable telegraph – the so-called *ticker.* This invention by music professor

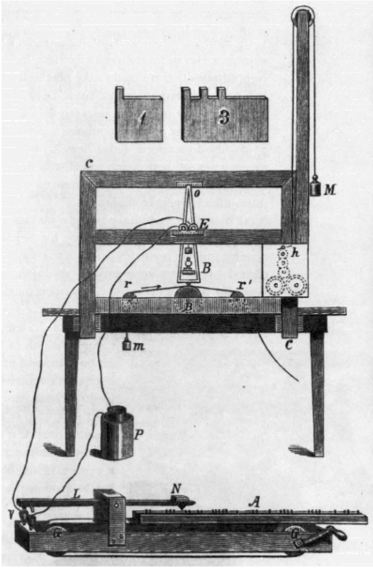


Fig. 2.12 Samuel F. B. Morse's first telegraph, from [246].

David Hughes (1831–1900) had a transmission speed of 150 characters per minute. All major telegraph lines began to use it starting in 1873. Optical telegraphy, barely a few years into operation, was being overrun by technical innovations whose possibilities met the increasing communication needs of a society formed by the Industrial Revolution. The gains in transmission capacity and speed, as well as the opening of telegraphy to individuals and private message traffic, ensured massive expansion.

Especially in terms of range, electric telegraphy opened up completely new dimensions. The first cable between England and the continent was laid in 1851 and with it the boundary created by the sea was essentially conquered. The U.S. businessman *Cyrus W. Fields* (1819–1892) succeeded in laying the first sea cable between Europe and North America in 1858. However, it could only be operated a few weeks before finally being abandoned as unusable. It was not until 1866 – and a further number of costly failures – that a reliable telegraph connection could be set up across the Atlantic between Newfoundland and Ireland. It didn't take long after that until the telegraph network had spread out throughout the whole world.

2.6 The Advance of Personal Telecommunications

2.6.1 Telephone

Telegraphy was only used for private communication in exceptional situations. Yet the desire and need to use the new form of communication for private purposes increased, particularly at the end of the nineteenth century. Coded data transmission was only carried out in one direction in telegraphic technology . But now the idea arose of transporting speech over greater distances with the help of electricity, thus opening up the possibility for a genuine dialogue to take place. A prerequisite was the realization that the **sound** received by human ears is nothing more then the periodic rise and fall in changing air pressure – in other words it takes the form of a wave. The wave character of sound was already recognized in antiquity. Roman architect *Marcus Vitruvius Pollio* (first c. BC) compared the expansion of sound to the waves of water. This knowledge was lost in the Middle Ages and it was only the physicist *Isaac Newton* (1643–1727) who was first able to establish a connection between the speed of sound and air pressure based on the wave theory he developed.
Physics teacher *Phillip Reis* (1834–1874) constructed one of the first "apparatus for the reproduction of all types of sounds,"which was modeled on the human ear. He succeeded in conducting a first public test in 1861 to electrically transmit – more or less successfully – a French horn solo with the apparatus he had developed. In contrast to Reis, whose sound transmission was based on the interruption of an electrical circuit by the vibration of a membrane, the U.S. physiologist, *Alexander Graham Bell* (1848–1922) used the electromagnetic induction discovered by *Michael Faraday* (1791–1867) to transmit speech.
"*Mr. Watson – come here – I want to see you*", is the historical phrase that comprised the first telephone call in Bell's Boston home on March 19, 1876. Watson heeded Bell's request – in other words the **telephone** – had worked. Thomas A. Watson, Graham Bell's technically gifted assistant, has this phone call to thank for his fame today. It also shows the shift in research from one scientist working alone to scientists working in research groups to advance technical innovations by way of teamwork. Bell's telephone was demonstrated for the first time on June 25, 1876 as part of the centennial celebration of America's independence in Philadelphia. After further improvements, the final, and thereby simplest, version of Bell's phone was ready in May 1877. In this case, the transmitter and the receiver were one, which meant that to make a telephone call Bell's device had to be held interchangeably to the mouth to speak and to the ear to hear.
At the same time as Graham Bell, *Elisha Gray* (1835–1901) turned in a patent for a telephones he had invented to the Washington Patent Office. A legal battle of eleven years ensured until the Supreme Court finally deter-

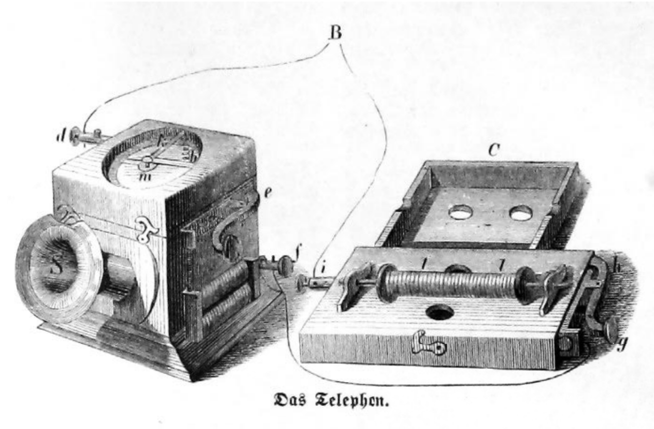


Fig. 2.13 The Phillip Reis telephone (1863).

mined Graham Bell to be the telephone's inventor.It is believed that Bell filed his patent application approximately two hours before Gray did. The *Bell Telephone Association,* founded to implement Bell's patents, used the authorization granted by the patent law ruthlessly and suppressed all other productions of telephones with its monopoly. The *American Telephone and Telegraph Company* (AT&T) eventually emerged from this company as the largest private telephone company in the world.

Just a year after Bell's invention, the first telephone network went into operation. It had just five connections and it was owned solely by bankers. Initially, the telephone had the same purpose as the telegraph, with the advantage of much greater speed and more extensive performance. As early as 1910 one fourth of all private households in the U.S. had a telephone connection. This number grew to 40% by 1925. The telephone no longer played only a significant role in business but became more and more important in inner-family communication and social life.

There were many problems that had to be solved before the telephone network would see worldwide expansion. For a long time, for example, there were unresolved issues concerning signal attenuation on longer telephone lines. While in telegraphy essentially a "digital binary" signal was transmitted, in analog telephone conversations it was necessary to transmit a complete frequency spectrum of signals. The degree of an electrical signal's attenuation on a cable depends on the signal's frequency. This means that different frequencies are attenuated in different degrees and the more the cable length increases the greater the distortion of the original signal becomes. American electrical engineer, *Michael Idvorsky Puppin* (1858–1935) developed the self-induction coil in 1899. Bestowed with the name of its inventor, the coil improves the transmission performance of telephone lines.

Pupin induction coils, installed in regular intervals on telephone lines, enabled long-distance calls over several hundred kilometers with economically still viable cable diameters. The range restriction could first be eliminated with the introduction of electron tubes. Thus, the New York to San Francisco connection could be opened in 1914, while the first transatlantic telephone cable was not finalized until 1956. Long-distance calls across the Atlantic had been possible since 1927 via intermediate radio connections. Initially, the small number of phone subscribers could still be easily managed via plug-in connectors run by the fabled "switchboard operator". The growing number of telephone subscribers, however, made it necessary to eventually change to automatic switching centers – the so-called automatic exchange. In 1889, the undertaker *Almon Brown Strowger* (1839–1902) was granted the first patent for this development, but his invention could only take effect with the expiration of Bell's 1893 patent. It was then that smaller, more flexible telephone companies arrived on the scene and gave new impetus to the market. The first completely automatic telephone exchange in the world began operation in La Porte, Illinois in 1892. In 1896, Strowger's company invented the first rotary-dial telephone.

2.6.2 From the Phonograph to the Gramophone

Around the same time as the advent of the telephone, devices for the permanent recording and conservation of sound and speech were being developed. *Thomas A. Edison* (1847–1931) set up his famous research laboratory in Menlo Park in 1876. Together with fifteen colleagues, he worked on the problems of telegraphy and telephony. In 1877, he developed the carbon microphone which considerably improved the transmission quality of the telephone and came up with the basis for constructing the **phonograph**, a device for recording sound. Three days before December 6, 1877, when Edison played the nursery rhyme "*Mary had a little lamb*" on his phonograph, a sealed envelope was opened at the Paris Academy of Science with the plans of Frenchman *Charles Cros* (1842–1888). Cros described his voice recording and playback machine, the „Pa(r)leophon," which he had already submitted on April 30 of that same year. But Cros lacked the financial means to patent his invention. Edison's phonograph, or "speaking machine" basically consisted of a tinfoil-wrapped metal cylinder that was turned with a hand crank. Recording and playback were separate. A horn directed the sound to a recording diaphragm that was caused to vibrate. With the help of a steel needle, the vibrations were scratched as spiral-shaped elevated and recessed grooves on the cylinder. If the cylinder was played again at the same speed with the needle, the recorded sound moved the diaphragm via the needle and the recorded vibrations became audible again through the horn. Copies of recordings could not be made as each cylinder could only be spoken on (= recorded) once. The sound of the recording was tinny and flat, but improved considerably after 1888 when Edison replaced the tinfoil cylinder with a wax cylinder.

Fig. 2.14 Edison with an early phonograph in 1878.

In the beginning, the phonograph was solely intended as a dictating machine for business use. Edison even tried to position his phonograph as the first telephone answering machine – without success. Due to the complex processing necessary to obtain a relatively high degree of accuracy in self-recording, and of the electric motor needed to power it, the Edison phonograph was very expensive initially. The phonograph only achieved widespread use when less expensive devices with a spring drive came on the market. The major disadvantage of the phonograph was primarily the absence of a practical method for copying the recorded cylinders.
Emil Berliner, (1851–1929), an American electrical engineer of German descent, presented the first music playing device in 1887. He called it the the **gramophone**. The gramophone was different than the phonograph from the start since it was intended purely as an entertainment medium. Because of its simple construction it could be offered much more cheaply than the phonograph. This device was only for playing and not for recording, but the Edison cylinders, which were difficult to produce on a large scale, gave way to the much easier to manufacture record. Upon entering the private market, the gramophone established itself quickly and the record became a mass product. In the years before World War I, record companies were making incredible dividends of up to 70 percent. There were already over one hundred record ("labels") by 1907. This including one dedicated to Emil Berliner's legendary dog Nipper, who was pictured famously in front of the horn of a gramopho-

ne listening to “his masters voice.“ Edison ended the production of cylinder phonographs in 1913 and changed to the record business.

2.6.3 Photography

Much earlier in history the development of photography had already begun with the attempt to capture a real image. As early as 900, Arab scholars had used the **pinhole camera** as an astronomical instrument for observing the solar and lunar eclipses. The principle of this invention had been discovered in antiquity and outlined by *Aristotle* (384–322 BC). The pinhole camera was described by Arab physicist and mathematician *Ibn Al-Haitham* (965–1040). In the sixteenth century this invention was fitted with a lens and developed further into the **camera obscura** (=[Lat.]dark room). The camera obscura is nothing more then a box that was blackened on the inside. On its transparent back wall (the focusing screen) an image outside of the camera, seen from a hole or a converging lens on the front of the box, is produced. The image is reduced in size, upside down and reversed. The Thüringian Jesuit priest and natural scientist *Athanasius Kircher* (1601–1680) was the first to come up with the idea of installing a lens in the camera obscura. At night, with the aid of candles, he would project pictures on the paper windows of the house across from his. He amused and terrified viewers by projecting frighting devils or enormous flies on the wall. Such images led to the use of the name magic lantern – or laterna magica – in popular vernacular.

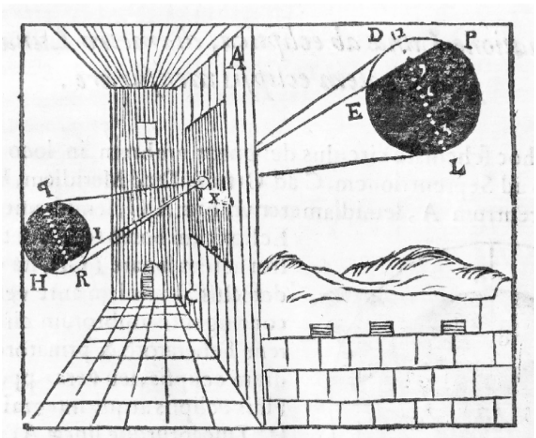


Fig. 2.15 The principle of the camera obscura (1646), from [135].

The camera obscura was also used as a tool by artists to make their drawings as life-like as possible up through the nineteenth century. *Antonio Canaletto* (1697–1768), famous for his magnificent cityscapes, worked out initial sketches of the view of a city using a portable camera obscura. But what was still missing in photography was a way to make a lasting image on the screen.

By the seventeenth century it was known that numerous substances, such as silver compounds, change their color or become black when exposed to the sunlight. In Halle on the Saale River in 1727, the German physician *Heinrich Schulze* (1687–1744) discovered that this phenomenon was not caused by the sun's heat but by light energy. Schulze successfully produced the first – albeit non-permanent – photographic images.

An article written *Thomas Wedgewood* (1771–1805) appeared in London in 1802 providing a complete description of the most important ideas of photographic technology. Fifteen years later, the French officer and scholar *Nicéphore Niepce* (1765–1833) was successful in the first practical application of these ideas and developed lasting photographs using a method he had invented called **heliography**, The celebrated Paris theater designer *Louis Jacques Mandé Daguerre* (1787–1851), a highly ambitious businessman, became his partner, carrying on Niepce's work after his death. Daguerre developed a technique that was subsequently named after him: the **daguerreotype**. With this technique an exact reproduction of the scene was created using silver iodine plates. However, the image could not be duplicated and therefore remained an original. He asked the famous French scientist *Francois Dominique Arago* (1786–1853), to present his invention at the Paris Academy of Science in 1839. Because Daguerre's background was non-academic he was not taken seriously in scientific circles. Arago succeeded in justifying the new process as a scientific method and motivated the French government to buy the process from Daguerre for a considerable sum of money. Daguerre had already ordered a patent application for the procedure in London five days earlier.

The first positive-negative process to allow the reproduction of unlimited prints was invented in 1839 by Englishman *William Fox Talbot* (1800–1877) and called the **calotype**. Talbot had the ingenious idea of creating a negative image from which any number of positive prints could be made, rather than making just a single positive image as had been done previously. To do this he pressed an already exposed paper together with one that was unexposed under a glass plate and placed them in the sunlight. The dark objects appeared on the second sheet and – in contrast to previous methods – as a non-reversed image. This image, which is still produced today in a similar manner, is known as a contact print. In the years that followed, the market for photography expanded rapidly. Besides the artistic abilities required, craftsmanship skills were also necessary. Photographers had to produce their photo material themselves, which stood in the way of even greater dissemination of the medium.

With the further development of photographic technology it became possible to reduce the exposure time needed. While with Niépce's method several hours were necessary, Daguerre was already able to reduce this time to minutes. The English sculptor *Frederick Scott Archer* (1813–1857) developed a wet process based on collodion plates in 1851. Exposure time could be decreased to just a few seconds, which made the daguerreotype obsolete. Collodion is a viscous emulsion composed of nitrocellulose in alcohol and ether. It was commonly used in medicine to close open wounds. Archer's collodium plate had to be prepared at the photo location directly prior to being exposed and put into the camera while it was still wet (thus the name of the procedure). English physician *Richard Leach Maddox* (1816–1902) improved the technique even further. In 1871, he replaced Archer's collodion with a gelatin mixture containing bromide silver as a photosensitive layer. The bromide silver paper prepared this way enabled reprints to be produced from negatives in seconds. It is still the basis for the process used today. In contrast to Archer's collodion plates, the gelatin coated plates did not need to be processed immediately, but could be stored for months at a time before their actual exposure.

The breakthrough of photography for the general public was initiated by the American *George Eastman* (1854–1932). Eastman, a former savings bank employee, brought to the market a flexible and easy to handle roll film in 1888. This film was part of a complete infrastructure ranging from the camera to the development and enlargement service, all of which was incorporated under the name he invented: "Kodak." Eastman's "Kodak box" camera was sold already loaded with film and cost 25 U.S. dollars. After the hundred film images had been photographed, the camera was sent to the Kodak plant. The pictures were then developed and camera returned with a new film – all in just a few days. By separating the actual photography process from the chemical film development process it suddenly became possible to be an amateur photographer without any special training or prior knowledge. With his slogan, "You press the button, we do the rest," Eastman paved the way to mass market photography.

The path from analog film to the digital image was a short one. It began between 1960 and 1970 when ideas were being generated during the U.S. space program about how to get still images and moving video images from groups of discrete sensor elements. The breakthrough in the development of **digital photography** came in 1973 with a CCD image sensor (Charge-Coupled Device), developed by the Fairchild company. With this high-resolution sensor, light pulses could be transformed into electrical signals. *Steven Sasson* (*1950), developmental engineer at Eastman Kodak, constructed the first prototype of a digital camera in 1975 using this technology. The black and white photographs could be saved on an incorporated tape cartridge. The camera's resolution was just 10,000 pixels (0.01 mega pixels). Weighing nearly 4 kg, the camera required 23 seconds to take one picture. The first reasonably priced digital camera appeared on the retail market at the end of 1990s, sparking a huge interest in digital photography. Digital camera technology has now almost completely replaced its analog predecessor.

2.7 Wireless Telecommunications – Radio and Television

2.7.1 Wireless Telegraphy

In terms of their historical origin – the telegraph – the development of both wireless telegraphy and the radio are closely connected to telephone technology. A number of radio pioneers were fundamental in laying the groundwork for wireless technology. They include Michael Faraday, *James Clerk Maxwell* (1831–1879), *Heinrich Hertz* (1857–1895) and *Eduard Branly* (1846–1940). Two other great figures stand out in light of their work at the end of the nineteenth century, which paved the way for wireless communication: the Russian naval architect *Alexander Stephanowitsch Popov* (1858–1906) and the Italian engineer and physicist *Guglielmo Marconi* (1874–1934).
Maxwell was the first to postulate the existence of electromagnetic waves that originate when electric and magnetic fields rapidly change their strength. He created the theoretical basis for a new way to communicate over virtually boundless distances. Maxwell's **radio technology** theory, as described in his essay published in 1873,"*A Dynamical Theory of the Electromagnetic Field,*" was completely unknown until that time. In his laboratory in Karlsruhe, Hertz succeeded in producing evidence of Maxwell's wave theory in 1885. Hertz proved that electromagnetic waves do in fact have all of the characteristics of physical waves and only differ in their frequencies. He did not however yet see a practical use for his discovery. The next step in developing the radio receiver was undertaken by French physicist Branly in 1890. Branley was able to convert electromagnetic waves into electrical impulses. He discovered that metal shavings, which are normally poor conductors, align themselves into coherent – unidirectional and contiguous – bundles under the influence of electromagnetic waves. On the basis of this discovery, he developed the first radio tube in the world known as the *coherer*.
Popov presented a complete receiver for electromagnetic waves in 1895. Because an adequate transmission device was still lacking, Popov constructed a thunderstorm detector on the basis of Branly's coherer. It could receive the electromagnetic waves in the atmosphere caused by lightning discharges. The next year at the University of St. Petersburg he succeeded in sending wireless signals over a distance of 250 meters with the help of a transmitting device he had constructed. That same year Popov was also able to prove that wide area signal transmission is possible over a distance of more than 30 kilometers. He did this by means of his specially developed balloon antenna.
One of the first areas of application for this new **wireless telegraphy** was in marine radio. Marconi's first experiments were designed for this area. Marconi received a patent in 1896 for his work, combining the technology of Popov (antenna, relay and bell), Hertz (high frequency generator) and Branly (coherer). This was the foundation of his ongoing work in increasing the remote effect of radio signals. Up to that time electromagnetic waves had

been generated using a spark gap. German physicist and radio pioneer *Karl Ferdinand Braun* (1850–1918) used an oscillating circuit, which he coupled directly with an antenna. By way of this 1898 patented “coupled“ transmitter it was possible to direct radio waves in a certain direction and achieve greater range.

Fig. 2.16 Portrait of the radio pioneer Guglielmo Marconi (1874–1937).

On December 12, 1901 Marconi carried out the first wireless transmission across the Atlantic between England and Newfoundland. The first commercial, transatlantic wireless telegraphy service was then set up in 1907. The military’s demand for the written documentation of a message was an important reason why the new technology was only able to catch on slowly. Nevertheless, the new wireless technology was used by the army and the navy on opposing sides in World War I. With the sinking of the Titanic in the night from April 14 to April 15, 1912, the new wireless technology was suddenly seen in a different light. It had become a medium to enable coordinated rescue operations on the high seas. The most advanced ship in the world had gone down, but even as it was sinking the new technology had made it possible to maintain a connection with the mainland. The sinking of the Titanic had far-reaching consequences. Only a few months later at the Third International Radiotelegraphic Convention in London – the so-called Titanic conference – it was decided that all owners would have to equip their ships with wireless technology. Additionally, the international distress frequency and establishment of the “SOS“-emergency signal were declared.
The introduction of the three-electrode vacuum tube with metal mesh, known as the **triode**, was invented in 1908 by the American *Lee De Forest* (1873–1961) and the Austrian *Robert von Lieben* (1878–1913). This led to a breakt-

hough in amplifier technology, which until now had been based on the Branly coherer. From this point on, until the advent of the transistor in 1947, triode tubes became the foundation of wireless technology.

2.7.2 Radio

The first radio broadcast in history happened on December 25, 1906. Radio operators on ships off the coast of Newfoundland were undoubtedly astonished to suddenly hear a voice – between the beeps of the Morse code – read the Christmas story from the Gospel of Luke, followed by a violin rendition of "Silent Night". *Reginald Fessenden* (1866–1932), a Canadian engineer and inventor, can be credited with this first experimental transmission. Fessenden and his assistant had already been able to carry out the first broadcast of a voice in 1900 with the help of the modulation process he had developed.
The idea of establishing a "broadcast medium for everyone" and developing it as a viable financial commodity can be attributed to *David Sarnoff* (1891–1971), one of Marconi's radio technicians and later the deputy director of the American Marconi Company. Sarnoff achieved fame as the radio operator who received the signal of the sinking Titanic at Nantucket Island in Massachusetts. For a continuous seventy-two hours thereafter he received and forwarded the names of those who had been saved. Sarnoff had already contacted Marconi in 1916 with his idea of a "radio music box." He visualized it as a household consumer article such as the piano or phonograph. Initially dismissed as a crazy idea, Sarnoff's vision was seen as having little chance of success in the face of the ongoing patent war between various wireless pioneers. But he presented his plan once again in 1920 in the light of its financial promise, and this time he was successful. The **radio** was born. Given the prevailing laws of warfare, the American government controlled all patents. This situation resulted in the formation of an pan-American radio company: the Radio Corporation of America (RCA). Subsequently, RCA became the largest manufacturer of radios worldwide.
The first commercial radio station to regularly broadcast was the American station KDKA. It received its license in October 1920 and then began transmission on November 2, 1920 in Pittsburgh. KDKA used the medium wave range and broadcast entertainment and informational programs. This first radio station was born out of the activities of an early radio operator, former navy officer and employee of the telegraph company Westinghouse, *Frank Conrad*, (1874–1941). Between 1918 and 1919, Conrad began playing phonograph records and piano compositions on the radio from his garage, at first, only for testing purposes. He requested that neighboring amateur radio operators give him feedback on the quality of transmission. His "ether concerts," alway broadcast Friday nights, soon turned into a popular recreational activity. Conrad began working on a broadcast station. The first public

radio transmission was a live broadcast of the American presidential election results. Within just a few months numerous other stations and companies in a range of branches began the autonomous transmission of shows and programs for promotional purposes.

At the same time in Germany a public broadcasting system was also developing. On November 19, 1919, radio pioneer *Hans Bredow* (1879–1959) showed the function of entertainment broadcasting during a public demonstration. It was Bredow who first coined the German term for radio broadcasting: "Rundfunk." A decisive event took place in the development of the medium with the so-called "*Funkerspuk*" (radio operator ghost). Following the example of the revolutionaries in Russia, on November 9, 1918 workers took over the headquarters of the German Press News Service and erroneously announced the victory of the radical revolution in Germany. As a result, the first control laws went into effect to prevent abuse of the new medium. The German Empire adopted the right of sovereignty in 1919. This meant that the establishment and operation of transmission and receiving equipment was subject to authorization. From 1922, the reception of radio broadcasts was forbidden for private citizens. Although this law was revoked the following year, an obligatory fee was enacted. The birth of German radio is considered October 29, 1923, the date that the first radio entertainment show was broadcast from the Vox-Haus in Berlin-Tiergarten, near Potsdamer Platz in Berlin.

Radio broadcasting quickly became a mass medium with politicians also recognizing the immense potential of wireless communication. The abuse of broadcasting for manipulative propaganda took place at the latest in 1933 with the German National Socialists much promoted "Volksempfänger" – the so-called people's wireless. The first inexpensive Volksempfänger, the famous VE301 (the number 301 signified the day that the National Socialists had seized power in Germany), was produced in the millions. Two of its features were that it could not be attached as an asset in the case of financial debts nor could it receive foreign broadcasts.

On December 23, 1957, the Americans *John Bardeen* (1908–1991), *Walter House Brattain* (1902–1987) and *William Shockley* (1910–1989) presented the first **transistor** at Bell Laboratories/New York. As a group they were awarded the Nobel Prize for their invention in 1956. For demonstration purposes they removed all vacuum tubes from a conventional tube radio and replaced them with transistors. This marked the birth of the transistor radio. The Bell Telephone company, which laid out tremendous personnel costs for the upkeep of their telephone network, had offered the challenge of developing a more reliable and durable switch than the error-prone vacuum tube. After countless trials, the team led by Shockley was able to develop the first transistor from semiconducting materials as a switching element. No one at that time could guess what the impact of this discovery would be and its importance in all areas of electronics. Because Bell laboratories had to release the patent in return for payment of license fees, many producers were able to share in a further utilization of the transistor from the beginning. The U.S. company Texas Instruments put the first commercial transistor radio on the market in 1954. The transistor allowed the construction of lighter and more mobile devices, which was a crucial advantage for radio manufacturers. Transistor radios achieved dramatic widespread success.

2.7.3 Film and Cinema

The film or moving picture created by optical or mechanical means did not originate using images from the real world but with man-made sketches and pictures. The underlying principle relies on the phenomenon of retinal inertia, which was already described by *Ptolemy of Alexandria* (85–165 AD) in the second century. A visual image remains on the retina of the human eye for approx. 1/16 second before it disappears. This phenomenon, only first rediscovered in the nineteenth century, led to the development of the first mechanical apparatus for viewing moving images. Viewed in rapid succession, a sequence of stroboscope pictures gives the illusion of movement. Founded on developments such as French physiologist *Étienne Jules Marey's* (1830–1904), "photographic gun" (1882), Thomas A. Edison turned in a patent in 1889 for the **cinematographer**. This was followed in 1894 by the cinematoscope, a projection device for the new medium. Both apparatus were based on the same principle. A celluloid film strip was mechanically transported past a lens and could thereby be illuminated and viewed. A definite disadvantage of the cinematoscope was that only one person at a time could use it. Because Edison underestimated the importance of film, he did not make any further efforts to develop the cinematoscope as a projection device.
This was first accomplished by the brothers *Louis Jean Lumière* (1864–1948) and *Auguste Lumière* (1862–1954) with their fully developed cinematographic process in 1895. On December 28, 1895 the team introduced their first film to a large, paying audience at the Grand Cafè on Boulevard des Capucines in Paris. The event heralded the beginning of the cinema era. It should be noted that two months before the success of the Lumière brothers, the two German showmen *Max* and *Emil Skladanowsky* (1863–1939 and 1859–1945) had shown their first film to an astounded audience at the Berlin Wintergarten vaudeville. They used a projector of their own invention called a bioscope. As factory owners, the Lumière brothers had the necessary capital and contact to the industry as well as their own "cinématographe," which functioned as a film camera, copier and film projector all in one. They were thus able to support their invention's success in the years ahead. The Lumières lent and sold their apparatus to showmen who presented short films, first at county fairs and then later in their role as traveling cinema operators. As the recognition and popularity of films grew, the first local cinemas sprung up. In Germany they were given the name "kintop" and in the U.S. "nickelodeon."

To attract visitors, these cinemas relied on a continuous supply of new films. The Lumières saw film purely as an expansion or complement to photography and limited themselves to documenting actual experiences. The French theater owner *Georges Mèliés* was the first film producer to recognize the narrative (story-telling) potential of moving pictures. The birth of the film industry is recognized as taking place in 1896 when *Mèliés* started to make films exclusively presenting staged narratives.

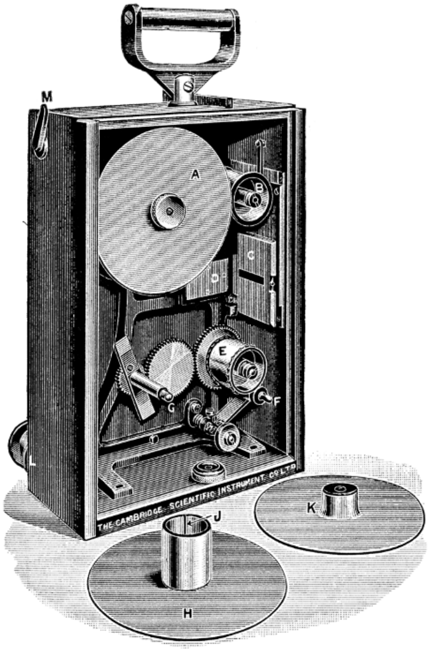


Fig. 2.17 1917 Cinematograph, from [46].

As soon as film came into being an attempt was made to combine it with the Edison phonograph, yet the necessary synchronization of both media presented a significant problem that had yet to be solved. In scenes with dialogue, irregularities in synchronization were perceived immediately. A way still had to be found to capture image and sound in one medium. At the same time, cinema films were never truly silent. From the beginning, live music accompanied films in movie theaters. Usually pianists called "tappeurs" performed this task. However, at film premieres or in large theaters, orchestras might even be used to carry out accompaniment. A practical procedure to make the "talkies" possible first came along with implementation of the so-called photo-electric effect. This effect allowed the conductivity of certain substances to change their properties in different lighting conditions. With this optical sound recording process, a soundtrack can be stored synchronous with the image on the optical film carrier medium. In 1922, the Polish engineer *Jòzef Tykociǹski-Tykociner* (1877–1969) developed the first technical implementation of this optical sound recording process in the U.S. Independent of Tykocinski-Tykociner's invention, the German engineer *Hans Vogt* (1890–1979) also developed an optical sound process, and on September 17, 1922 presented the first short optical sound film to the public in the Berlin movie theater Alhambra on Kurfürstendamm.The talkies were not immediately successful in Germany. The sound film patent was purchased by *William Fox* (1879–1952) in the U.S. who would make the talking picture into a worldwide success. On October 6, 1927 the "The Jazz Singer,“ with Al Jolson in the leading role, premiered. The film, produced by Warner Brothers, was the first full-length talkie and a fitting beginning to herald the new era in film making. Now there are digital optical tracks, such as the Dolby Stereo SR Digital, the most often used digital sound procedure today. Here, in contrast to the analog optical sound process, the sound is not copied onto the movie in analog form, but rather as digital information. This information is collected by a photo cell and subsequently converted into audio signals via a decoder. Digital optical tracks allow a higher dynamic range and thus a better sound quality, more channels for improved spatial imaging of sound and increased noise reduction.

2.7.4 Television

Just as with film, television uses the phenomena of retinal inertia. Television, the electromagnetic transmission of moving pictures, is founded on the principle of the resolution of a mosaic image, consisting of a series of lines and points. When instantaneously reassembled, the original image appears. Retina inertia is exploited in television viewing in the sense that it is possible to recognize a whole picture when each individual image frame is displayed. Based on the systematic scanning of a scene for obtaining signals, engineer *Paul Nipkow* (1860–1940) developed a scanning disk. The disk, with a series of holes spiraling toward the center, rotates as it picks up a part of the image. Nipkow obtained a patent for his invention in 1884. On the transmitter side, the scene to be recorded is scanned line by line with the help of the Nipkow disk. Thereby, the spatial juxtaposition of the individual image points i.e., their brightness value, is converted, with the help of light sensitive selenuium cells, into a temporally aligned coexistence of different voltage levels. The same principal is applied on the receiving side and the image is reassembled. The invention was called the "electrical telescope“. Nipkow's patent, which had already expired in 1885 due to a lack of funds, served as the foundation for the work of numerous other television pioneers. The word "television“ came into use in France and the U.S. after the turn of the century, whereas the German word "fernsehen“ first came into being around 1890.

With the advent of the cathode radio tube, invented by Karl Ferdinand Braun in 1897 and named after him, it became possible to develop the first electromechanical television in the world. This was first done by the German physicist *Max Dieckmann Rosing* (1882–1960) and the Russian physicist *Boris Iwanowitsch Rosing* (1869–1933) and intended for use as a playback device. The first public telecast did not take place until 1925, when it was then broadcast – nearly simultaneously – in three countries at once: in Germany by *August Karolus* (1893–1972), in Great Britain by *John Logie Baird* (1888–1946) and in the U.S. by *Charles Francis Jenkins* (1867–1934). The first era of the electromechanical television ended in 1928/1929. At this time there were already 60-line scanning instruments available and the first "regularly scheduled" television shows were being aired in the U.S.
The first completely electronic television camera, the iconoscope, was patented in 1923 by *Vladimir K. Zworykin* (1889–1982), who is considered the father of modern television. The first electronic picture tube – the kinoscope – followed in 1929. Initially, Zworykin could only broadcast a simple cross with his method. Thus the company where he worked, the Westinghouse Electric Corporation in Pittsburgh, showed little interest in his new invention. Armed with a new version in 1929, Zworykin succeeded in convincing radio pioneer David Sarnoff about the promise of his invention. Sarnoff hired Zworykin as the director of electronic research at RCA. Zworykin received the patent for his completely electronic television system based on the iconoscope and the kinoscope in 1939.
The first regular television program started in Germany in 1935, but it would only be in operation for half a year. It was based on a 180-line method. The British Broadcasting Corporation (BBC), founded in 1922, was already operating a high-resolution 405-line television service between 1936–1939. This is generally considered to be the first modern television service in the world. The BBC television service was based on a system developed by *Isaac Shoenberg* (1880–1963). It was a further development of Zworykin's method using microwaves for signal transmission. BBC retained the Schoenberg system (405 lines, 25 images per second) until 1962. In 1953, the American NTSC color television process (NTSC=National Television System Committee) was released. While the American company CBS had already presented a color television system in 1940, it still had a long war to go. The American public made a slower than expected transition from the black and white to the color receiver. The NTSC sytem had been developed too quickly to ensure a truly optimal coloration. Consequently, NTSC was soon dubbed "Never The Same Color." The NTSC color television system was finally able to prevail over the black and white television because of its compatibility properties. Color television broadcasts could be viewed with a black and white receiver without a loss of clarity, and black and white television broadcasts could be seen via color television receivers as well as black and white receivers.
The SECAM ([Fr.] *Séquence á Mémoire*) norm followed in France in 1957. In 1963, based on the experience with NTSC and SECAM, *Walter Bruch*

Table 2.2 Milestones in the History of Communication Media (2)

1184 BC	News of the fall of Troy is telegraphed to Greece via torch signals
150 BC	First description of retinal inertia
1608	Invention of the telescope in Holland
1684	Robert Hooke's "On Showing a Way How to Communicate One's Mind at Great Distances"
1690	Guillaume Amonton's first experiment with the semaphore
1730	Stephen Gray shows that electricity propagates along a wire
1745	Electricity can be stored for the first time by means of the Leyden jar
1794	Start of the first regular optical telegraph line between Paris and Lille
1809	Samuel Thomas Sömmerring improves the electrolyte telegraph
1816	Nicèphore Niepce develops photography
1819	Christian Oerstedt discovers electromagnetism
1820	Andrè Marie Ampére's invents the electromagnetic needle telegraph
1831	Michael Faraday discovers electromagnetic induction
1833	Carl Friedrich Gauss and Wilhelm Weber develop the pointer telegraph
1838	Samuel Morse's writing telegraph heralds the breakthrough for the telegraph
1840	Introduction of the Morse alphabet
1845	Star-shaped optical telegraph network established throughout France
1851	First undersea telegraph cable laid between England and the Continent
1856	Laying of the first Transatlantic cable
1860	James Maxwell develops a unified theory for electricity and magnetism
1877	Alexander Graham Bell and Elisha Gray develop the telephone
1877	Thomas A. Edison demonstrates the first phonograph
1886	Heinrich Hertz discovers electromagnetic waves
1888	George Eastman develops photography for the general public
1889	Almon B. Strowger invents the automatic telephone exchange
1889	Thomas A. Edison's cinematography heralds the dawning of a new age
1893	The first automatic exchanges for telephone calls are set up in the U.S.
1893	Louis und Auguste Lumière present a public viewing of the first film
1896	Alexander Popow succeeds in making the first wireless message transmission
1901	Gugliemo Marconi carries out the first wireless communication across the Atlantic
1919	Hans Bredow propagates the notion of "radio for the people"
1924	August Karolus succeeds in transmitting the inaugural television picture
1927	"The Jazz Singer,"the first talking movie, is released in cinemas
1935	First regular television program service in Berlin is set up
1935	First tape recorder with electromagnetic recording from AEG
1962	Premier of direct television transmission via satellite between U.S. and Europe
1973	Earliest digital image sensor (CCD) for digital cameras
1982	Phillips and Sony introduce the digital audio compact disc (CD)
1995	Introduction of the digital versatile disc (DVD) as a storage medium
2002	Specification of the Blu-ray Disc and the HD DVD
2008	Terrestrial analog television is replaced in Germany by the digital version DVB

(1908–1990) developed PAL (*Phase Alternation Line*) color television broadcast technology in Germany. And in 1983, the first high definition television technology was introduced in Japan (High Definition TeleVision). A more detailed look is presented in section 4.6.1.

2.7.5 Analog and Digital Recording Methods

The possibility of recording image and sound content on the basis of an electromagnetic process can be traced back to the nineteenth century. The first magnetic recording technologies, for example from *Paul Janet* (1863–1937) in 1887, proposed magnetic sound recording on steel wire. *Kurt Stille's* (1873–1957) dictaphone, "Dailygraph,"made a recording time of two hours possible via its extremely thin 4400 meter long wire. The great breakthrough came however with magnetic tape. In 1928 a magnet tape method based on paper was patented by *Fritz Pfleumer* (1897–1945). The AEG and BASF companies subsequently replaced the paper with plastic-based magnetic tape . The first **tape recorder** in the world, the "Magnetophon K1," was presented to the public at the Berliner Funkausstellung (Broadcasting Exhibition). Used at first only in the professional arena, tape recording technology witnessed a worldwide boom in the wake of a complete loss of German patent ownership following World War II. The first device for private use was put on the market in 1947 by the the American company Brush Development Co. In 1956, the first technologically feasible method for magnetically recording wide-band television signals was presented in 1956. *Charles P. Ginsburg* (1920–1992), an engineer at the Ampex company, introduced a new frequency modulation method for picture signals.
The replacement of analog storage media, and thus the introduction of digital storage and reproduction technology, had its origin in wide-area telephone transmission via a wireless connection. *Alec A. Reeves* (1902–1971) developed the pulse code modulation method (PCM)in 1938. A series of individual impulses were transmitted in rapid succession with a constant amplitude. The discrete signals to be transmitted can be represented with the help of a binary code. Because the stored information is not dependent on the pulse amplitude, i.e., signal noise does not change the coded information, PCM signals are virtually disturbance free, compared to the standard modulation procedurePCM audio recorders were first used at the end of the sixties. Phillips and Sony introduced the digital audio **compact disc** (CD-DA) to the public in 1979. This disk-shaped storage medium has a radius of 11.5 centimeters (coincidentally the same size as Emil Berliner's first record!) and offered (initially) a storage space of seventy-four minutes or 650 MB. A CD is a 1.2 thick polycarbonate disk coated with a vaporized layer of aluminum. Digital information is pressed inside before the disc is sealed with a lacquer coating. In contrast to the spiral grooves of the analog audio record, the in-

formation on the CD is represented on microscopically small, long recesses called ("pits"). These recesses are scanned by a 780 nanometer laser beam and then converted back into acoustic signals by the electronics of the player. The running track from the inside to the outside has a recordable spiral of nearly six kilometers (with a width of 0.6 μm). The transition from the pit to the higher area around it, called the "land", or from the land to the pit, represent a logical one. A transition from pit to pit or land to land represents a logical zero.
A long battle ensured over the establishment of a unified standard and methods of copyright protection. Once agreement had been reached the first Digital Versatile Disc (DVD) was born in 1995. In comparison to a CD it offered multiple memory (up to 17GB by using multiple optical layers and both sides of the DVD). It was initially used for the digital storage of compressed video data. At the same time, demand increased for even greater storage capacity such as was necessary for recording the high resolution television standard **HDTV** (High Definition TeleVision). At the beginning, there were two competing standards in this area: the Blu-ray disc and the leading HD DVD (High Density DVD), developed by Toshiba. The **Blu-ray Disc**, whose name comes from the violet-blue short-wavelength laser beam employed in the scanning process, has a higher storage capacity, at 25GB (single layer) up to 50GB (dual layer), than does the HD DVD, with its 15GB or 30GB storage capacity. The Blue-ray Disc was able to gain a firm foothold on the market in February 2008 with Toshiba's announcement to cease further development and production of the HD DVD.

2.8 The Computer as a Universal Personal Communication Manager

Today the computer is often viewed as the "key medium" of the future, having already surpassed television in this role. It is often overlooked that viewed from the perspective of its historical development the computer was actually not intended as a medium specialized in the functions of recording, storing, transmitting and reproducing information. Developments in the past twenty-five years have allowed the computer the capabilities of processing analog, acoustic or optical information But first with the advent of the Internet and WWW did the computer come to the forefront as a medium offering the integrative transport of multimedia information.
The computer's origin as an instrument for performing automatic calculation goes back to antiquity. Calculating instruments made of wood, metal or stone – the so-called **abacus** – were prevalent as early as the third century BC in Greece and Rome. The size of a postcard, they were easy to transport and widely used. Our word "calculation" stems from the name for the stones of the abacus – *claviculi* or *calculi*. These stones were moved on the board

by the counting master, the *calculator*, to carry out the four basic types of arithmetic.In China the use of a calculating instrument much like the abacus – the suan-pan – can even be traced back to the first century BC. To be able to carry out complicated multiplication more easily, the Scottish mathematician *John Napier* (1550–1617) invented the first slide rule in 1617. It was a simple multiplication table of movable rods that was based on the logarithms and decimal point that Napier had introduced in 1614.

Fig. 2.18 The personified arithmetic (Arithmetica) with Pythagoras (left) and Boethius (right), as they carry on a contest of calculation using the abacus and modern Arabic numerals (1504).

Even before this time, *Leonardo da Vinci* had designed the first mechanical clock with a pendulum in 1494. Two hundred years would still pass before a successfully working pendulum clock was to be constructed. At the same time, the precision engineering necessary to create the clock became the basis for the first mechanical calculator. Work on designing a complex calculating machine was done in the seventeenth century mainly by *Willhelm Schickard* (1592–1635), *Blaise Pascal* (1623–1662) and *Gottfried Wilhelm Leibniz* (1646–1716). Schickard constructed the first **gear-driven calculating machine** in 1623 to help reduce the tedious calculation his friend, the astronomer *Johannes Kepler* (1571–1630), had to carry out in determining the position of the planets. Unfortunately, Kepler never had a chance to implement the machine as it was destroyed by a fire still in its semi-finished state. Schickard's machine could perform the four basic arithmetic operations, whereby it was necessary to rely on the manual assistance of calculating rods in figuring subproducts. There was a six-digit decimal display. His invention was subsequently forgotten, and in 1642 French mathematician Blaise Pascal reinvented the gear-driven calculating machine. For centuries Pascal was considered the inventor of the mechanical adding machine. The nineteen-year old Pascal developed his adding machine to help his father, a royal tax official, with his work. Both basic arithmetic types – addition and subtraction – could be performed with the machine and it was built over fifty times with just a few sold. One of the first **mechanical calculating machines**, which also allowed direct multiplication based on repeated addition, was constructed by German mathematician Gottfried Wilhelm Leibniz.

In order to perform multiplication with larger numbers it is necessary to store the multiplicand, in contrast to a simple adding machine. The entry register must also be movable parallel to the result register so that correct addition can be performed with multiple positions. To do this Leibniz used the so-called stepped drum, an arrangement of axially parallel ribbed teeth of graduated length. Depending on the position of a second movable gear, as the stepped drum turned it was rotated from zero up to nine teeth. In his lifetime Leibniz was never ever to solve the problem of the ten transfer across multiple positions. His machine was first perfected in 1894 with the advance of precision mechanics. Leibniz developed the binary number and arithmetic system in 1679, which was to become the foundation for the construction of the modern computer.

The **punched card** first appeared as an important element for the storage and calculation of information when *Joseph Marie Jacquard* (1752–1834) perfected his early programmable pattern loom in 1805. Jacquard first separated the software – the control program in the form of punched cards or strips – from the hardware – the machine itself, which worked according to instructions punched into the cards. Depending on the punched card or program, the machine was capable of producing a fabric with a predetermined pattern and colors. Via the punched card, Jacquard designed the basic architecture of all data-processing machines and computers binary systems in mechanical engineering that is still relevant today. Where the needle met a hole in the punched card that had a one one a change took place. The state remained unchanged – a zero – when the needle touched the pasteboard.

The punched card was first used in a mechanical calculating machine in 1822 – *Charles Babbage's* (1791–1871) "**difference engine.**" As a professor of mathematics, Babbage noticed that the creation of mathematical tables was often based solely on the simple "mechanical" repetition of certain steps. However, errors in calculation very often resulted. His subsequent research was thus based on the mechanical transformation of mathematical problems and their solution. His steam-driven and locomotive-size difference engine, presented in 1822, was designed to solve differential equations and to print out the results immediately. After Babbage had worked for ten years on this machine he had the idea of designing a freely programmable calculating machine capable of performing any given calculations. He called it the "**analytical engine.**" Conceptually, it exhibited all the qualities of a modern computer:

a number memory for fifty-digit decimal numbers to be implemented with the help of 50,000 individual gear wheels, an arithmetic unit and a control unit for the entire program operation, including calculating operation and data transport. Babbage's assistant, *Augusta Ada King, Countess of Lovelace* (1815–1842), daughter of English poet Lord Byron, contributed significantly to the design of the machine. As one of the few people who was in able to assess the possibilities of the analytical engine, she developed the first program routines with such advanced concepts as branching logic, program loops and jump instructions, which made possible the cyclical operation of computational instructions. Babbage's conception of mechanized computing was ahead of its time. He was however thwarted by precision mechanics that were not yet advanced enough for the manufacture of such a complex machine. It was not until 1989 and 1991 that a fully functional reproduction of Babbage's Difference Engine could be made by the London Science Museum.

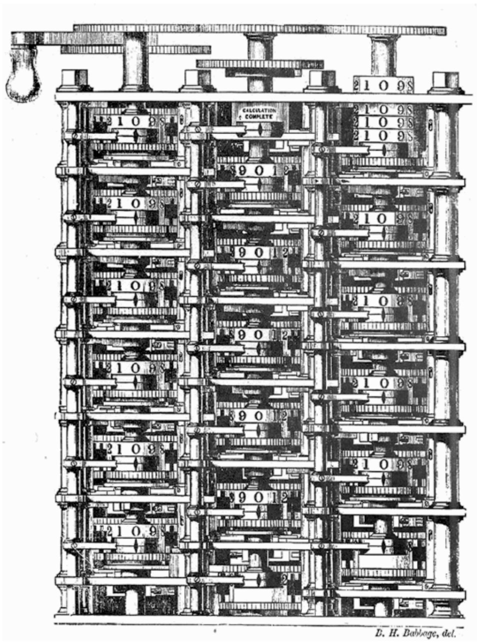


Fig. 2.19 Conceptual sketches for Charles Babbage' Difference Engine (1833).

Like Babbage, the American inventor *Hermann Hollerith* (1860–1929) also used punched cards and, with the help of the first functional data processing system, supported efforts to carry out the American census. Analyzing the previous U.S. census without any mechanical means had been a huge undertaking and lasted nearly seven years. With the population boom and increase in the number of questions, the authorities feared that the time needed for a new census could even stretch to ten years. It was clear that they had to find a solution. Hollerith received the patent for a **punched card tabula-**

ting machine in 1890. In contrast to Babbage's machine, it used punched cards to store data rather than to control the calculation process. Hollerith's punched card was a highly flexible storage medium, which together with an electro-mechanical reader anticipated the possibilities of today's data processing: database setup, counting, sorting and searches based on specific criteria. Using Hollerith's machine it was possible to complete the evaluation of the 11th U.S. population census in a period of only six weeks instead of the ten years that had been originally projected.

The first operational, **program-controlled computing machine** was constructed in 1937 by *Konrad Zuse* (1910–1995). The fully automatic "Z1", was based on the principles of the binary calculation introduced by *George Boole* (1815–1864). In 1941, on orders of the Reich Ministry of Aviation, Zuse built one of the first electromechanical computers, the "Z3."It used logical switching elements based on electromechanical relays [261]. Besides Zuse there were a number of other scientists who worked on the realization of freely programmable computing machines at the end of the 1930s. The American mathematician *Howard H. Aiken* (1900–1973) began constructing a mainframe computer at Harvard University in 1939. The "Harvard Mark I,"was completed in 1944. In addition to punch-card assemblies, it was consisted of electromechanical relays and tubes. The war effort and new possibilities of secret military wireless communication, for example the German cipher machine "Enigma," for the encryption of alphanumerical information, or the prediction of missile trajectories, encouraged the development of automatic computing systems. England began construction of a computing system under the alias "Colossus."It became operational in 1943 and was used for decrypting secret radio messages transmitted by the German Wehrmacht.

The first **fully-electronic**, **general-purpose** computer, based entirely on electron tubes, was invented in 1945 at the University of Pennsylvania. It was constructed by *John P. Eckert* (1919–1995), *John W. Mauchly* (1907–1980), *Herman H. Goldstine* (1913–2004) and *John von Neumann* (1903–1957). It was given the name "**ENIAC**" (Electronic Numerical Integrator and Calculator). The ENIAC contained 18,000 electron tubes, an unbelievable number for that time, and required an output of 160 kilowatts of electrical energy for operation. Unlike its predecessors, "Colossus" and "Mark I," the "ENIAC" was a fully programmable computer. It was capable of a computational performance that was up to 1,000 times faster than its predecessor due to its entirely electronic construction, Upon completion of the "UNIVAC I" in 1951, the Sperry Corporation began mass production of the standard, general purpose computer.

The invention of the transistor in 1947 by Americans *John Bardeen* (1908–1991), *Walter House Brattain* (1902–1987) and *William Shockley* (1910–1989), at Bell Laboratories in New York, changed the development of the computer to a large degree. The extremely complex tube construction, which involved a high degree of maintenance, entered a whole new phase by way of the smaller and more reliable **transistor** as a switching element. Based

The Five Generations of the Modern Computer

First Generation (1945 – 1956)
The development of the modern computer started at the beginning of World War II. It was based on the efforts of individual governments in the hope of gaining a strategic advantage. The machine commands and work instructions implemented in computers of this first generation were especially designed for the specific purpose of the computer. Every computer had a different set of instructions (machine code), which was binary coded in different ways. This made programming a costly and time-consuming endeavor. Basic technology in computers of the first generation were: vacuum tubes, punch cards, and magnetic drum memory storage.

Second Generation (1956 – 1963)
The 1947 transistor revolutionized the design and development of the computer. Computers constructed on the basis of a transistor were more reliable, more energy efficient and smaller than their tube predecessors. With the second generation of the computer, programming languages, such as COBOL or FORTRAN made their debut. Programming turned out to be much easier now than with cryptic machine code. Computers allowed only so-called batch processing, i.e., the jobs to be processed could only be done individually, one after another. With its cost significantly lowered, the computer was gaining a foothold in the business world. Punch cards continued to be used for input and output but now magnetic tape was used as well.

Third Generation (1964 – 1971)
While transistors had clear advantages over vacuum tube technology, the surplus heat they produced was often so great that it damaged the computer. In the next step of miniaturization and with the introduction of integrated switching circuits, a much larger number of switching elements could be built in a much smaller space and implemented in a more energy efficient way. As a result the computer became more powerful, smaller and also cheaper. Operating systems were simultaneously developed that allowed a multiprogram operation. In this way, different jobs could be processed at the same time using the computer's resources.

Fourth Generation (1971 – present)
Since the development of the first microprocessor, miniaturization has continued to advance rapidly. The high integration (VLSI – Very Large Scale Integration) at the beginning of the 80s, and the subsequent ULSI (Ultra Large Scale Integration), allow for the possibility of millions of transistors on a single integrated switching circuit. Due to the steady drop in prices computers entered private households in the form of the PC. The easy to use graphical interface makes it possible for even a layperson to operate a computer. Internet and local networks enter the computer world.

Fifth Generation (present –)
The end of the 80s saw the fifth generation of computers developed further in terms of artificial intelligence as well as the arrival of the super computer. This development is characterized by a parallelization of computation in multi-processor systems combined with speech recognition and natural language understanding.

Fig. 2.20 The five generations of the modern computer.

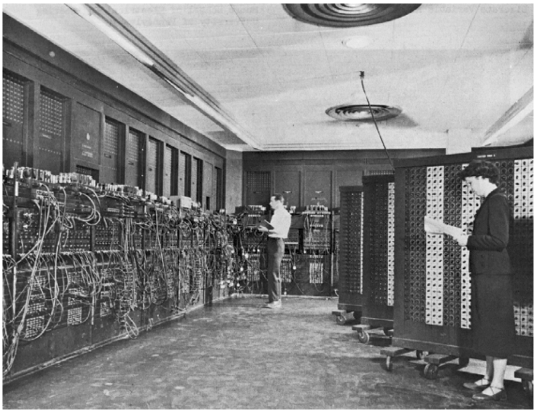


Fig. 2.21 ENIAC – the first completely electronic digital, universal computer.

on Bell Telephone Laboratories' 1955 first transistor computer "TRADIC,“ the transistor came to the forefront along with the IBM development of the magnetic disk memory in 1956. For the first time, the complicated programming of the computer – which until had been carried out customized in the binary code machine language in correspondence with the architecture of the individual computer – could be replaced with a programming language on a higher level of abstraction. For example, the commercially-oriented COBOL (Common Business Oriented Language) or the scientific FORTRAN (Formula Translator).
Already in the 1950s, the tendency toward a gradual reduction in the use of transistors was evident. In 1958, *Jack S. Kilby* (1923–2005) succeeded in inventing a circuit consisting of several components at Texas Instruments. These were resistors, transistors and capacitors on a crystal germanium plate serving as an integrated carrier. The **integrated circuit** (chip) was born. The steady decrease in switching elements led to the emergence of a new computer size at the beginning of the 1960s, the so-called **minicomputer**. The first minicomputer, equipped with a smaller switching element, was the "PDP-1“ from the Digital Equipment company. It came on the market in 1960 and for the first time at a cost less than a million dollars. The "PDP-1“ was not a universal computer, but limited to tasks of process control. At the same time, the new minicomputers with their specialized areas of work resulted in an unprecedented boost in automation in the 60s and 70s. Integrated circuits were produced industrially for the first time on a large scale starting in 1961. The next step in reducing switching elements took place in 1970 with the development of the **microprocessor**. For the first time, all of the components of a universal computer – the arithmetic logic unit, the control unit, the data bus, and the various registers – could be accommodated on a single chip – the Intel 4004. Nevertheless, until 1976 microprocessors were still used only as components of minicomputers and in process control.

Table 2.3 Historical Development of the Computer

30,000 BC	Use of primitive numerals
3,000 BC	First abstract numerical concepts in Mesopotamia based on the sexagesimal system
3rd c. BC	Use of the abacus by the Greeks
circa 500	Introduction of the Arabic decimal numbering system
1494	Leonardo da Vinci constructs the first pendulum clock
1617	John Napier develops a slide rule
1623	Willhelm Schickard constructs the first mechanical calculator for addition and subtraction
1642	Blaise Pascal constructs a mechanical calculator for addition and subtraction
1675	Gottfried W. Leibniz constructs a mechanical calculator for all four basic mathematical operations
1679	Gottfried W. Leibniz introduces the binary numerical system
1805	Joseph Marie Jacquard invents a punched card to control the operation of mechanical looms
1822	Charles Babbage constructs the differential engine, a mechanical calculator for solving differential equations
1832	Charles Babagge designs the analytical engine, the first freely programmable mechanical computer; Babbage's assistant, Ada Augusta King develops the first computer programs
1890	Herman Hollerith develops a punch card counting machine for the US census
1937	Konrad Zuse constructs the Z1, the first program-controlled and actually deployable mechanical computer
1941	Zuse constructs the Z3, the first electromechanical and freely programmable computer
1943	In England the mainframe computer Colossus is built to be used for deciphering German secret wireless transmission
1944	The first American mainframe computer, Harvard Mark I, is completed
1945	Work on ENIAC, the first fully electronic computer, is finished at the University of Pennsylvania
1947	Invention of the transistor
1951	First series computer is built – UNIVAC from Sperry
1955	First computer based on transistors is built – TRADIC from Bell Labs
1956	IBM develops magnetic disk storage
1958	Jack S. Kilby develops the integrated circuit
1960	The first minicomputer is born – the DEC PDP-1
1969	Launch of the ARPANET, predecessor of the Internet
1971	First microprocessor, the Intel 4004, comes on the market
1977	Market entry of the first personal computer – the Apple II
1981	IBM introduces the first IBM PC
1984	Apple introduces Macintosh, the first user-friendly computer

The idea of making the microprocessor the heart of a universal computer was not born in a big computer company but came to fruition among students. This group of young people included *Steve Jobs* (1955–2011) and *Stephen Wozniak* (*1950), who founded the Apple company in 1976. A few years later they succeeded in developing the first successful **personal computer**: the „Apple II.“ IBM introduced its first personal computer (PC) to the market in 1981. It was targeted for offices, schools and home use. The new computer age had dawned. Every year more powerful and ever-smaller microprocessors appeared on the market, offered at constantly lower prices. The PC was equipped with graphic and acoustic output capabilities. Introduction of the Apple Macintosh window-based graphic user interface in 1984 provided the user with easier operation and the PC finally took off in the mass market. Bill Gates (*1955) founded the Microsoft company in 1975 with Paul Allen. The company's success was based on its deployment of the operating system MS-DOS for the IBM PC. It became market leader in the 1990s with the graphic operating system Microsoft Windows and the office software Microsoft Office. New unfathomable possibilities were opened up for the PC as a universal communication medium with the introduction of local networks and public access to the Internet. Equipped with a user-friendly interface – the browser – everyone was now able to use the Internet, or more precisely the World Wide Web. It is a mean of communication that makes it possible to exchange information in every imaginable form whether text, voice, music, graphic or video – thus, a virtual multimedia exchange.

2.9 The Inseparable Story of the Internet and the Web

2.9.1 The ARPANET – how it all began ...

The beginning of the Internet stretches back to the time of the Cold War. The idea of a packet-switched communication service was conceived to ensure a resilient and reliable command and communication connection – even capable of withstanding an atomic attack. Capable of bridging the most different computer networks, this service was called the ARPANET. It was named after its sponsor the American government authority ARPA. Different American universities were involved from the onset in the basic research. Launched in 1969, ARPANET was soon split up into a subnetwork, one area used purely for military purposes and another area used for civilian scientific communication. The civilian section developed rapidly, especially after the National Science Foundation (NSF) began supporting its own high speed network between American universities and research institutions (NSFNET). As a result, the original ARPANET gradually lost its importance and was finally deactivated in 1989.

The idea of packet switching is a cornerstone of Internet technology. It would be hard to imagine secure communication in an uncertain, error-prone network without it. This method of network communication was already developed at the beginning of the 1960s by Paul Baran at the American RAND Cor-

poration, Donald Davies at the British National Physical Laboratory (NLP) and Leonard Kleinrock at Massachusetts Institute of Technology (MIT).
At a meeting of the ARPA research directors in the spring of 1967, the **Information Processing Techniques Office** (IPTO or only IPT), under the direction of Joseph C. R. Licklider and Lawrence Roberts, first put the topic of how to bridge heterogeneous networks on the table. The connection of non-compatible computer networks suddenly became the order of the day. Already in October 1967 the first specifications were being discussed for **Interface Message Processors** (IMP). These dedicated minicomputers, similar to the currently used Internet routers, were to be installed upstream via telephone connection to be coupled to computers. The decision to use standardized connection nodes for the coupling of proprietary hardware to a communication subnet (cf. Fig. 2.22) simplified the development of the necessary network protocols. It was thus possible that the software development for communication between IMPs and the proprietary computers to be left up to each communication partner. In the 1960s and 70s it was also not necessary to grapple with the problem of comptuers not implementing a standardized architecture. Neither the operating system architecture nor the hardware used had common interfaces. Thus for every communication connection between two computers a dedicated interface needed to be developed. Based on the use of a communication subnet in which communication itself depends on the specially provided computers only a special interface would need to be created between the host computer and the communication computer in each case . Accordingly, the number of newly created interfaces grew linearly with the number of different computer architectures and was therefore much more efficient business-wise.

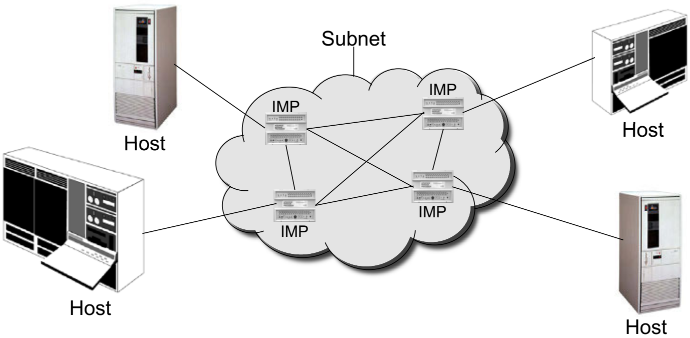


Fig. 2.22 ARPANET – network model with communication subnet.

It was then possible at the end of 1968 to lay down the final specifications of the IMPs based on the work of the **Stanford Research Institutes** (SRI). The respective host computer communicated with the upstream IMPs via a

bit-serial high speed interface in order to connect with the communication subnetwork.. The design of the IMP, based on proposals by Larry Roberts, was implemented by the company Firma Bolt, Beranek & Newman (BBN) using Honeywell DDP-516 minicomputers. The IMPs themselves communicated with each other via modems. The modems were connected via permanently switched telephone lines and could thus cache data packets as well as forward them (store-and-forward packet switching). The first four network nodes of the ARPANET to be connected were based at university research institutes. These were the universities of Los Angeles (UCLA, Sigma-7), Santa Barbara (UCSB, IBM-360/75), Stanford (SRI, SDS-940) and Utah (DEC PDP-10). On October 29, 1969 the long awaited day had finally arrived. The first four IMPs were successfully connected with each other and also with their host computers. Despite the network node at UCLA crashing when the letter `G` of `LOGIN` was entered on the first login attempt, the age of the Internet had clearly begun.
In March 1970, the new ARPANET's expansion first reached the East Coast of the U.S. By April 1971 there were already twenty-three hosts connected with each other via fifteen nodes. The first "prominent" application of the new network was a software for the transfer of text messages from the first email program, developed in 1971 by Ray Tomlinson of BBN. In January 1973, the number of computers in the ARPANET had grown to thirty-five nodes. With the addition of computers in England and Norway, in mid-1973, the first international nodes were added. In that same year the first application for file transfer – the File Transfer Protocol (FTP) – was implemented. Starting in 1975 the network nodes located outside of the U.S. were connected via satellite link. The number of computers in the net grew from 111 connected host computers in 1977 to over 500 hosts in 1983. One of the first successful public demonstrations of internetworking took place in November 1977. Via a special gateway computer, the ARPANET was interconnected with one of the first wireless data networks, the Packet Radio Network, and a satellite network, the Atlantic Packet Satellite Network. 1983 was turning point year in ARPANET history. The communication software of all connected computer systems was changed from the old **Network Control Protocol** (NCP) to the communication protocol suite **TCP/IP**, developed in 1973 under the direction of Vinton Cerf (Stanford University) and Robert Kahn (DARPA). The changeover to the TCP/IP protocol, initiated by the **Department of Defense,** was necessary because the possibilities to ensure communication across heterogeneous networks with the NCP were limited. This changeover proved to be crucial for the worldwide expansion of this network of networks. A decisive factor in the development of an **internet** – a network association made up of networks with different communication architectures – was to find the answer to one important question. How can the communication between computers at the endpoints of networks with different technologies be carried out without the computers themselves being involved in what happens along the path between each other? The ARPANET was split into a military (MIL-

NET) and a civilian user area in 1983. Administratively and operationally there were now two different networks, but because they were linked by gateways the user was oblivious to this separation. The ARPANET had grown to become an Internet. More and more independent local networks were being connected to the Internet so that in the first half of the 1980s the Internet resembled a star. The ARPANET was at the center of different networks grouped around this focal point. However, this picture changed at the end of the 1980s. At the beginning of the 1980s the ARPANET-integrated CSNET (Computer Science Network) from the American **National Science Foundation** (NSF) had been linking more and more American universities. It finally became possible for its successor, the NSFNET, to connect all universities via a specially designed high speed backbone, thus giving every college student the chance to become an Internet user. The NSFNET quickly developed into the actual backbone of the Internet. One reason for this was its high-speed transmission lines – more than twenty-five times faster than the old ARPANET. Besides its scientific use, a commercial use also became established via the NSFNET. This had been strictly forbidden in the original ARPANET.
At the beginning of the 1990s, the number of networked computers in the NSFNET far exceeded those in the ARPANET. DARPA management – in the meantime the ARPA had been renamed the **Defense Advanced Research Project Agency** – made a crucial decision in August 1989. Having been determined that the ARPANET had outlived its purpose, it was shut down on the occasion of its twentieth anniversary. The NSFNET and the regional networks that emerged from it were to become the new, central backbone of the Internet as we know it today.

2.9.2 The Internet Goes Public

There are two primary reasons for the Internet's triumph as a mass communication medium. First, the opening of the new medium for the general public and the provision of a simple user interface – the WWW browser. Laypeople were also empowered with the ability to easily use the medium of the Internet and the services it offered, such as WWW or email. The date of the Internet's birth is often set at the same time as the changeover from the until then valid network protocol of the ARPANET – NCP – to the new **protocol family TCP/IP**. The three basic protocols of the TCP/IP protocol family are: IP (Internet Protocol), TCP (Transmission Control Protocol) and ICMP (Internet Control Message Protocol). These had already been established and published as Internet standards in 1981 in the form of RFCs (Request for Comments). By using the TCP/IP protocol family the interconnection of different network technologies in a simple and efficient way was possible for the first time.

Table 2.4 From the ARPANET to the Internet – An Overview (1957 – 1989)

1957	Launch of the first Soviet satellite Sputnik and founding of the ARPA
1960	Paul Baran, Donald Davies and Leonard Kleinrock produce their first works on packet switching
1962	The IPTO is launched as a department of the ARPA
1965	The ARPA sponsors groundbreaking research at American universities
1967	First meeting of ARPA managers on the subject of ARPANET
1968	Specification of the IMP communication computer concluded
29.10.1969	The first four nodes of the ARPANET are interconnected
1970	ALOHANET, the first wireless computer network connecting the main Hawaiian islands, begins operation
1971	Ray Tomlinson sends the first email
1972	ARPA is renamed the Defense Advanced Research Projects Agency (DARPA); Larry Roberts organizes the first public ARPANET demonstration
1973	The ARPANET contains 35 nodes; Vinton Cerf and Robert Kahn develop the TCP protocol; Robert Metcalfe develops ideas for Ethernet technology (LAN)
1973	The FTP file transfer program is implemented
1975	Launch of the satellite network connection: Hawaii, the U.S. Mainland, London via Intelsat 1
1975	ARPA hands over operation of the ARPANET to the DCA
1977	First public demonstration of internetworking
1978	The standardization organization ISO adopts the OSI communication layer model
1983	Splitting of the ARPANET into one section for civilian purposes and another for military use (MILNET); conversion of the entire ARPANET to TCP/IP
1984	The supercomputer program of the National Science Foundation (NSF) includes construction and maintenance of a high-speed network (NSFNET, 56kbps backbone)
1986	NSFNET begins operation
1988	First Internet worm attacks the net; 10% of the 60,000 hosts at that time are affected
1989	150,000 hosts are connected on the Internet; the decision is made to close the old ARPANET

The new technology was quickly accepted by the scientific community as it allowed the scientific communication process to become greatly simplified and accelerated. Interestingly, the ongoing development and refinement of the Internet constantly received new inspiration from the gaming instincts of its participants. The first weekly "net meetings", were already taking place between 1973 and 1975. Participants from a variety of linked research institutes organized "virtual" meetings to play "STAR TREK", , a distributed computer game based on the television series with the same name. The development and spread of the operating system **UNIX** also played an instrumental role in the expansion of TCP/IP and in contributing to the popularity of the Internet. This was particularly true with the development of the free operating system BSD-UNIX at the University of California in Berkeley. From the very beginning it was ARPA's aim to make the Internet as attractive as possible for university researchers and scientists. A great number of computer science institutes at American universities used UNIX as their computer operating system, in particular BSD-UNIX. On one hand ARPA supported BBN in their rapid implementation of the TCP/IP protocol and on the other hand Berkeley, in order that the TCP/IP protocols would be adopted in their operating system distribution. In this way it was possible for the ARPA to reach over 90% of the computer science departments at American universities. The first computer science departments were namely just being established at this time and in the process of buying their computers and connecting them to a local network. The new communication protocols therefore arrived at the right place, at the right time.

Internet Design Principles

In 1974, Vinton Cerf and Robert Kahn publish architectural principles known as **Open Network Architecture** These principles remain the foundation of today's Internet:

Minimalism and autonomy: A network should be able to work in autonomously. No internal modifications should be necessary in order to link to other networks.

Best possible service: Crosslinked networks are designed to offer the best possible service from one terminal to another. So that reliable communication can be guaranteed, corrupted or lost messages are retransmitted by the sender.

Stateless switching computer: The switching computer in crosslinked networks should not store or process information on the state of an existing network.

Decentralized control: There should be no global control over individual crosslinked networks. Organization is carried out in a decentralized manner.

Further reading:

Cerf, V., Kahn, R.: A Protocol for Packet Network Interconnection, in IEEE Transactions on Computing, vol. COM-22, pp. 637–648 (1974)

Fig. 2.23 Internet design principles from V. Cerf and R. Kahn.

While the original ARPANET was shut down in 1989, the NSFNET network association, created by civilian funding, was technologically superior as a backbone and had a considerably higher bandwidth. The number of computers connected to the Internet had risen to over 150,000 in 1989. When on the evening of November 2, 1988 the first **Internet worm**, a self-replicating program, paralyzed a fabled 10% of the 60,000 computers connected to the Internet it was a public sensation. Directly affected were the VAX and SUN-3 computers. The widely used Berkeley BSD-UNIX operating systems ran on various versions of these computers, which were then used as a base for attacking other computers. Within a few hours the program had spread across the entire U.S. Thousands of computers were put out of commission due to system overload caused by the high level of activity. In the meantime, the significance of data networks such as the Internet for public life has greatly increased. It is a growing dependency that makes such attacks a serious threat to public life. In an extreme case scenario an entire country and its economy can be thrown into information chaos In response to this early attack, the **Computer Emergency Response Team** (CERT) was set up by the U.S. Department of Defense, its headquarters at the Carnegie Mellon University in Pittsburgh. The role of the CERT is to establish the strongest possible expertise in cyber security, to identify weaknesses of previous Internet installations and applications, as well as to to give recommendations, which should be followed by the users and operators of the Internet. Security incidents are reported to the CERT, with attempts made to clarify them and to take the necessary precautions to prevent such incidents from occurring in the future or bringing those responsible to justice. CERT is however purely a research institute without any police or government authority and may not tax legal action against a threat or its cause.

2.9.3 The WWW Revolutionizes the Internet

The World Wide Web (WWW) and its easy to use interface, the browser, finally helped the Internet to achieve its legendary success and worldwide dissemination. The fact that the browser, as an integrative interface, is able to combine access to many different types of Internet services, such as email or file transfer, simplified the use of this new medium to such an extent that it could expand to become a major mass communication medium.
The basis of the World Wide Web is the networking of separate documents via what are called **hyperlinks**. A hyperlink is nothing more than the explicit reference to another document in the web or to another location within the same document. As long as text-based documents are involved, one speaks of interlinked **hypertext** documents. The underlying idea of the referencing to another text or to another text document is not an invention of the computer age. The Jewish laws of the Talmud, whose origin goes back to the first century of our calender system, contains such cross-references. Another prominent historical example of a hypertext document is the great French encyclopedia (*Encyclopèdie, ou dictionnaire raisonnè des sciences, des arts et des mètiers*), which was published by Jean le Rond d'Alembert (1717–1783) and Denis Diderot (1713–1784) between 1751 and 1766. The history of the electronic hypertext first began in the the twentieth century. In 1945, an article by Vannevar Bush (1890–1974) appeared in the magazine "Atlantic Monthly" entitled "As We May Think."Bush envisioned a device he called the **Memex**. Working by electromechanical means it was designed to link and set microfilm documents in relation to one another, to represent the knowledge of a person and serve as a memory aid [34]. Bush is regarded as a visionary and a harbinger of the World Wide Web.

While many experts do not recognize the Memex as a genuine hypertext system, with his article Bush influenced the work of WWW pioneers who followed him. As early as 1965 the terms “hypertext“ and “hypermedia“ were coined by Ted Nelson, who in 1968 contributed to work on the development of the **Hypertext Editing Systems** (HES) at Brown University in Providence, Rhode Island. Douglas Engelbart (1925–2013) developed the **NLS** (oNLine System) between 1962 and 1968. This was a hypertext system with, among other things, a window-based user interface and a mouse as an input device. Hypertext and hypermedia reached the personal computer in the 1980s with Apple's **HyperCard**.

In 1989 at the Swiss nuclear research institute CERN, Tim Berners-Lee drafted “*Information Management: A Proposal.*“He described a distributed hypertext-based document management system designed to manage the documentation and research data produced in massive amounts at CERN. The following year he received the green light to actually implement his idea on a NeXT computer system with Robert Cailliau. It was already possible to run the first WWW server in November 1990. Tim Berners-Lee called it **WorldWideWeb** and in March 1991 the first WWW browser followed.

Table 2.5 The History of the World Wide Web

1945	Vannevar Bush describes the first hypertext system, Memex
1965	Ted Nelson is the first to coin the word **Hypertext** at the ACM yearly conference
1968	Douglas Engelbart develops a hypertext-based prototype system NLS and invents the mouse as its input device
1980	Tim Berners-Lee writes a first notebook program (ENQUIRE) with hypertext links
1989	Tim Berners-Lee writes a first memorandum about his documentation management system at the nuclear research center CERN
1990	Together with Robert Cailliau, Tim Berners-Lee develops the first WWW server and WWW browser: the WorldWideWeb is born
1993	NCSA Mosaic, the first WWW browser with graphic user interface introduced
1994	Netscape is founded
1994	The World Wide Web Consortium (W3C) is founded
1995	Microsoft debuts its operating system Windows95 together with the Internet Explorer as WWW browser
1998	Netscape is sold as AOL, the browser war comes to an end
2004	Dale Daugherty and Tim O'Reilly coin the term Web 2.0 and speak of a rebirth of the WWW

A few months later in September 1991, the American physicist Paul Kunz from Stanford Linear Acceleration Center (SLAC) visited CERN and was introduced to the WWW. Excited about the idea, he took a copy of the program back with him to the U.S. and in December 1992 the first WWW server entered the network at SLAC. The new server can be attributed to the personal initiative of university members. While in 1992 there were just twenty-six WWW servers, at the beginning of 1993 the number of worldwide operated WWW servers had doubled to almost fifty. The development of the first WWW browser with a graphical user interface – co-authored by Marc Andreesen for the X Window System – finally made it possible for the non-specialist to use the WWW from the end of 1993 on. This was even more the case after the NCSA released versions for IBM PCs and for Apple's Macintosh. The number of WWW servers rose to 500 by the end of 1993, with the WWW responsible for approximately 1% of the worldwide Internet data traffic.

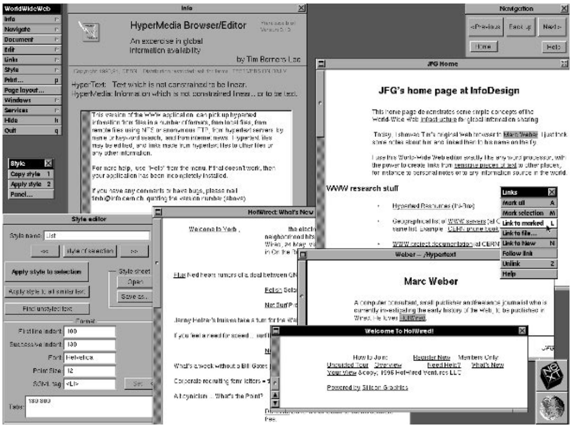


Fig. 2.24 WorldWideWeb – the first web browser for the WWW.

1994 was to become the year of the WWW. The first International World Wide Web Conference was held in May 1994 at CERN. Many more had actually registered than the 400 researchers and developers who were in attendance – there was simply not enough space to accommodate everyone interested in the WWW. Reports about the WWW reached the attention of the media and in October a second conference was announced in the U.S. It was attended by 1,300 people. Due to the widespread dissemination of the Mosaic browser, developed for the Netscape Navigator, and its market competitor the Microsoft Internet Explorer, included in every Microsoft operating system sold since 1995, the World Wide Web experienced unbridled popularity. If the growth rate of linked computers had been doubling yearly until this time, it now doubled every three months. The WWW spread like a wild fire around the world, finding its way into offices and homes.

Based on the Internet and its regulatory institutions, Tim Berners-Lee saw the necessity of an independent body regulating the development and growth of the WWW. Furthermore, standards should only be defined by an independent body and not solely by the industry to prevent the formation of monopolies. Thus, together with Michael Dertouzos, the director of the Laboratory of Computer Science at MIT, Berners-Lee started raising resources for the creation of a **World Wide Web Consortium** (**W3C**). The W3C was laun-

Table 2.6 The WWW – how it all began

First WWW server in the world: `nxoc01.cern.ch`
First WWW page in the world: `http://nxoc01.cern.ch/hypertext/WWW/TheProject.html`

ched in 1994 with the support of MIT, the Institute National de Recherche en Informatique et en Automatique (INRIA) in Europe, the DARPA and the European Commission. It set its goal as monitoring the further development of WWW protocols and supporting the interoperability of the WWW. As economy and trade discovered the WWW and its myriad of possibilities, **E-Commerce** became a recognized concept starting in 1995. The first shopping systems were set up and companies such as **Amazon.com** or **Google.com** emerged overnight to quickly become trading giants on the stock market. The registration of Internet addresses and names became a paid service, with large companies often spending large sums of money for legal protection of their name in the WWW. A virtual hype was created and took the entire business world by storm. The "New Economy" became a way to describe the euphorically celebrated new Internet-based economic model. The so-called Silicon Valley in the U.S. saw the birth of **dot-coms**; businesses so named because of their WWW address **.com** suffix. Most of the time these companies were based on a simple business idea of a web-based service. Supported by venture capital and investors, they were built up within just a few months before being bought out by a larger competitor and – if successful – earning astronomical profits However, in most cases the earnings these companies had projected never materialized. The consumer remained hesitant about online shopping – at least as long as no unified and secure transaction mechanism was available. Suddenly in the middle of 2000 the market collapsed and, at the same time, the "dot-com bubble" burst. In keeping with the old stock market adage, after the exuberant hype a long descent followed, before a real market assessment could – slowly – be made.

2.9.4 Web 2.0 and the Semantic Web – The Future of the WWW

Although the second decade of the WWW is coming to a close, there is no end in sight to the development of the WWW. The WWW is continuing its further development with the possibilities provided by new access devices. Already at the end of the 1990s the first attempts were made toward developing WWW accessibility on mobile devices and cell phones. This va-

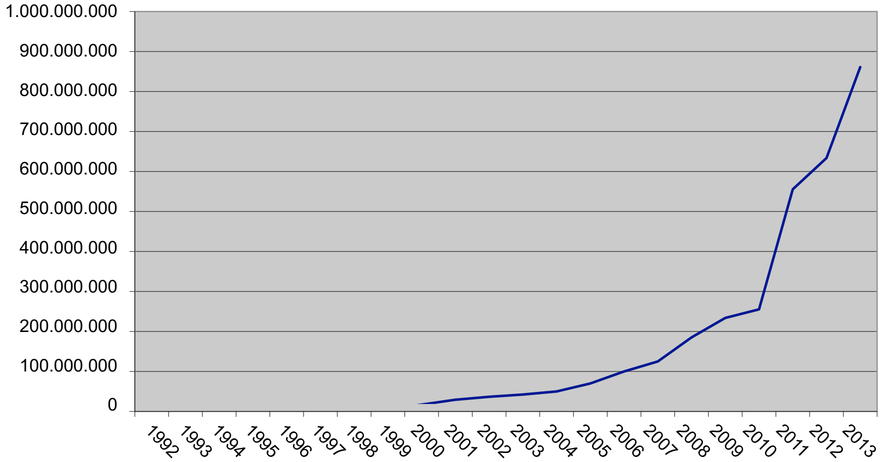


Fig. 2.25 Growth of the World Wide Web.

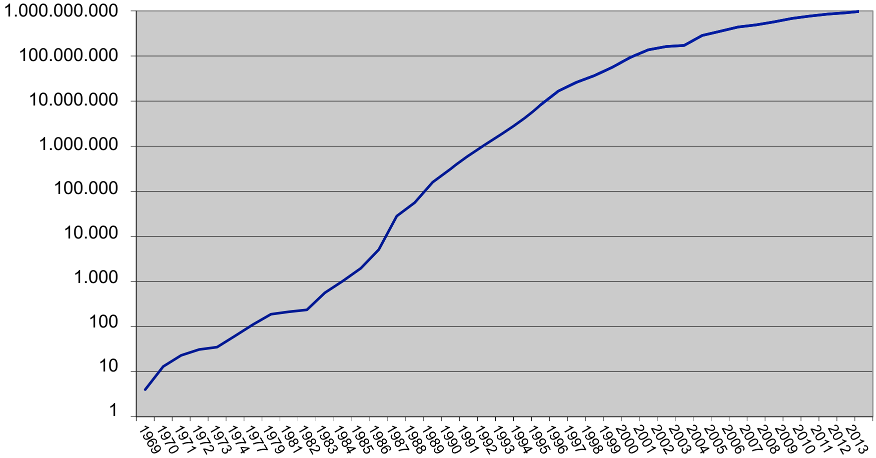


Fig. 2.26 Number of Internet-connected hosts.

riation of WWW data traffic could only find gradual success, due in part to the poor quality of the respective mobile user interface. Mobile devices as such offer a relatively small display for the WWW contents. Tight limitations were also set on mobile WWW traffic due to narrow bandwidths and weak display technology. Today however advanced miniaturization and fast mobile networks of the third generation allow nearly comparable operation in the mobile area. Additionally, satellite tracking systems (Global Positioning System, GPS) make possible geographical coverage of the respective browser

location and in this way offer special, location-dependent services, such as e.g., information and navigation systems.
Since its birth in 1990, the World Wide Web has also changed dramatically content-wise. Initially, a networked document management system connected via hyperlinks, with its availability limited to only a small number of users, in the years that followed the WWW developed into the largest information system of all time. With the arrival of e-commerce, the focus of the WWW changed from a personal communication and publication medium for specialists to one of mass communication. Information production and consumption remained strictly separate, with only a specialist capable of putting contents online. The public at large consumed the information offer, which paralleled that of commercial providers in traditional broadcast medium. The user's interaction was limited to reading web pages, ordering goods and consumer products online and clicking banner ads. But the WWW continued to change. New technology was developed and it became suddenly possible for laypeople to publish information contents in a simple way themselves. Blogs, chatrooms, file sharing, tagging systems and wikis have conquered the WWW and opened up paths to the user leading to genuine interaction and participation in the digital world on a broad basis. When in October 2004 media entrepreneur and web pioneer, Tim OReilly presented the changed face of WWW, under the name **Web 2.0**, to a audience made up exclusively of specialists, the repercussions of this "Renaissance of WWW" were not foreseeable. The Internet has been transformed from a pure broadcast medium into a genuine interactive market place. The user is the information consumer and the information producer at the same time. This new interactivity also allows for the direct and indirect formation of new social networks.
Besides the evolutionary development of the WWW, the amount of information offered has continued its extraordinary growth. **Search engines**, such as Google, were developed to lead the the user through the mass of information in the WWW. For this purpose, Google manages a gigantic index that provides comprehensive access to the relevant web document in a matter of seconds, on input of a search word. Based on the sheer size of the WWW this is only possible with the help of automatic methods for indexing. Using statistical methods, all items within a web document are evaluated and brought into ranked order in terms of a specific subject heading. The amount of returned search results is no longer comprehensible for the user. For example, the search item "Web 2.0" alone produces more than 74 million results (as of 10/2008). However, the result list only contains documents in which this term appears literally. In this way, paraphrases and synonyms cannot be found. Just as a document containing the search item does not necessarily address it as its focal point. Based on the problematic interpretation alone, it is not possible for the completeness and accuracy of search results to even come close to natural language.
To do this it would be necessary to systematically supplement the web document with the relevant meaningful data (so-called **metadata**). Such a web

document supplemented with metadata would contain along with each of the relevant terms in the document, a reference to one of the concepts described by the term. Besides containing any document relevant to this term, this type of a web document, supplemented with metadata, would need to have a reference to a descriptive concept that the term included. These conceptual descriptions – so called **ontologies** or knowledge representations – can be stored in a machine-readable standardized form and evaluated additionally by a search engine in order to raise the hit number of the search results. The WWW Consortium (W3C), the entity responsible for the WWW standardization, has already created the necessary foundation in the form of ontology descriptive languages such as RDF, RDFS, OWL, and SPARQL. Semantically annotated websites make it for possible autonomously acting agents to collect targeted information. The system then automatically makes decisions as defined by its client and initiates transactions via the web. This semantic network (**Semantic Web**) represents the next step in the evolution of the WWW and it is about to become a reality.

2.10 Glossary

Alphabet: The ordered sequence of letters (phonetic symbols) in a language; from [Lat.]*alphabetum*, [Gk.]*alphabetos*, the first two letters of the Greek alphabet: alpha (α) and beta (β). Beginning in the third century BC, the word designated the summary of all Greek letters. The word "alphabetum" was used for the first time in Latin by the early Christian poet Tertullian (ca. 160–220 AD). German script is based on the Latin alphabet, which evolved from a branch of the Phoenician alphabet. The German alphabet consists of twenty-six capital (majuscule) and small letters (minuscule), as well as letter combinations with umlauts and accented characters.

Analog: (*ana logum*=[Gk.] in the right proportion), Term for technology methods in which continuous, i.e., infinitely variable, physical qualities are used.

ARPANET (Advanced Research Projects Agency Net): The first packet switching data network and precursor of the Internet, it was launched by DARPA, a research initiative of the U.S. Department of Defense. The first network node (Interface Message Processor, IMP) was ready for implementation on August 30, 1969 and the ARPANET began operation on December 1969 with 4 IMPs in Stanford, Santa Barbara, Los Angeles and Utah. In its heyday it included several satellite links, among them from the west to the east coast of the U.S., to Hawaii, Great Britain, Norway, Korea and Germany. The ARPANET ceased operation in July 1990.

Block book: Multiple separate printed pages bound into a small book, whereby the texts and pictures of each page are printed from a woodcut.

Colophon: ([Gk.]= target, end point) Information about the printer, the place and date of printing, found at the end of a document or, as the case may be, information about the copyist of a manuscript.

Communication: Communication is understood as the process of a one-way or reciprocal transmission; the sending and receiving of information by people or technical systems.

Digital: (*digitus*=[lat.] Finger), Designation for technology/processes that use only discrete, variable, i.e., stepped, mathematical sizes. The foundation of digital technology is the binary number system that contains just two states: "true" and "untrue" or the numerical values "1" and "0". The binary numerical values are designated **bits** (**binary digits**) and represent the smallest possible unit of information.

Flyer: Politically or commercially motivated, event-focused, one page broadsheets. Originally flyers served less as a source of inciting political agitation and more as an actual trade article. Offered by barkers and traveling merchants, their author was usually anonymous.

Grammar: Description of the structure and rules of language as a part of linguistics (morphological and syntactic regularities of a natural language). In comparison to language and writing development, the fixed rule system of grammar as a basis for defining language use was a late development historically speaking (from the fifth century BC). In the realm of philology, grammar is viewed as a tool in language analysis for capturing the historical development of a language.

Homonym: Words that have the same pronunciation but designate different things or have a different meaning, e.g., „change" (as a noun and a verb).

Ideogram: Symbols or combinations of symbols that are used for the identification of non-object items, such as activities, abstract concepts, or feelings. The meaning of ideograms must first be learned and is based on the fixed formal system of each culture.

Illumination: Artistic highlighting and pictorial decoration of initials (sentence and chapter beginning) on a manuscript or an early printed work. Further decorative items (often vines) were sometimes added to an illumination. Depending on the importance of a paragraph, between two and ten lines were kept free for the design of an initial.

Imprimatur: ([Lat.]=it may be printed) Ecclesiastical permission to print a work. Papal bull by Pope Innocent VIII (1432–1492) and Pope Alexander VI (1430–1503) served to institutionalize the first censorship. Before a book was printed ecclesiastical permission was required.

Incunabula: ("in the cradle") Early printed matter that was produced between 1450 and 1500. The name derives from the Latin word for "diaper." The most famous among the incunabula works is the forty-two line, magnificent Gutenberg Bible. Of the original 185 copies only 48 have survived – some of them only partially.

Internet: The Internet is the world's largest computer network consisting of many networks connected to each other as well as individual resources. Among the most important benefits of the Internet – one speaks of "services"– are electronic mail (email), hypermedia documents (WWW), file transfer (FTP) and discussion forums (Usenet/newsgroups). The global network has attained its popularity mainly due to the introduction of the World Wide Web (WWW), which is often equated with the Internet, but is in fact just one of the many services the Internet offers.

Language: Linguistics defines language as the sound-based form of communication by humans. It is a method, not rooted in instinct, for the transfer of thoughts, feelings and wishes by means of a system of freely created symbols.

Medium: Manifestation of the transport channel for message transmission between a sender and a receiver.

Onomatopoeia: Words that describe a concept by way of sound transcription or imitation e.g., „bark".

Pamphlet: Although non-periodical, pamphlets are considered the forerunners of today's newspapers. Unlike flyers, they usually consisted of pages that were printed on both sides.

Parchment: Parchment is a writing material made of animal skin that was already known in antiquity. Parchment preparation involves curing animal skins with lye and cleaning them to remove flesh and hair. The skins are then stretched onto frames to dry.

Petroglyphs: Drawings by prehistoric, nomadic hunters that are carved in, or painted on, stone.

Photo effect: The photo effect (also photoelectric effect, Hallwachs effect, or light electric effect) describes the release of electrons from a metal surface when it is struck by electromagnetic radiation, in particular that created by light. The photo effect is the foundation of light-sensitive sensors, such as the CCD senors in digital photography.

Picotogram: Symbols that are used for the description of objects, people or animals, e.g., as information signs or traffic signs. Pictograms are considered an early stage in the development of writing.

Pulse Code Modulation (PCM): Method of analog-digital conversion, based on the sampling of an analog signal, which is followed by the discretization of the obtained sample value. **Sampling** disassembles the continuous time course of a signal into discrete, separate time points, thus capturing the current value of an analog signal in each discrete point in time (sampling time). These exact sampling values are subsequently rounded to binary coding in predefined quantization intervals.

Relief printing: Considered the oldest method of printing technology, whereby ink is applied directly to the raised portions of a printing block and transferred with pressure directly onto the material to be printed. In a mirror-image print, the non-printed areas must be cut deeper on the block before printing.

Retinal inertia: The concept whereby a visually perceived image remains on the retina of the human eye for approx. 1/16 of a second before disappearing. Described in antiquity by Ptolemy of Alexandria (85–165 AD), retinal inertia forms the basis for the technology behind film and television. When individual frames are displayed quickly enough one after another – in a sequence of fifteen frames per second – an impression of continuous movement is achieved

Semantic Web: The Semantic Web describes an expansion of the existing World Wide Web. In the Semantic Web every piece of information receives a well-defined and machine-readable meaning that enables programs acting autonomously to interpret the information contents and, based on this, to make decisions.The concept of the Semantic Web is rooted in a proposal by WWW founder Tim Berners-Lee.

Semantics: Semantics designates that area of linguistics dealing with the theory of meaning. The focus is on the sense and importance of language and linguistic signs. The focus is on the question of how the sense and meaning of complex concepts is derived from simpler concepts. Semantics relies on the rules of syntax.

Sign: Designation for "something"which stands for something else ("signifier"). The relation between a signifier and and what is signified is always a direct one. The relationship of the signs to each other and how they can be combined together to form new terms is defined by syntax.

Synonym: Phonetically different words used to describe the same object, or which have the same meaning, e.g., "charwoman" and „cleaning lady."

Web 2.0: Web 2.0 describes a "seemingly" new generation of web-based services, geared in a special way to the non-specialist and characterized by their simple possibility of participating and interacting in the WWW. Typical examples of these services are wikis, blogs, photo and video sharing sites or portals.

Woodcut: A variation of relief printing using paper as the printing medium. After a picture is drawn on the wooden block, the non-printed areas are deepened while the remaining raised portions are colored and then printed onto damp sheets of paper. These are laid over the inked wooden block and pressure is applied with a cloth roll. Because the ink often often seeps through paper, printing is usually done only on one side of the sheet. A woodcut printing pattern could be used several hundred times.

World Wide Web: Term for the "worldwide data network" (also WWW, 3W, W3, Web). The WWW refers to the youngest and at the same time most successful service on the Internet, characterized to a certain degree by its user-friendliness and multimedia elements. WWW actually denotes a technology capable of implementing a distributed, Internet-based hypermedia document model. Internet and the World Wide Web (WWW) are often erroneously used as synonyms. The WWW is just one of the special services transmitted by the HTTP protocol.

WWW server: Process on a computer with the functionality of answering enquiries from the browser via the WWW. From a technical point of view, a WWW server can be operated on every computer connected to the the Internet.

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