Technical Translation of the Astrolabe Description - the Astronomical Instrument

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ABSTRAKT

Předmětem této bakalářské práce je překlad a analýza vědecko-technického textu, který byl poskytnut firmou Festo. Tento text popisuje astroláb neboli orloj, přístroj ze starých časů, který byl postaven profesorem Hansem Scheurenbrandem, bývalým vedoucím pro výzkum a vývoj ve společnosti Festo AG. Teoretická část je zaměřena na poskytnutí více či méně obecných informací na téma technický text a překlad. V praktické části je přeložen zdrojový text, který je následně analyzován. Pro lepší orientaci při případném dalším překládání byl vytvořen slovníček zvláštních pojmů vybraných z tohoto textu. Původní text v Anglickém jazyce lze shlédnout v přílohách této práce. Hlavním cílem této práce je překlad vědecko-technického textu a následná analýza faktů, týkajících se překladu tohoto textu i textu samotného.

Klíčová slova: technický text, vědecko-technický styl, překlad, překladatel, astroláb, ekvivalence

ABSTRACT

English abstract

The subject of this bachelor thesis is the translation and analysis of the technical/scientific text which was provided by Festo company. This text describes the astrolabe and/or astronomical clock, the device from the ancient times, which was constructed by Profesor Hans Scheurenbrand, former director of research and development at Festo AG. The aim of the theoretical part is to provide more or less general information about the subject of technical text and translation. The source text is translated and subsequently analyzed in the practical part. The terminological dictionary of specific terms was created for better orientation in case of another potential translation of this text. The original text in English can be seen in appendices of this thesis. The primary aim of this thesis is translation of the technical/scientific text and subsequent analysis of the facts about the translation of this text and about the text itself.

Keywords: technical text, technical/scientific style, translation, translator, astrolabe, equivalence

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CONTENTS

INTRODUCTION

New technologies and inventions require both the exact description and the accurate translation, to provide comprehensible information about new scientific subject matter to people from different countries, who might need or use that information for some kind of purpose.

In today's world of science, new inventions and technologies are continuously being created. Nonprofessionals are not generally familiar with the technical terms, which are used in well-detailed descriptions of the new inventions and technologies. Therefore, it is essential for translators to learn the proper terminology in advance or to read the literature on similar topic to acquire some general knowledge about the target subject. Each scientific field, for example chemistry, physics, astronomy or earth sciences, uses its own sets of words and phrases (terminology) which differ from one another. For that reason, translator has to concentrate properly on the specific terminology, but also the grammatical and stylistic norms and regulations, which belong to the particular area of the scientific text. Despite the fact that the technical texts differ in vocabulary and terms according to individual scientific fields, there are some features which all technical texts have in common. Technical texts have in most cases the written form, they are comprehensive, compact, lucid and objective and they are often written in the impersonal style which is achieved by the use of passive voice. Last but not least, the grammar and lexis of the technical text should be clear; therefore no personal innovations are expected in the technical style.

To provide an accurate translation of manuals, descriptions and other technical texts into multiple languages, translator has to be familiar with the subject of the text, which is being translated. Original texts come from various languages and theirs translations into multiple languages are not always identical. The dissimilarities in individual translations are caused by different knowledge, positions and attitudes of individual translators and different scope of everyone's vocabulary as well. The principle precondition, to provide any kind of textual translation between two languages, is the knowledge of both source and target language to the extent which is needful for translation of such a text. In addition, the translator sometimes needs to add or omit some information from the text to provide the "good" and accurate translation.

Fortunately for translators, nowadays exist various tools which aim is to make the translator's work easier. These tools, utilized by translators, are variety of general and specialized technical dictionaries, computer-aided-translation (CAT) and machine translation (MT). In the case of machine translation the process of translation is fully mechanized, whereas in computer-aided-translation programs the assistance of a human translator is still required. The main purpose of this bachelor thesis is to provide the general and more specific information about the technical style of writing, translation, translation tools, translator's attributes and furthermore to provide the accurate translation of the astrolabe description. Translation engaged in this thesis was created for all people who are interested in science and, above all, for the marketing purposes of the Festo, Ltd. located in Prague.

I. THEORY

1 TECHNICAL TEXT AND ITS FEATURES

Technical and scientific texts and literature are indeed broad terms. Therefore, the main aim of this theoretical part is to characterize technical and scientific texts and their features; and thus to make this area of scientific writing more lucid to people who might be interested in it. Since the language and scientific discourse have been developed enough to record accurately new pieces of knowledge and because science and technology are still developing phenomena, we are obligated to write down every new piece of information so that everyone who is interested in that information can find it and use it later. Some characteristics can be applied to the most of technical and scientific texts, but the main difference remains in specialized terminology which differs among the individual branches of science. To the category of technical writings belong specialized manuals, guides, technical essays and treatises. The nature of these writings is mostly pragmatic, but some of them may sometimes contain elements which may be considered as entertaining.

1.1 How can we define technical text

"Scientific English" is, more often than not, a well-distinguishable variety of modern English language. It can be recognized by most experienced speakers of the English language. This is not caused by the fact that the "scientific English" is all the same, on the contrary, most of scientific works are unique. But there are specific collections of features which can reveal the very idea that what we are just hearing or reading is a scientific text. (Halliday 2004, 141-143)

Technical text is undoubtedly a part of scientific writing. The reason why scientific writing is so important in today's world is highly intelligible. Every new outcome in a form of measurement, invention or discovery has to be written down or otherwise recorded, so that it could be open to public later on. Another statement about scientific writing is much too clear, but still probably the most important statement of all, that without the perpetual swap of information there could be no science. The exchange of scientific information is exceptionally important, since many discoveries in science are based on information or discovery which was already uncovered before. It means that previous discoveries can serve as building blocks for other researchers in their ways to find something new, something astonishing. (Ebel, Bliefert and Russey 2004, 3)

Technical texts may sometimes seem unnecessarily complicated to non-professional readers. This is because the technical texts are written in "scientific" language, a "jargon" which is usually unfamiliar to common readers. The scientific "jargon" is a set of specialized terms used by professionals in the particular fields of science. (Halliday 2004, 159)

1.2 Features of technical and scientific style and writings

Technical and scientific writings such as manuals and guides are nowadays very common in our everyday life. Some people use these writings just occasionally, if they need them for some specific purpose. However, there are the people who are in touch with technical and scientific writings almost regularly. As time passed, technical writing gradually evolved and nowadays we can point out some of the features which are typical or common for the most of technical writings.

1.2.1 Nature of technical English

The main purpose of technical and scientific text is to provide factual information to the addressee. Technical style belongs to the nonfiction literature, because it´s role is to provide factual information, and not to tell some kind of imaginative narration. Czech linguists divided technical style into more specific educational and scientific styles. Mistrík, for example, divided technical style into "educational" and "administrative" style. He further divided "Educational" style into scientific and popular branch. Especially in the last few decades technical language was divided even more due to extensive specialization of technological and scientific areas. (Knittlová et al. 2010, 148)

1.2.2 Matter-of-factness in scientific style

One of the characteristics of the technical and scientific style is the matter-of-factness. The aim of matter-of-factness is to achieve the objectivity in the content of text. The matter-of-factness is occurring in both types of the scientific style. In the style of exact sciences, which are based on rigorous scientific research and verification, and in the popular scientific style which provides scientific information to people who are not experts in the field of science. The extent of the difference between the styles of exact sciences and the popular scientific style depends on the subject of research, theme of work or on the topic dealing with social or natural science. The degree of objectivity is much higher in exact sciences, because the results can be measured or counted, whereas to measure outcomes in social sciences may be sometimes difficult thanks to often different methods of research. (Urbanová and Oakland 2002, 48)

1.2.3 Logical function in a scientific style

The logical function is another feature of the scientific and technical style. The purpose of the logical function is to create logical and consistent relations in a discourse. The logical function of a text is typical especially for the matter-of-factness styles like the style of science, technical style, juridical style, etc. The function of a logical style can be perceived via specific organization in a discourse by using examples, graphical images or statistics. (Urbanová and Oakland 2002, 48)

1.2.4 Written and spoken form of a scientific style

Scientific style is primarily realized in the form of written text. The spoken form of scientific style is not as frequent as the written one. The spoken form of the scientific style is mostly realized via lectures and presentations. However, the spoken form is still subordinate to the written form. Scientific language is principally in the form of monologue. Therefore, situational context is suppressed because the author cannot see and immediately react to the signs of nonverbal communication such as gestures, eye-contact or facial expressions. (Knittlová et al. 2010, 149)

The content of technical texts is usually full of specialized expressions and complicated words. Hence, the text has to be clear, regarding linguistic and stylistic aspects, so that a recipient can understand it without any difficulties. A typical part of speech in the scientific text is noun or adjective. Expressions, which are subjective or expressive, are not desired. The more technical the text is, the more the vocabulary is likely to be stereotypical. Regarding the syntax of the scientific style, it is rather poor and often also stereotypical. But this stereotype of vocabulary and syntax is welcomed in a scientific style, because it suits to the function of this style and the scientific style is thanks to these stereotypes even more understandable. (Knittlová et al. 2010, 149-150)

Scientific and technical findings are usually recorded in a written form so that they can be preserved for a long period of time and be there at anybody´s disposal, no matter when those findings will be needed. Therefore the written form of language is optimal for scientific and technical purposes. One of the main functions of the written language is its referential function where an author is usually making some statement about new findings or discoveries. Of course, a new scientific discovery may also be presented to others in a spoken form by having presentation or lecture. The written language is also important for its educational and social function. It has high social prestige and it is significant for its descriptive function as well. When writing, a writer is usually being more objective, factual and sometimes even more abstract than when just speaking. From the point of view of stylistics, the written form is more condensed than the spoken form. That means that there is more information contained and the written text is ordinarily not as free as the spoken one. (Urbanová and Oakland 2002, 31)

1.2.5 Terminology of a scientific discourse

Whether it is language of computer technology, quantum physics, astronomy or language used in a juridical area, each of these subjects nowadays has and uses their own specialized terminology. The fact that each technical field has its own terminology is totally understandable, but there are differences in the syntax in each particular area of science as well. Due to the consistent use of technical terminologies and sophisticated sentence structures, there is a tendency towards constant improvement of the technical language, which is getting more and more accurate. This direction is especially useful in technical and scientific style, because to express new findings accurately and comprehensively is the main function of the technical language. (Knittlová et al. 2010, 148-149)

1.2.6 Formal vocabulary in technical texts

The vocabulary of technical English is usually formal. Technical writings can be characterized by a great concentration of formal vocabulary. Formal vocabulary is often used in scientific and technical documents, administrative documents, official papers, deeds and speeches, literary works and academic lectures. Even though, formal vocabulary is used in both written and spoken forms of language, written language prevails in the concentration of formal vocabulary over the spoken form. Formal words have often three or more syllables. This can be explained by the fact that many formal words come from Greek and Latin origin. See examples of some of their English derivations: *asteroid*, *bilingual, chronology, circular, consistent, dichotomy, miscellaneous, bilingual, pulmonary,* etc. (Kvetko 2005, 77)

1.3 Technical text from the historical point of view

In order to show how features of technical writing developed, we have to search in history a little bit and look at technical writings which are from different periods of time and are written by various authors. At the end of the 14th century, Geoffrey Chaucer wrote the essay *Treatise on the Astrolabe* in which we can see the first signs of technical writing in the English language. These signs are mostly directed towards nominalized discourse. One of these sings are technical nouns which appeared in the Chaucer´s treatise. Technical nouns used there are both the parts of the astrolabe and terms from mathematical and geometrical fields. Other entities which could be claimed as typical sings of technical writing are extended nominal groups and clauses expressing the process of using a technical device and the events which are under the study. It can be said that this Chaucer´s work is a kind of predecessor of technical English discourse. (Halliday 2004, 143–144)

Another typical feature which is nowadays common in technical English discourse is passivization. Passive voice used in technical texts was not characteristic till the late of 19th century. Among the first, who used the passive voice in technical English, was Isaac Newton in his *Treatise on Opticks*. In this treatise Newton established the discourse of experimentation, using descriptions of doing things, which often come in the form of passive voice. Passive sentences in the text are frequently describing results of an action or experiment, stressing the affected object rather than the doer of the action. Except the use of passive voice, Newton applied in his work another lexicogrammatical phenomena typical for today's technical texts such as: "intricate and less intricate clause complexes; abstract nouns as technical terms of physics; abstract nouns as mathematical technical terms; some nominalizations with grammatical metaphor", etc. (Halliday 2004, 145-46, 150)

The fact, needed to be pointed out, is that these grammatical instruments were not invented by scientific writers themselves. The writers of scientific texts just brought the already existing features and used them to set up a consistent discourse of science. (Halliday 2004, 152-53)

In about the last hundred years, the scientific discourse underwent a significant change in the form of depersonalized image of technical texts. So instead of: *Leary proposed that…* we would now use: *Leary´s proposal was that…*; whilst the very personal form: *I proposed that…* is nearly no longer in use in a scientific discourse. The key role, in such a depersonalized sentence, plays ordinarily the verb which represents some kind of process. (Halliday 2004, 155)

1.4 Sorting of technical writings

To define the term "technical writing", meaning the very nature of this term, can be quite intricate. If we have a look at for example "legal writing", it is obvious that a legal writer writes about laws, restrictions and other legal matter connected with this field. But how can be accurately stated what is the primary concern of the "technical writing"? To answer this

question by saying that the technical writing deals with technical information would be at least insufficient. It is simply a term too broad to be defined. (Byrne 2006, quotes White 1996, 47)
According to National Writers´ Union (NWU), which seats in the United States, minimally three areas of technical writing should be taken into consideration:

- ***Technology education*** – this type of technical writing is determined for the audience whose knowledge of technology is low. Writings in this field are guides, manuals and reports for non-professional audience. The NWU holds the opinion that writers in this area of technical writing do not need to have more specific knowledge than an ordinary reader.
- ***Traditional technical writing*** – the main difference between *technology education* and *traditional technical writing* is in its complexity. Guides and manuals are again typical writings, only in this case a reader as well as a writer need to have an extensive knowledge about the particular scientific sphere.
- ***Technology marketing*** – deals with technical writings which are used mostly for advertising purposes of technological companies. Regarding the difficulty of these writings, it could be placed somewhere between the *technology education* and *traditional technical writing.* (Byrne 2006, 48)

1.5 Grammatical features of a scientific style

Technical style can be characterized by its nature of impersonal objectiveness. The aim of technical style is to describe facts and phenomena in an objective way. The degree of impersonality in technical texts is very high. From the grammatical point of view, the impersonal statement is realized by the use of passive voice. When using passive voice, the author of the information is suppressed and the main attention is focused on the facts described. For example: *"It has been discovered that…"; "This definition can be considered well suited for…"; "This fact should be pointed out, because…"* etc. Especially suitable for the technical style is the fact that there is no necessity to mention who is "an author" or "a doer" of the action, e.g.: *"The broken particles were removed…"; "The level of the radiation was controlled…"; "The amount of noxious substances in the air was eliminated..."* etc. (Knittlová et al. 2010, 150–151)
Another frequently used way of expressing statements, which is commonly used in scientific style, is the use of "general" pronominal subject *"we".* For example: *"we assumed…", "we have found out…" or "we can express…"* (Knittlová et al. 2010, 151)

Except for the impersonal nature of the technical texts, there is another noticeable syntactical feature worth to be mentioned in consideration with the technical style; and that is the proper formulation of individual clauses and their logical sequence. Very frequent and important are words which function is to connect individual clauses and thus make the text more comprehensible, such as: *thus, however, therefore, moreover, nevertheless, again, also, yet, still,* etc. The same effect is fulfilled also by some collocations, like for example: *in fact, in general, in this way, in other words, as we have just seen* and so on. (Knittlová et al. 2010, 155)

Regarding the organization of individual parts of speech within a clause or an organization of individual clauses within a complex-compound sentence; technical style always moves forward from the "old", already known information, to the "new" information. We call the old information "theme" and the new information "rheme". "Theme" is the information which usually appears at the beginning of a sentence. It continues on the situation already mentioned in the text. Whereas "rheme" is the new information, not previously mentioned, which is usually at the end of a sentence or clause. (Knittlová et al. 2010, 156)

2 TRANSLATION

Translation plays a key role in our lives. Without it, it would not be possible for many people to read some of the world's most significant literary works written in foreign languages. The subject of translation can be basically every text in the written or spoken form. The cases in which the translation is especially valuable are translations of various kinds of texts such as books, manuscripts, manuals, guides or brochures. Translation in the form of interpretation (which means translation in a particular moment and in a particular place), for example at court, political debates, in international organizations, etc., is very common too.

The second part of the theoretical part of this bachelor thesis is going to focus mostly on general information about translation, translation theory and "tools" which purpose is to make the translation easier. The part dealing with translation "tools" is going to be aimed mainly at dictionaries, mechanical translation and computer-aided-translation. As probably in almost every kind of study, it is good to have at least some minimal background knowledge about the translation subject. Therefore, the information about translation and the study of translation, contained in this theoretical part, should serve as the indispensable background knowledge for everyone who is more or less interested in translation studies.

2.1 Translator

The key role of a translator is to translate a text from one language into another one. The process of translation is in many respects a very creative activity. Each individual person (translator) has different knowledge of the languages, which are involved in the process of translation, different experience and practice of translation and different life knowledge. For that reason, if you give the task to translate the same text to several translators, each translator would probably translate that text slightly differently than his/her colleague. There would be some deviations in those translations because each individual translator has his/her own knowledge of the language and has his/her own creative approach to the translation.

2.1.1 Who is a translator?

Under the word "translator" we usually imagine a professional translator who is translating books or texts for living. These translators are people educated and trained for the purpose of translation. However, besides professional translators, there are people whose profession is not "translator" fundamentally, but they translate some kind of text, from time to time, for various purposes. Those are mostly people who are specialists in various scientific fields, but also, for example, students studying foreign languages. Therefore, if we speak about the word "translator" here, we mean, above all, a person who is dealing with the process of translation from the source language into the target language, no matter if he/she is professional translator, layman or a student. (Fišer 2009, 28-29)

We can say that the personality and knowledge of each individual translator is unique. To specify the attributes of a "creative translator", we have to consider the purpose for which is a translation being created. We also need to be familiar with the translator's personality and have to know his/her competences and factors which influence him/her in the process of translation. (Fišer 2009, 28)

2.1.2 What are the requirements to be a translator?

The fact that each individual translator has his/her own specific characteristics and knowledge was already mentioned. Nevertheless, there are characteristics (requirements) which all translators should have in common. Not surprisingly, one of these requirements, and maybe even the most important of all, is the knowledge of both – source language and target language. Other requirements are in particular the ability to interpret and analyze the text in the source and target languages, and last but not least, it is the competence to create the text itself. Besides these basic requirements, there are specialized skills and abilities which one can master only throughout a "longer" period of time thanks to practicing. (Fišer 2009, 30)

If someone is reading a text about which he/she knows that it is a translation of some original text which was originally written in a foreign language, he/she will probably have certain expectations about the credibility of that translated text. The aspect of credibility is maybe even more important for translators themselves. For translators, the credibility of their translations is crucial because for them it is a matter of the "professional pride." Another aspect, which is of the great importance for translators, is, of course, their paycheck for finished translations. (This aspect of income applies only to the professional translators who are receiving payment for their work). And finally, the enjoyment from translating should be a very relevant aspect for translators as well. From the above mentioned facts, we might assume that for the reader ("user") of a translation the credibility of the translation is relevant above all, in other words the translation should be "good". Whereas, for a translator is the payment and the pleasure of translating of a great significance as well. (Robinson 2003, 24)

2.2 Types of translation

A good translation should be perceived as an original text by its recipients, not as a translation. For that reason, translation should meet many demands and expectations in order to be perceived as a good-quality translation. It should satisfy at least these criterions:

a) Translation should make a very natural impression, it should sound like that the interpretation is carried out by a person for whom the target language of the translation is the mother language.
b) The meaning of individual words, expressions, collocations and sentences should be identical or nearly the same in both - source language and target language. In other words, there is a tendency to suppress the degree of vagueness in translations.
c) The dynamics of the translated text should be the same as in the original. This means that the reaction of a recipient, reading translation, should be the same or at least similar like if he/she was reading the original work. (Knittlová et al. 2010, 14-15)

These criterions are concerned mainly with the successful transposition in a target language. The specific grammatical features of a target language should not coincide with the specifics of a source language. Important is also to maintain the pragmatic aspects, stylistic aspects and norms of usage of a given language. (Knittlová et al. 2010, 15)

2.2.1 Three major types of translation

Roman Jakobson (1971) distinguishes between three kinds of translation:

a) Intralingual translation is a translation which is being carried out within one language. This type of translation encompasses repetition, rewording and paraphrases of a certain text within the same language. It is, basically, a sort of synonymous substitution with the regard to lexical and syntactical forms.
b) Inter-semiotic translation is the transformation and ensuing interpretation of information into one system of signs, which is originally represented by means of another system of signs. We do not usually even notice this kind of transformation in our everyday life and we simply do it unconsciously. It is a reading of signs from various instruments, tables, charts, graphs, formulas, etc.
c) Interlingual translation is the interpretation of the information, which is expressed in one language, by its counterpart in another language. It is a shift from source language into target language with the preservation of a content of the text and, if possible, the preservation of formal and stylistic aspects of a text. (Knittlová et al. 2010, 15)

2.2.2 Types of interlingual translation

In the interlingual translation, which is the translation from one (source) language into another (target) language, we may distinguish between four types of translation. The first two types concentrate mainly on the formal side of a text, whereas the other two types are oriented towards the meaning of a text. Each of these types of interlingual translation has in most cases some practical utilization; nonetheless, sometimes the translations may be awkward and not very easy for people to understand:

a) *Interlineal translation* is absolutely inapplicable for the common translations of books, articles, or interpretations of some talks. It is a type of an excessive literal translation which might be used, at most, for the metalingual purposes. Interlineal translation is concerned only with the definite linguistic information; it does not respect the grammar system of a particular language (for example: *I want to marry you – Já chtěl vzít si ty/tebe*). If the general grammatical structures of two languages are similar or partly coincident, the interlineal translation is usually well-understandable.

b) *Literal translation* respects the grammar system of a target language, but it renders individual lexical units from one language into another one with no respect to idiomatic expressions, collocations and other commonly used set phrases, which are important for the inherent casual impression. For example: *I am going to take a shower – Jdu si vzít sprchu.*

c) *Free translation* is the real opposite of the interlineal translation. It is often perceived as incorrect because it does not respect a source language very much. Because of this, the translations are deprived, especially, of their aesthetic qualities. Free translations are mostly produced by the unprofessional translators and interpreters.

d) *Communicative translation (idiomatic translation)* is used especially in situations where there are no adequate counterparts in a target language to those in a source language. We use communicative translation usually for translation of various sayings, proverbs, idioms, greetings, etc. It is important to consider the pragmatic aspect of a translation and the context of a text while communicative translating. (Knittlová et al. 2010, 16-17)

2.3 Tools utilized at translation

2.3.1 Dictionaries

A dictionary, also known as a lexicon, is probably one kind of a book which in most cases comes in handy while translating some text from one language into another one. Nowadays, we can choose from a wide range of specialized monolingual, bilingual and multilingual dictionaries.

Monolingual dictionaries are for example encyclopedic dictionaries, which are giving information about historical events, things, people, places, etc., or linguistic dictionaries which fulfil their function by providing the information about the meaning of a lexical entry, its pronunciation or grammatical status. The bilingual and multilingual dictionaries serve for the purpose of translation. (Kvetko 2005, 112)

The discipline dealing with the study and compiling of dictionaries is called lexicography. To define accurately what the dictionary is, we have to consider the fact that there is a variety of dictionaries. However, most of the dictionaries have the following features in common: dictionaries are specialized books which assemble and explain the words of one language or they provide equivalents in multiple languages, they usually contain an introduction and/or preface, a guide of how to use the dictionary, a key to pronunciation, the main part i.e. the list of words, and sometimes also supplements, for example, the list of symbols, abbreviations, etc. Individual words/entries are in most cases arranged into alphabetical order and they are highlighted by the bold type of font. Individual entries are often added with the information about pronunciation (e.g. IPA), meaning of the words, their usage in exemplary sentences, their synonyms, etc. (Kvetko 2005, 110)

Pavol Kvetko in his book *English Lexicology in Theory and Practice* distinguishes between individual dictionaries according to their sizes. There are: "**large** dictionaries (e.g.: *The New Oxford Dictionary of English* 350,000 words and phrases; *The Random House Dictionary of the English Language*, 260,000 headwords), **medium-sized** dictionaries (*Oxford Advanced Learner´s Dictionary*, 6th ed., 80,000 ref.; *Longman Dictionary of Language and Culture*, 2nd ed. 80,000 ref.) and **small** dictionaries (*Longman Active Study Dictionary of English*, 45,000 ref.; *Oxford Wordpower Dictionary*, 30,000 ref.)." (Kvetko 2005, 111-112)

2.3.2 Machine translation (MT)

Nowadays, we live in the era of information technology (IT). Information technology has developed substantially, especially in the last few decades. The development of IT has brought immense improvements and simplifications in people's everyday life as well as their work. That applies to the work of translators as well. Thanks to the "Machine Translation" (MT) and the "Computer-Assisted Translation" (CAT) the process of translation is much faster and easier.

Machine Translation or in other words, fully automatic translation, has started developing just after the invention of the first computers during the Second World War. The first MT systems were implemented by the US government and they initially served for the military purposes. MT programs were able to translate a text only on the word-for-word basis, thus, the translations were not very convenient, since the MT programs were not able to capture the grammatical aspects of a particular language properly. For many imperfections the Machine Translation was not very popular and people were looking at it in a rather sceptical way. (Hatim and Munday 2004, 115-117)

Since the first development of MT more than half century already passed. Even though, the technology of the Machine Translation has improved significantly since then, MT is still not faultless, therefore, it cannot substitute a human translator so far. But still, great improvements have been accomplished in the development of MT. That was possible due to the progress in technology, larger databases of words, grammar rules and other essential knowledge. Also, additionally, the great improvements were brought by new approaches to the Machine Translation and people's more down-to-earth stance towards the expectations of MT. (Bowker 2002, 3-4)

2.3.3 Computer-Assisted Translation (CAT)

Computer-Assisted Translation, shortly CAT, is a technology which uses computer tools and programs of which the primary aim is to facilitate the work of translators. Unlike MT, CAT requires still the human assistance in the process of translation. CAT technology expanded considerably in recent years due to the development of modern computer technologies. The majority of contemporary translators use CAT tools still more and more to make their work easier. The knowledge of CAT technologies, and the ability to use them efficiently in practice, is nowadays the indispensable requirement for anyone applying for the job of translator. (Bowker 2002, 6)

Hatim and Munday describe how such CAT tool works. More specifically, it is a translation memory tool which is just one of the several existing CAT technologies. Computers work with the translation databases which show to the translator the identical or similar phrases to those of being translated. The translation database then offers some viable translation equivalents to choose from. It may happen that the offered equivalents are sometimes inaccurate. In that case translators simply reject them and search for others, more suitable equivalents. The most widely used translation memory tools are "TRADOS´s Translator´s Workbench (www.trados.com) and ATRIL´s Déjà Vu (www.atril.com)." (Hatim and Munday 2004, 114)

2.3.4 Corpora

"A corpus is a collection of texts used for language-related research or lexicographical purposes. Since the 1960s, it has become increasingly common to both store and explore corpora electronically using computerised storage and search facilities, parsers and concordancing programmes." (Malmkjær 2005, 116)

Susan Hunston in her book *Corpora in Applied Linguistics* introduces these types of corpora:

- *Specialised corpora* include texts which engage only one particular kind of materials, e.g. magazine editorials, student theses, specialized articles on particular topics, etc.
- *General corpora* consist of texts from various areas. General corpus is a mixture of all possible texts, thus it is usually very large. It is used for translation purposes or language learning. The well-known general corpora are, for example, *the Bank of English* or *the British National Corpus.*
- *Comparable corpora* contain two or more corpora of different varieties of one language or two or more corpora of different languages. These corpora work with the similar types of texts of approximately the same extent. The utilization of a comparable corpus is common for translators and language learners.
- *Parallel corpora*, as in the case of comparable corpora, consist of two or more corpora of different languages. Parallel corpora contain the texts which have already been translated from one language into another one and vice versa. These corpora may serve as a useful resource for a translator training as well as a translating practice.
- *Learner corpus* consists of texts which were created, for example, by people who study a language.
- *Pedagogic corpus* is a collection of all materials a learner has used.

- *Historical corpus* contains texts from the different time periods and it is used for the examination of language from a historical point of view.
- *Monitor corpus* is used for the observation of changes in a language as they occur.

(Hunston 2002, 14-16)

For the purpose of translation the first four types of corpora listed above are widely used. The rest of corpora serve mainly for other than translation purposes, therefore their explanations have been shortened.

2.4 The problem with (non)equivalence

2.4.1 Non-equivalence at word level

When translating a text form one language into another language, it may happen that some words which are not very easy to translate with the preservation of absolutely the same level of uniqueness are encountered. This is because the word in a source text has not the exact counterpart in the target language. This phenomenon is called "non-equivalence at word level" and it may vary a lot in different types of translations and among different languages. (Baker 1992, 17-18)

Various techniques and strategies can be used to deal with the problem of non-equivalence at the word level. Sometimes the translation of a word from the source language into target language can be simple, but it might be also very difficult to render some word from one language into another one or it may seem almost unfeasible. Mona Baker in her book *In other words: a coursebook on translation* describes some commonly used techniques and strategies how to deal with the problem of non-equivalence at word level:

a) *Translation by a more general word (superordinate).* Translation of a word which has not the direct equivalent in target language by using a more general word is extensively used method. It enables translators to cope with several types of non-equivalence at word level. Practically each particular word has a different level of uniqueness in individual languages. Therefore the use of the method of translation, where the word in a source text is substituted by its more general counterpart in the target language may cause a loss of the word's uniqueness. However, the needs of proper translation will be satisfied since the meaning of a word in source language and the meaning of its more general counterpart in target language can not be absolutely worlds apart.

b) *Translation by cultural substitution*. The purpose of this strategy is to make a translation more comprehensible by the use of an equivalent which have similar or nearly the same impact on the recipients in both – the source and target language. The factual meaning is of secondary importance. For that reason the translator has to be cautious about the use of this strategy and use it only in appropriate situations.
c) *Translation using a loan word or loan word plus explanation*. This method is used, particularly, for the translation of fashion words, modern concepts and words which are specific to certain culture. By providing the additional information about the meaning of a word, it is possible to perceive the meaning of a loan word correctly later in the reading without the possibility of misunderstanding.
d) *Translation by omission.* If the meaning of a word or an expression is not utterly important for the context of the text, that word or expression may be omitted in the target language translation and this act may not even have a negative effect on the translated text. However, we should use this method only in suitable situations to adjust the translation for the target recipients and to make the translation more felicitous without endue loss of meaning.
e) *Translation by paraphrase using unrelated words.* Refers to the paraphrase of some content which aim is to modify the meaning of a translated expression or sentence and make the meaning more precise and specific. The disadvantage of this paraphrase method is that it tends to elongate the text, because more information is being added in the process of specification and explanation.
f) *Translation by illustration.* Instead of translating an item, which is too complicated to be explained, a picture of that item may be used as the evident translation equivalent. Because of the demand for the sufficient amount of space in the text of translation, this method is not suitable for every occasion. (Baker 1992, 26-42)

The techniques, illustrated above, are not the only techniques which can be used in dealing with the problem of non-equivalence at word level. Other techniques are for example: “Translation by a more neutral/less expressive word” or “Translation by paraphrase using a related word”. Individual strategies may be used differently in diverse contexts by different translators; this only supports the fact of how creative the job of translators really is. (Baker 1992, 26-42)

2.4.2 Grammatical equivalence

Lexical resources and their differences among individual languages are not the only ones which may cause problems in the process of translation. Another system, which varies a lot among languages, is the grammatical system. If some grammatical category is more or less developed in one language than it is developed in another language, it will cause the problem of non-equivalence at grammar level in the process of translation. The lack of some grammatical category in one language may be in many cases compensated by the lexical resources of the other language. (Knittlová et al. 2010, 121)

Differences can be found in:

a) *Number.* The category of number and countability does not have to be always the same in the grammatical systems of individual languages. The plural form of English nouns is in most cases realized by the addition of a suffix to a noun or by the transformation of the word's form. However, this rule may cause confusion while translating some words or expressions from English into Czech language *(watch – hodinky, currents – rybíz, talk nonsense – mluvit nesmysly, etc.)*

b) *Gender.* English language distinguishes between male and female gender in the field of profession by the addition of the suffix *–ess* to the female individuals *(steward/stewardess).* However, in some cases the suffix may cause an undesirable effect of the overtone. Therefore, in the case of many professions the same word is used for both sexes *(lawyer, cook, manager, etc.)* It may cause problems if translating such words into Czech, if the gender of a person is not specified otherwise. In Czech, two expressions exist for each of those professions *(lawyer – advokát, advokátka; cook – kuchař, kuchařka; manager – manažer, manažerka).*

c) *Person.* The category of person in English as well as in Czech is divided into *masculine, feminine, and inanimate* third-person singular, i.e. *(he/she/it).* However, in the third-person plural English language does not distinguish between *masculine* or *feminine* participants, whereas Czech language does *(they – oni/ony).*

d) *Tense.* Some languages have the category of tense developed more than others. If we translate a text from English into Czech, we may notice that English has some extra tenses which do not exist in Czech language. Therefore, the absence of, for example, *past perfect simple* tense in Czech language has to be compensated in the translation by the addition of other lexical and grammatical means.

e) *Voice.* The passive voice is frequently used in written English. If the text is translated from English into another language which does not use the passive voice so frequently or, perhaps, does not use passive voice as such, it is suggested not to translate the text exactly on the word-for-word basis, but to adjust the passive structures for the recipient in target culture. (Baker 1992, 87-102)

2.4.3 Pragmatic equivalence

The utterance of the context of a text may be expressed in various ways by the participants of the act of communication. The essential role in the understanding of the meaning of an utterance, in various languages, plays the cultural knowledge and conventions. Translators may customize the utterance in order to make it more understandable for the recipients in target language who are used to different cultural conventions. Language can be studied from different angles and at different levels. The study dealing with the "language in use" is called pragmatics. (Baker 1992, 217)

Dagmar Knittlová in the book *Překlad a překládání* shows some strategies of how to deal with the problem of pragmatic non-equivalence:

a) *Addition of information.* This strategy is used especially for the specification and clarification of the proper nouns and other entities which are unknown for the recipient in the target language *(Maine – stát Maine; Ubangi – řeka Ubangi)*. In Czech translation of the geographical names were particularized by the addition of the auxiliary word.

b) *Omission of information.* The purpose for the omission of the information in translation is to generalize the meaning. The semantic component is released *(Coca-cola – limonáda; brazil-nut – ořech).*

c) *Substitution by analogy.* This strategy is widely-used when translating units of measurement such as length, height or size which are expressed differently among languages *(about five inches – okolo pětadvaceti centimetrů; one hundred miles an hour – stošedesát kilometrů za hodinu).*

d) *Explanatory transcription.* This strategy should be used only in some rare occasions and the explanation should be as short as possible *(ten spot – banknote of the ten dollar value; valley girls – girls who come from California).* (Knittlová et al. 2010, 92-95)

3 MAJOR TRENDS SPOTTED IN THE TECHNICAL TEXT TRANSLATION

The two theoretical parts above, i.e. *Technical text and its features* and *Translation* should provide at least minimum background knowledge about the subject of this bachelor thesis which is translation of the "technical" text. Translation in many of its forms is the phenomenon known for centuries. From the historical records we now know that the first translations between different languages were carried out hundreds or thousands years ago. Throughout such a long period of time, translation has changed and developed, even the languages have changed, some died out and some were just about to be created. Despite the countless translation strategies, recommendations and grammatical rules, translation is in many ways considered as a creative activity which requires critical thinking and often also innovative approach from the translator. That is, perhaps, the reason why mechanical translation and information technology can not still fully replace the human translator.

Modern technical writing as we know it today has started noticeably developing just about seven centuries ago and it is still expanding due to creation of new scientific and technical fields. Together with the new technical branch or study, a new set of specialized terminology comes usually along. The new specialized terms are at first implemented into the language system of its origin and later taken over by different languages. But the lexical aspects are not the only ones which somehow define the scientific and technical writing. The scientific style of writing is also characterized by the presence of some grammatical and other features, such as the high level of objectiveness, frequent use of passive voice or the impersonal approach.

The constant exchange of new technical discoveries and information among people speaking various languages is crucial for the field of science and technology, and as the trends suggest, new scientific facts are still going to be discovered. As these new findings will be written down later on, there will be also the need for the new translations.

II. ANALYSIS

4 TRANSLATION OF THE ASTROLABIUM AWARD

Tyto dvoje hodiny (přibližně 4’7”x 4’7”, 1.40 x 1.40m) Festo Harmonices Mundi, neboli harmonie světů, stojí v technologickém středisku Festo AG & Co. KG v Esslingenu jako dvojvaječná dvojčata.

Obsah

Tisk Vydalo: Festo AG & Co. KG

Koncept a editace: Hermann-Michael Hahn

Návrh, rozvržení a sazba: Andreas Hild, Hild Design

Astrolabium Award – Astroláb firmy Festo

4.1 Předmluva doktora Wilfrieda Stolla

Při astrolábu *Astrolabe Award,* Festo vytvořilo mimořádnou cenu pro velmi zvláštní příležitosti a pozoruhodné úspěchy. Astroláb firmy Festo je menší kopií astrolábu Harmonices Mundi, umístěného v technologickém středisku firmy Festo v Esslingenu. V jádru astrolábu jsou astronomické hodiny, které přesně ukazují pohyby slunce, měsíce a hvězd. Užitím zlatého převodu a ponecháním stejného stupně funkčnosti jako u originálu, byl vytvořen mistrovský kus, který je identický se svou předlohou, co se týče vzhledu, estetiky a harmonie.

Harmonices Mundi firmy Festo, které bylo vytvořeno jako trojdílné umělecké dílo za použití nejnovější technologie, představuje sloučení moderní astronomie, mechaniky, melodie a elektroniky. Originální verze v Esslingenu zahrnuje vedle kalendářních hodin astronomické hodiny ve formě astrolábu a atraktivně navrženou zvonkohru se 76 zvonky, 40 naladěnými takty a klaviaturou. Je to symbol inovace a byl propočítán, navržen a zkonstruován v průběhu let po pracovní době profesorem Hansem Scheurenbrandem, bývalým ředitelem pro výzkum a vývoj ve firmě Festo AG. V roce 2003 německá společnost pro chronometrii (DGC), ocenila profesora Scheurenbranda za jeho práci medailí Philippa Mathäuse Hahna.
Projekt, který započal jako soukromá záliba, nakonec dorostl do celkového systému, který silně symbolizuje nejen celosvětovou korporační síť firmy Festo, nýbrž také touto sítí dané základní principy harmonické mezilidské spolupráce.
Na základě použití Esslingenského originálu, profesor Scheurenbrand později vytvořil menší verze astrolábu a kalendářních hodin.
Astroláb symbolicky tlumočí vědecké a technické úspěchy firmy Festo z vedení společnosti širšímu světu. V jejich nových prostorách bude astroláb sloužit jako velvyslanec firmy Festo a jako viditelné vyjádření blízkého spojení se společností.
Doufám, že kouzlo technologie a harmonie, které tento astroláb vyjadřuje, inspiruje čtenáře této brožury nadšením pro čas a věčnost, a že jejich setkání s Harmonices Mundi - kalendářními hodinami firmy Festo bude zkušenost plná hvězd.

Dr. Wilfried Stoll

4.2 Astroláb

Historie a základní principy

- závlačka
- síť
- vkládací talíře (planisféra – otáčivá mapa hvězdné oblohy)
- matka
- rameno
- hledí
- alidáda (část měřicího přístroje se zaměřovacím zařízením)
- osa

Astroláb je jeden z nejstarších přenosných přístrojů, určený k pozorování oblohy. Tím, že je to přístroj určující čas hlavně v nočních hodinách, (pomocí měření astronomických nadmořských výšek), se astroláb těšil rozkvětu ve středověku a počátku moderního věku v civilizacích ovlivněných islámem, proto umožňoval zkušenému uživateli snadno určit čas motliteb a později také Kiblu (směr k Mecce, ke které se muslimové musí obracet při motlitbě), což bylo velmi důležité obzvláště pro cestovatele.

Nebesa jako hodiny

Měřící princip lze jednoduše vysvětlit. Protože se země otočí kolem své osy stálou rychlostí jedenkrát za každých 24 hodin, slunce, měsíc a většina hvězd vystoupí nad obzor na východě, dosáhnou svých nejvyšších výšek na jihu a zapadnou na západě. Pomoci měření výšky hvězd a azimutu (měření směru), může člověk určit kolik času uplynulo od stoupání hvězdy nebo jak dlouho to potrvá, než dosáhne poledníku. Tyto hodnoty nicméně závisejí na zeměpisné šířce pozorovatele, jakož i na aktuálním datu, takže v každém jednotlivém případě musejí být použity obsáhlé tabulky nebo příslušné výpočty k vyhodnocení měření. Takové výpočty se staly obecně nadbytečnými prostřednictvím speciálního provedení astrolábu, protože tento poskytnul přímý převod měřené místní výšky a úhlů azimutu do (geocentrické) souřadnicové sítě, jejíž příslušné natočení je určeno pouze aktuálním časem (přesněji: hvězdným časem).
Z matematického hlediska není astroláb nic jiného, než počítací disk pro převádění takzvaných sférických úhlů.

Konformní zobrazení oblohy

Správné fungování takového počítacího disku vyžaduje, aby sférické úhly měřené na obloze byly promítnuty bezchybně (to znamená: zachovat úhly) na rovnou plochu. Toto je docela výzva uvážíme-li, jak snadno se rozerve slupka pomeranče, když se ho pokusíte rozplácnout pomocí velké hmotnosti. V tomto případě matematici a zeměpisci používají stejnoúhlé průměty, z nichž jeden je obzvláště vhodný stereografický průmět, jehož principy byly známy již řeckému astronomovi Hipparchosovi před více než 2200 lety.
Astroláby proto obsahují dva disky, které se můžou otáčet směrem k sobě: planisféra (což doslova znamená „stlačená sféra“, to je rovné znázornění klenby oblohy s její výškou a směrovými úhly) a obvykle velmi složitá a filigránem zdobená síť znázorňující pozice vybraných hvězd. Kromě toho obsahují otočnou měřící a směrovací tyčinku (alidádu) pro měření nadmořských výšek nebeských těles. Nezbytná podpůrná konstrukce, takzvaná matka,

je jak kryt, tak doplňkový nosič informací, protože jeho zadní část poskytuje prostor pro několik měřítek a nomogramů. Části přístroje drží pohromadě a jsou zajištěny osou a závlačkou. K určení denní doby stačí změřit výšku a směr hvězdy a otáčet plexem do doby, než jeho ručička zaměří správnou výšku a směrové linie planisféry. Poté okraj matky naznačí, jak dlouho bude trvat, než tato hvězda dosáhne jižní linie (nebo kdy dojde k průchodu jižní linie). Tento údaj a znalost data, které může být odvozeno ze sluneční pozice ve zvěrokruhu, nakonec poskytne místní čas.

4.3 Astronomické pohyby

V měnícím se pohledu na svět

Když byly sestrojeny první astroláby, obecně se věřilo, že Země leží ve středu vesmíru a každý den je Země obklopena pohybujícími se nebeskými tělesy. Zdálo se, že se putující hvězdy (slunce, měsíc a planety) pohybují odlišnými rychlostmi před pozadím nehybných hvězd. Nejrychlejší, a tudíž nejblíže k zemi byl měsíc, který se pohyboval napříč souhvězdími zvěrokruhu jednou za každých 27.32 dní. Ve větší vzdálenosti obíhaly Merkur, Venuše a slunce, které dokončily jednu cestu napříč zvěrokruhem přibližně za 365,25 dní.
K dosažení stejné pozice ve zvěrokruhu, potřeboval Mars 687 dní, Jupiter necelých 12 let a Saturn téměř 29,5 let. Skutečnost, že planety měnily směry svých pohybů v pravidelných intervalech a pohybovaly se chvílemi směrem zpět, vedla k jistým nejasnostem a poskytla původ termínu planeta (který je odvozen od řeckého významu slova „potulovat se po“), ale toto bylo nakonec do určité míry vysvětleno složitým překrýváním několika kruhových pohybů.

Slunce a měsíc jako „hodiny“

Od té doby co slunce svým světlem a teplem má podstatný vliv na každodenní životy lidí a zejména pak ovlivňuje životní prostředí změnou ročních období, doba jeho oběžné dráhy (sluneční rok) se stala rozhodujícím kalendářním obdobím. Podobný význam byl přisuzován měsíci, jehož pravidelná změna fáze se jevila jako spojník mezi pomíjivou povahou lidského života a navěky neměnným nebeským světem bohů. Taková změna fází od jednoho novu k dalšímu trvá přibližně 29,53 dní. První objevení malého srpku měsíce na večerní obloze ukončilo několikadenní neviditelnost („neživý měsíc“) a dokonce již tenkrát byl nazýván „nov“. Dokonce již ve starověkém Řecku se vyskytly určité pochybnosti o tomto geocentrickém pohledu na svět, ovšem tyto myšlenky nebyly přijaty. Byl to Klaudios Ptolemaios (Ptolemy), který ustanovil tento světový názor ve svém díle „Almagest“ v polovině druhého století. Až v 16. století rostoucí pochybnosti nakonec způsobily převrat tohoto pojetí světa.

Astronomické teorie

Mikuláš Koperník, narozen na dnešním uzemí Polska, započal změnu, když byla vydána jeho kniha „De revolutionibus orbium coelestium“ v roce 1543 a zastávala nový názor na svět. Umístil slunce do středu planetárního pohybu, zatímco Země nyní obíhala kolem slunce společně s ostatními planetami, ale stále ještě v esteticky překrývajících se kruhových oběžných drahách dle učení řeckého filozofa Aristotela. Ze všeho nejvíc Koperník chtěl, aby jeho pohled na svět byl viděn jako vylepšený model pro snazší a preciznější výpočty planetárního pohybu, avšak jeho model vyhověl tomuto speciálnímu požadavku pouze za určitých okolností. Tabulky planet se ve skutečnosti staly přesnějšími, když Jan Kepler z Weil der Stadt ve Württembergu v Německu rozpoznal na začátku 17. století eliptický tvar planetárních drah a následkem toho tak zasadil osudovou ránu starodávnému pohledu na svět. Přibližně v téže době, právě vynalezený dalekohled poskytl první „blízké zobrazení“ planet, což potvrdilo nový Koperníkův neboli heliocentrický pohled na svět. Toto otevřelo cestu pro nový pohled na přírodu, který pouze o několik desítek let později vedl k formulaci všeobecného zákonu gravitace Isaacem Newtonem.

Na konci roku 2007 a na začátku roku 2008, Mars před zimním souhvězdím nabude smyčkového směru, když ho Země předběhne na vnitřní dráze.

4.4 Ohromující vlastnosti astronomických hodin

Slunce, měsíc, planety a zatmění

Ozubené měsíční soukolí s nakloněným měsíčním kotoučem.

Brzy po vynálezu hodinových mechanismů ve 13. století, hodináři použili sled nebeských událostí jako předmět svého umění. Po tisíciletí bylo určování času charakterizováno nebeskými pohyby (zejména těmi s jasnou každodenní změnou v systému stálé hvězdné sféry), ale nyní jsou hodináři schopni zvrátit situaci a napodobit sled nebeských událostí. Od té doby, kdy současně vytvořili také astronomický „plán stvoření světa“, kostely byly často

zákazníky, kteří si takové astronomické hodiny objednávali, ačkoli i světští panovníci měli zájem o takové symboly síly, jak dnes ostatně názorně ukazují mnohé radnice a galerie.
V průběhu času se vzhled i přesnost astronomických hodin neustále měnily. Nejstarší dochované a stále funkční velké hodiny tohoto typu lze nalézt v kostele svaté Marie v Rostocku. Byly sestrojeny v letech 1379 až 1380, zrestaurovány přibližně o 90 let později a ukazují nejen čas, ale také polohu slunce na sluneční dráze (tedy datum), polohu měsíce a jeho fázi, jakož i den v týdnu a na přídavném kalendářním kotouči ukazují datum velikonoc až do roku 2017.

Hodiny jako astronomický model

Novější hodiny obsahovaly rovněž zobrazení planetárních pohybů, stejně jako takzvaný lunární uzel, který sloužil jako ukazatel bezprostředních slunečních a měsíčních zatmění.
Ve stejnou dobu se stavitelé hodin pokoušeli derivovat rozdílné časy oběhu jednotlivých ručiček od již existujícího hodinového pohonu, prostřednictvím nesmírně jednoduše sestrojených převodů. Nicméně protože jednotlivé doby otáček nemohly být vyjádřeny jako malé poměry celých číslic, více či méně podstatné nepřesnosti musely být akceptovány. Synodický měsíc například, tj. čas od jednoho novoluní k dalšímu, trvá v průměru 29.53059 dní. Jestliže by si někdo přál odvodit tuto dobu oběhu přímo z denní rotace, rotační rychlost měsíčního ukazatele by musela být snížena na 1-1/29.53059, anebo zaokrouhlena na pět míst, 0.96614. Konstruktéři se potom často spokojili s rotační rychlostí 1-1/29.5 nebo 0.96610 za den, což mohlo být odvozeno například z denní rotace pomocí kombinace ozubených kol 114/118 nebo (57/59). Nicméně tedy přijali fakt, že přibližně po třech letech byl měsíc o jeden den napřed před svou cílovou polohou před souhvězdími.

Hranice přesnosti

Například dvoustupňový převod 22/54 · 83/35, který by nevedl k odpovídající odchylce měsíce dříve nežli po 130 letech, by měl za následek výrazně lepší znázornění měsíce, a doslova astronomická přesnost by byla dosažena s čtyřstupňovým převodem 11/13 · 23/16 · 23/18 · 23/37, který by měsíc zanechal pouze jeden den pozadu za 95,000 let!
Avšak, takto extrémně přesné zobrazení by bylo zbytečné, pokud by ovšem někdo také nechtěl znázornit zřetelné nepravidelnosti v pohybu jako protiopatření. Takové odchylky, způsobené gravitací jiných vesmírných těles, se staly znatelnými obzvláště při pohybu země a měsíce. Poprvé byly brány v potaz ve třetích astronomických hodinách Štrasburské katedrály,

které postavil Jean Baptiste Schwilgué mezi lety 1838 a 1842, a které jsou považovány za neobyčejně přesné.

4.5 Celkový pohled na astroláb Festo

Ukazující jednotlivé komponenty

4.6 Čtení astrolábu

Doby východu a západu nebeských těles

Novoluní a jasné slunce jsou na obloze společně.

Symbol jasného slunce je rozhodující ke stanovení východu a západu slunce. Když je slunce na obzoru, tak právě vychází (ráno) anebo zapadá (večer).

Ukazatel dorůstajícího měsíce je nalevo od jasného slunce.

Tři fáze stmívání jsou určeny hloubkou slunce pod obzorem.

Občanský soumrak
Čtení venku bez jakéhokoli dodatečného světla je možné během občanského soumraku (Linea crepusculi civilis ukazuje začátek a konec).

Úplněk je naproti jasnému slunci

Námořní soumrak
Nejjasnější hvězdy a obzorová čára jsou viditelné během námořního soumraku. Navigátoři mohou provést astronomické určení svých poloh (Linea crepusculi nautici ukazuje začátek a konec).

Ukazatel ubývajícího měsíce je napravo

Astronomický soumrak

od jasného slunce

Skutečná tma existuje pouze před nebo po astronomickém soumraku (Linea crepusculi astronomici ukazuje začátek a konec).

Znamení zvěrokruhu dělí dráhu slunce do 12 rovnoměrných částí.
Dráhy azimutu ukazují směr nebeského tělesa.
Obzorová čára (Horizon obliquus) ohraničuje právě viditelnou část oblohy jako rám.
Linie soumraku (Linea crepusculi civilis, nautici a astronomici) označují fáze soumraku.
Zenit označuje nejvyšší bod oblohy nad pozorovatelem.
Souhvězdí jsou na planisféře ukázány jako zrcadlový obraz.
Dráhy nadmořské výšky a azimutu.
Obzorová čára s liniemi soumraku.
Zenit astrolábu Festo.

Dráhy slouží k určení nadmořské výšky nebeského tělesa nad horizontem.
Obratníky označují nadmořskou výšku slunce v pravé poledne během změny ročních období.
Linie pozemských hodin dělí noční pásmo do 12 rovnoměrných částí.
Ukazatel sítě označuje hvězdný čas.
Astrologické části oblohy.
Dráhy obratníků a pozemských hodin.

Azimut a nadmořská výška, hvězdný a pozemský čas a astrologické části oblohy

Vnitřní planety Merkur a Venuše se nikdy nemůžou vzdálit daleko od slunce: Merkur maximálně o 28 stupňů a Venuše nejvíce o 47 stupňů. Jejich pozice na sluneční dráze jsou označeny průsečnicí mezi tyčí planety a měřítkem vnějšího okraje sluneční dráhy.
Sluneční dráha: ukazatel novoluní a jasného slunce jsou umístěny společně vedle ukazatele draka.
Vnější planety Mars, Jupiter a Saturn mohou být umístěny na obloze naproti slunci („opozice“). Jejich pozice na sluneční dráze jsou také označeny průsečnicí mezi tyčí planety a měřítkem vnějšího okraje sluneční dráhy.
Měsíční dráha: ukazatel úplňku a jasného slunce jsou naproti sobě vedle ukazatele draka.

Poloha jasného slunce ve vztahu k šedým kruhovým obloukům na planisféře je velmi důležitá pro určení pozemského času, ve kterém je každá noc rozdělena do 12 sekcí rovnoměrné délky. Pozemské hodiny jsou delší v létě (nahoře) než v zimě (dole).

4.7 Design Astrolábu Festo

Síť, planisféra a ukazatele

Astronomické hodiny

Astroláb Festo Harmonices Mundi (harmonie světů) volí tradiční formu geocentrického ztvárnění a vynáší jej na jedinečnou úroveň přesnosti díky novým výpočetním metodám ozubených převodů. Začíná to planisférou a sítí, které jsou pozoruhodné díky neobvyklému stupni kompletnosti. Například planisféra ukazuje místní souřadnicovou síť (azimut a nadmořskou výšku), rozdílné linie soumraku, dělení takzvaných pozemských hodin, jakož i hranice astrologických částí oblohy, zatímco síť kopíruje (zrcadlový obraz) obraz hvězdné oblohy se všemi jasnějšími hvězdami a liniemi souhvězdí, zvěrokruh a obratníky jednotlivých souhvězdí zvěrokruhu. Ukazatele pro jasné slunce, měsíc, pět planet viditelných pouhým okem a měsíční uzel, který slouží jako indikátor bezprostředních zatmění slunce a měsíce, se pohybují před touto nebeskou modelovou scénou jakoby kouzlem.
Celek je ohraničen několika měřítky času a zeměpisných délek, použitých pro odečítání různých časů a souřadnic jednotlivých vesmírných těles, jakož i duhou považovanou za most mezi nebem a zemí. Na rozdíl od originálu Festo Harmonices Mundi, pohyby jednotlivých ukazatelů jsou odvozeny od minutového pohonu rádiově řízených křemenných hodin pomocí početných převodů, z nichž některé mají velmi složitý design. V menším astrolábu Festo jsou jednotlivé ukazatele ovládány krokovými motory. Takzvané dlouhodobé orbitální údaje, které rovněž počítají se vzájemnými odchylkami planet jako průměrnými hodnotami v průběhu století, tvoří základ pro výpočet převodů a/nebo procesorem řízených pohybů krokových motorů. Toto zajišťuje, že pozice jednotlivých ukazatelů, včetně sítě jako znázornění nebeské klenby (a tak nepřímo ukazatele zemské rotace), se odchylují do prakticky zanedbatelné míry od pozic „přírodních modelů“ na pozemské obloze dokonce v průběhu mnoha staletí.
V originále, který je umístěný v technologickém středisku Festo AG & Co. KG v Esslingenu, zhruba 300 ozubených kol, seskupených do početných soukolí, zajišťuje nejpřesnější možné zobrazení pohybů slunce, měsíce a hvězd. V menší verzi astrolábu zajišťuje správnou polohu

ukazatelů 11 krokových motorů. Ty jsou řízené procesorem, který vypočítává příslušnou aktuální pozici úhlu pro síť, právě tak jako pro ukazatele slunce, měsíce, draka a planet z časových signálů radiových hodin v minutových intervalech, pomocí v paměti uloženého programu. V případě potřeby, může být indikace času také ovlivněna a konkrétně upravena tak, aby pohled na oblohu mohl být přizpůsoben k volně volitelným dobám v minulosti a budoucnosti.

4.8 Čtení časů

Zobrazení času

Hodinová ručička

Ukazatel slunce

Ukazatel sítě

Astroláb umožňuje čtení různých časů, s přesností na minutu, z nichž všechny jsou určeny denní rotací země pod sluncem. Zahrnují:

- místní čas
- pravý sluneční čas a
- hvězdný čas

Slunce to vynáší na světlo

Místní čas se odvozuje od světového času vysílaného prostřednictvím satelitů Global Positioning System (GPS) a je označen zlatým prstencem na špičce „ukazatele" na vnější 24hodinové stupnici. Hodina může být odečtena přímo z pozice prstence; naproti tomu minuty musí být odečteny pomocí tyčinky ukazatele na minutovém prstenci přilehlém na vnitřní straně – každé černé či bíle políčko odpovídá jedné minutě a pět minut je v každém případě sloučeno do delší značky na stupnici.

Pravý sluneční čas je vyjádřen zvláštním zlatým symbolem slunce na prstenci zvěrokruhu a může být přečten na jeho pomyslném prodloužení na vnější stupnici. Liší se více či méně výrazně od místního času. Na straně jedné, toto je díky skutečnosti, že místní čas je rozdělen do takzvaných časových pásem, z nichž každé je široké 15 stupňů zeměpisné délky, kdežto pravý sluneční čas představuje pozici slunce v místním horizontálním systému, tj. horizontální systém založený na dané lokalitě. Rozdíl v zeměpisné délce od srovnávacího stupně délky místního časového pásma je proto zodpovědný za konstantní rozdíl mezi místním časem a pravým slunečním časem. Navíc pravidelně kolísající odchylka vyplývá z eliptické dráhy

Země okolo slunce a sklonem zemské osy. Následkem těchto jevů, se pravý sluneční čas navíc liší během roku až plus mínus 15 minut od místního času.

Hodiny hvězdného času pracují odlišně

Hvězdný čas může být přečten pomocí zlaté šipky na rámu nejvnitřnější stupnice. Ukazuje (měřeno hodinami a minutami hvězdného času) před jakou dobou byl poslední průchod bodu jarní rovnodennosti poledníkem (severo-jižní poledník). Proto tedy tato stupnice také začíná v místě poledníku nebo jižní pozici astrolábu, která odpovídá poloze dvanácté polední hodiny na běžných hodinách. Vzhledem k tomu, že hvězdný den je přibližně o 4 minuty kratší než sluneční den, viditelná část hvězdné oblohy se posunuje každý den přibližně o jeden stupeň na východ s ohledem na stále stejný místní čas. Hvězdný čas proto ukazuje znalému pozorovateli oblohy, která část oblohy je právě v poledníku a která část oblohy je tedy viditelná.

Stáří měsíce, tj. čas, který uběhl od polohy posledního novoluní, je označeno malou kuličkou měsíce na hrotu měsíčního ukazatele. Má jednu světlou a jednu tmavou polokouli, jakož i denní stupnici, která má rozsah od 0 do 29.53 dní. V novoluní kulička měsíce ukazuje tmavou polokouli a ukazuje tak měsíc při stáří 0 dní; při úplňku lze vidět pouze světlou stranu se stářím měsíce okolo 14.75 dní – mezi nimi připadají všechny ostatní hodnoty v úvahu.

4.9 Čtení souřadnic

Polohy astronomických těles

Kromě ukazování času, poskytuje astroláb také určování různých poloh astronomických těles:

- ekliptickou délku
- rektascenzi a deklinaci jakož i
- azimut a nadmořskou výšku

Poloha na dráze slunce

Ekliptická délka astronomického tělesa (slunce, měsíce a planet) ukazuje jeho vzdálenost od bodu jarní rovnodennosti při měření na dráze slunce. Protože tyto objekty cestují na nebo v blízkosti roviny ekliptiky, průsečík mezi odpovídajícím ukazatelem a prstencem zvěrokruhu označuje polohu astronomického tělesa na planisféře. Ekliptickou délku lze přečíst na stupnici vnějšího okraje prstence zvěrokruhu. 23. června 2004 v 10 hodin světového času byly indikovány následující ekliptické délky (zaokrouhleno na 0,5°):

Ukazatel	**Stupeň**
Jarní bod	0.0°
Lunární uzel	39.0°

Venuše	71.0°
Slunce	92.5°
Merkur	97.0°
Saturn	102.0°
Mars	115.0°
Měsíc	155.5°
Jupiter	159.0°

Místo na vesmírné scéně

Rovníkové souřadnice (rektascenze a deklinace) označují polohy vesmírných těles na nebeské sféře v porovnání s jarním bodem. Rektascenze na nebeském rovníku je počítána od západu k východu (proti směru hodinových ručiček) a je vyjádřena v hodinách, minutách a sekundách (15° odpovídá 1 hodině), zatímco severní nebo jižní deklinace popisuje úhlovou vzdálenost nebeského tělesa od nebeského rovníku.

Aktuální hodnoty rektascenze slunce, měsíce a planet v podstatě vyplývají z úhlového rozdílu mezi udanými polohami jarního bodu a objektu (měřeno na stupnici na vnějším okraji planisféry). Konkrétní poloha nulového bodu na stupnici (u východního bodu) nemá žádný význam. Následující úhly lze přečíst na konkrétním čase (hodnoty rektascenze z toho vypočítané jsou uvedeny v závorkách):

Ukazatel	Stupeň	Výpočet rektascenze
Síťový ukazatel	161.0°	0.0° = 00:00
Lunární uzel	124.5°	36.5° = 02:26
Venuše	92.0°	69.0° = 04:36
Slunce	69.0°	92.0° = 06:08
Merkur	63.5°	97.5° = 06:30
Saturn	58.0°	103.0° = 06:52
Mars	44.0°	117.0° = 07:48
Měsíc	3.5°	157.5° = 10:30
Jupiter	0.5°	160.5° = 10:42

Obloha z pohledu pozorovatele

Místní souřadnice azimutu a nadmořské výšky označují polohu nebeského tělesa vzhledem k jižnímu bodu příslušného pozorovatele. Azimut (linie procházející zenitem) a nadmořská výška (kružnice soustředěné na zenit) všech viditelných objektů mohou být určeny pomocí souřadnicové sítě na planisféře. Od té doby – jak bylo v minulosti běžné – jsou hodnoty azimutu indikovány podle kvadrantů (od východu či západu (0°) k severu či jihu (90°) v tomto pořadí), příslušný kvadrant (jihovýchod, jihozápad, severovýchod, severozápad) je rovněž součástí indikace azimutu. V současnosti je jižní bod považován za nultý bod (astronomického) výpočtu azimutu. Nadmořská výška je měřena od obzoru (Horizont obliquus) v nadmořské výšce 0°. Ke konkrétnímu datu byly v Esslingenu indikovány (zaokrouhleny na 0.5°) následující azimuty (v závorkách „novodobé“ hodnoty) a nadmořské výšky slunce, měsíce, planet a několika vybraných hvězd.

Ukazatel	**Azimut**	**Nadmořská výška**	
Venuše	jihozápad	87.5° (2.5°)	62.5°
Slunce	jihovýchod	49.5° (-40.5°)	60.0°
Merkur	jihovýchod	40.0° (-50.0°)	56.0°
Saturn	jihovýchod	33.5° (-56.5°)	54.0°
Mars	jihovýchod	19.0° (-71.0°)	42.5°
Měsíc	severovýchod	4.0° (-94.0°)	10.0°
Jupiter	severovýchod	5.0° (-95.0°)	6.0°
Sirius/C.Major	jihovýchod	59.5° (-30.5°)	19.5°
Capella/Auriga	jihovýchod	24.0° (-66.0°)	84.0°
Riegel/Orion	jihovýchod	81.5° (-8.5°)	32.5°

4.10 Zobrazení zatmění slunce a měsíce

Žádný strach ze zatmění

Zatmění patří mezi nejvíce fascinující podívané, jaké může obloha nabídnout. Nicméně jejich očividně nepravidelný výskyt byl v minulosti opakovaným důvodem nepokoje a strachu mezi lidmi. Na astrolábu je naproti tomu vidět, kdy lze zatmění slunce nebo měsíce očekávat. Zatmění slunce se může vyskytnout pouze při novoluní, zatmění měsíce pouze při úplňku. Avšak ne každé novoluní s sebou přináší zatmění slunce v jakékoliv formě, stejně jako ne při každém úplňku se koná zatmění měsíce. Protože je oběžná dráha měsíce nakloněná o něco více než o 5 stupňů směrem ke dráze slunce, novoluní se obvykle pohybuje nad nebo pod sluncem, zatímco úplněk se shodně pohybuje nad nebo pod stínem země. Aby došlo k zatmění slunce či měsíce, musí být poloha novoluní nebo úplňku v blízkosti jednoho ze dvou bodů

průsečíku mezi oběžnou dráhou měsíce a dráhou slunce. Tyto body průsečíku jsou označovány jako okružní uzly nebo dračí body.
Dračí ukazatel astrolábu ukazuje polohu okružních uzlů nebo dračích bodů na dráze slunce. Pokud se tedy ukazatele pravého slunce a měsíce pohnou blíže směrem k pozici novoluní v bezprostřední blízkosti k dračímu ukazateli, objeví se někde na zemi zatmění slunce. Záleží na úhlové vzdálenosti k dračímu ukazateli, zda je toto zatmění centrální nebo částečné. Pro centrální zatmění tj. prstencové zatmění nebo úplné sluneční zatmění, nesmí být novoluní umístěno o více než 11.6° od dračího ukazatele, pro částečné zatmění je maximum 18.8° - bez ohledu na to, zda v porovnání k hlavě či ocasu draka. Protože pásmo stínu měsíce je velmi malé (maximálně okolo 270km v průměru), zatmění slunce může být vždy pozorováno pouze z velmi malé části zemského povrchu – může zůstat naprosto bez povšimnutí z místa, kde se nachází astroláb!
Naproti tomu zatmění měsíce lze pozorovat, kdykoli je měsíc v době zatmění těsně nad obzorem. Lze jej očekávat, když se poloha úplňku (pravé slunce a ukazatel měsíce jsou umístěny naproti sobě) vyskytne v blízkosti dračího ukazatele. Zde jsou opět stanoveny mezní hodnoty. Aby úplněk zcela zmizel ve stínu země, vzdálenost k dračímu ukazateli nesmí být větší než 5.4 stupňů, kdežto u částečného zatmění úplněk nesmí být více než 12 stupňů od dračího ukazatele.

4.11 Ozdobné detaily

Kořeny astrolábu sahají zpět do starověku, takže jeho celkový vzhled je také založen na starobylém geocentrickém pojetí vesmíru, v centru s „pozorovatelem“. V dávných dobách bylo známo sedm planet, pohybujících se proti pozadí zdánlivě nehybných hvězd: byly to slunce, měsíc, Merkur, Venuše, Mars, Jupiter a Saturn. Tyto všechny jsou zobrazeny na astronomických hodinách Harmonices Mundi Award firmy Festo jako pohybující se objekty (indikátory).
Koperníkova revoluce změnila naše chápání vesmíru. Dnes víme, že slunce je středem sluneční soustavy se Zemí jen jako jednou z jejích planet. Po vynalezení dalekohledu na začátku 17. století byly objeveny další tři planety, Uran, Neptun a Pluto, které nelze vidět pouhým okem. Společně se Zemí, považovanou za jednu z planet už od doby Koperníka, jsou tyto tři pozdější zobrazeny v symbolické podobě na čtyřech rohových panelech astrolábu. Početné planetky mezi pásmy Marsu a Jupiteru jsou zastoupeny symboly prvních čtyř

objevených asteroidů Ceres, Pallas, Juno a Vesta společně s některými důležitými symboly používanými v záznamu astronomického kalendáře.
Jsou to

- v levém horním rohu Uran s Junou (vespod) a Vesta (vpravo),
- v pravém horním rohu Neptun s Pallas (vlevo) a Ceres (vespod),
- v pravém dolním rohu Pluto se symbolem pro protichůdnou pozici (nahoře) a pro zpětný pohyb planety (vlevo), stejně jako
- v levém dolním rohu Země se symboly pro vzestupný lunární uzel (vpravo) a měsíc (nahoře).

Harmonie tvarů a vzorců
Zadní část astronomických hodin Festo Harmonices Mundi Award ukazuje sbírku starodávných „posvátných" tvarů, které se objevují téměř ve všech raných, vysoce rozvinutých kulturách společně se vzorci, které změnily svět. Základní vzor znázorňuje „květ života", který je vytvořen spojením dokonalého kruhu a pravidelného šestiúhelníku – vzor který může pokračovat nekonečně do všech směrů. Určité body v tomto „moři květů" mohou být spojeny k vytvoření „stromu života", který donedávna utvářel základní architektonický vzor mnoha sakrálních staveb.
Z „květu života" je rovněž odvozeno pět platónských těles (čtyřstěn, šestistěn, osmistěn, dvacetistěn a dvanáctistěn), které jsou základem krystalografie, stejně jako zobrazení čtvercového kříže prvočísel, příkladu moderní geometrie čísel – u jednoduchého kříže prvočísel, jsou všechna prvočísla uspořádána tak, aby přímky je spojující vytvořily kříž.
Naproti tomuto složitě tkanému pozadí se objevuje pět důležitých rovnic, zastupujících astronomův moderní náhled na vesmír:

- Druhý Keplerův zákon (vlevo nahoře), který popisuje vztah mezi vzdáleností od slunce a rychlostí planety na její eliptické oběžné dráze
- Třetí Keplerův zákon (vpravo nahoře), který určuje řád mezi vzdáleností od slunce a oběžnou dobou planety
- Newtonův gravitační zákon (vpravo dole), který popisuje vzájemné ovlivňování nebeských těles z klasického (nerelativistického) hlediska a
- Keplerova rovnice (vlevo dole), která v matematické transcendenci není přesně řešitelná, ale může být pouze „rozlousklá" pomocí metod přibližného odhadu,

- Einsteinova rovnice ekvivalence hmotnosti a energie (ve středu), která odhaluje vztah mezi energií a hmotou, a je také výchozím bodem pro obecnou teorii relativity, jakožto moderního popisu struktury časoprostoru.

5 ANALYSIS OF THE STRATEGIES AND METHODS USED IN THE PROCESS OF TRANSLATION

5.1 Analysis of the source text, translator and tools

The analysis of the translated text may be aimed primarily at the lexical, syntactical and morphological features, which are noticeable at the first sight, but the text may also be analyzed from the point of view of stylistics, pragmatics and phonetics as well. In order to provide the appropriate analysis of the source text translated in this thesis, the general information about the source text will be provided as well as tools utilized in the process of translation and the analysis of the translator himself.

5.1.1 General information about the source text

The source text was provided by Festo Ltd., industrial control and automation company established in Germany which has now its branches and production halls all over the world. The text was published by Festo AG & Co. KG in Esslingen. Concept and editing was prepared by Hermann-Michael Hahn; design, layout and typesetting by Andreas Hild, Hild Design. The title of this text is Astrolabium Award. It describes Astrolabium Award – the astrolabe, which was construed by Professor Dr. Ing. Hans Scheurenbrand, the former director of research and development at Festo AG. Even though the text does not describe any of the typical Festo's products, it denotes the scientific and technical achievements of the company in a very specific and attractive way.

5.1.2 The style and characteristics of the source text

The source text can be characterized as scientific and/or technical text, because it contains features which are typical for both scientific and technical style. The features of the technical text may be spotted in the specialized vocabulary, for example, in the description of the astrolabe's parts *(cotter pin – závlačka, rete – síť, insertable plates – vkládací talíře, mater – matka, limb – rameno, sight – hledí, alidade – alidádá, axle – osa, pointer – ukazatel, scale – měřítko, calculating disc – počítací disk, gear – převod, rim – rám, gearwheel – ozubené kolo).* The chapters describing the process of how the times and coordinates are actually measured by the astrolabe may be considered as technical parts as well, because they describe how the astrolabe actually works in the way very similar to that of technical guides and manuals. The main aim of this text is not only to provide the factual information about the astrolabe, but also to provide the information about the planets, sky and the basic background knowledge about the exploration of the outer space during history. Therefore, another feature of this text is its noticeable scientific and historical aspect. The source text contains combinations of the astronomical, geographical, mechanical and historical information which is expressed in the way typical for the scientific style. The chapters *Celestial Motions* and *The Amazing Features of the Astronomical Clock* are also very educational, because they contain information about the history of the astronomical theories and about how the planets are actually positioned in our solar system. From the facts mentioned above we may conclude that the text is technical, scientific, educational and also popular because it should serve above all to entertain and to educate people.

The source text is divided into eleven chapters including a preface by Dr. Willfried Stoll. The text in each chapter is further divided into the paragraphs and it contains many images of the astrolabe and other astronomical motifs. However, these pictures were not included in the target text, because for the purpose of this thesis is the most important the text itself. Moreover, the images can anyone see in the appendices at the end of this thesis.

5.1.3 Translator

The task to analyze the translator in this case should better be left to a third person, since the translation of this text was carried out by myself. Nevertheless, I am not going to evaluate myself, instead I am going to state some information and circumstances about me in the position of the translator. Even though this was neither the first nor the last translation of a text in my life, it was definitely the most demanding translation which I have done and written it down. Since I am not a professional translator neither the specialist in the field of astronomy, it was not a simple task to translate the text which was full of technical terms and specialized vocabulary. I tried to study as many materials as possible to get the general background knowledge about the astronomy and the subject of translation even before I have started with the translation itself. Therefore, I was familiar with the topic of the source text from the previous parallel readings, I had the needful knowledge of both source and target language and I had the previous experience with the translation. One may claim that I had met all the requirements of a "good" translator, but the question remains if the translation is credible enough to be seen as an original work by the Czech readers.

5.1.4 Tools utilized in the process of translation

For the purpose of this translation, the bilingual *English – Czech* dictionaries were used above all. Even though I did use two technical dictionaries, I didn't find in any of them some of the key words related to astrolabe's description and, therefore, other tools had to be used to find those missing words. Electronic dictionaries with their larger capacities served as a better variant to the printed dictionaries. When even the electronic dictionaries failed to provide the correct equivalent, the texts from literature on similar topics were used to deduce the meaning of the translated item. The use of the machine translation in this particular text would be probably senseless, because MT is still not developed enough to deal with the translation of such a text.

5.2 Analysis of the strategies used in the process of translation

To translate a text from one language into another one is always very a challenging task, if the languages which are involved in the process of translation are not of the similar origin or the translator has mastered only of one of the languages. The translator has to deal with the problem of non-equivalence, the grammatical dissimilarities and with the different cultural conventions of both languages. Linguists and translation theoreticians often diverge in the opinion of how the proper translation should look like. The translation is still to the large degree very creative activity even though many restrictions and recommendations of how to deal with the process of translation nowadays exist. As it is going to be exemplified, it was not always easy to preserve the identical meaning of some of the terms. Therefore, also the utterance of the text may sometimes deviate a little bit from the original text. Nevertheless, the translator tried to maintain the uniformity of the source text as much as possible and tried not to deviate unnecessarily from the source text.

5.2.1 Techniques used in dealing with equivalence at word level

If an item in the source text has not the exact equivalent in the target language, the translator has to reach for an alternative solution in order to provide at least the similar meaning of the translated item. In this process the translator has to choose from the variety of strategies which one will be the most suitable for purposes of the particular translation.

Examples from the source text:

a) *It begins with the planisphere and* ***rete****, which are striking due to their unusual degree of completeness. - Začíná to planisférou a* ***sítí****, které jsou pozoruhodné díky neobvyklému stupni kompletnosti.*

b) *..., but still is* ***artistically*** *overlapping circular orbits according to the teachings of the Greek natural philosopher Aristotle. - ..., ale stále ještě v* ***esteticky*** *překrývajících se kruhových oběžných drahách dle učení řeckého filozofa Aristotela.*
c) *The Sky* ***as Seen by*** *the Observer. – Obloha* ***z pohledu*** *pozorovatele.*
d) *The ecliptic longitude of a celestial body (the sun, moon and planets) indicates its distance from the* ***vernal point*** *when measured on the ecliptic. - Ekliptická délka astronomického tělesa (slunce, měsíce a planet) ukazuje jeho vzdálenost od* ***bodu jarní rovnodennosti*** *při měření na dráze slunce.*
e) *At new moon the moon ball presents* ***its*** *dark side and indicates a moon age of 0 days. - V novoluní kulička měsíce ukazuje tmavou polokouli a ukazuje tak měsíc při stáří 0 dní.*

The words and phrases in the bold type, in the sentences above, represent the words which were translated into the target language by the use of one of the strategy dealing with the problem of non-equivalence at word level. In sentence *a)* the word ***rete*** in English means an anatomical mesh such as of nerves or veins. In target language ***rete*** was replaced by the more general word ***síť***. In Czech language the exact equivalent of the word ***rete*** does not exist. Therefore, if the text would be back-translated into the target language from Czech translation, the word ***rete*** would be probably translated by the less specific equivalents *mesh* or *net*. In sentence *b)* the word ***artistically*** was in the TL replaced by the less expressive word ***esteticky*** which back-translated into TL would be *aesthetically*. The verb phrase ***as seen by*** in the example *c)* was translated into Czech as ***z pohledu*** which back-translated into TL mean ***from the point of view***. In this case the verb phrase was translated by paraphrase using unrelated word. The example of the opposite translation strategy can be seen in the sentence *d)* where the noun phrase ***vernal point*** was translated by paraphrase using related word into ***bodu jarní rovnodennosti***. This noun phrase back-translated in English would be then ***the point of vernal equinox***. The form of the adjective ***vernal*** remained unchanged in both examples, but in the case of back-translation the extra information ***equinox*** was added. The last example *e)* demonstrates the translation strategy by omission. The possessive pronoun ***its*** in Czech ***jeho***, ***svojí*** is omitted in the translated text and, in this case, it does not harm the context of the text.

Another strategy which was used in the process of dealing with non-equivalence at word level was translation by using loan word or loan word plus explanation.

Examples of words translated by using loan word or loan word plus explanation:

f) *Harmonices Mundi – Harmonices Mundi (astroláb)*

g) *Linea crepusculi civilis – Linea crepusculi civilis*

h) *Linea crepusculi nautici – Linea crepusculi nautici*

i) *Linea crepusculi astronomici – Linea crepusculi astronomici*

j) *Planisphere – Planisféra (otáčivá mapa hvězdné oblohy)*

k) *Alidade – Alidáda (část měřícího přístroje se zaměřovacím zařízením)*

The examples *f) – i)* are Latin words which were used in the English source text as well as in the Czech translation. Except for example *f) Harmonices Mundi*, no further explanation to these expressions was provided. However, the meaning of these Latin expressions is clearly understandable from the context and they make the text sounds more sophisticated. Examples *j)* and *k)*, i.e. *Planisphere* and *Alidade* were translated into Czech adaptations of these terms and these highly technical terms were subsequently explained.

5.2.2 Techniques used in dealing with grammatical structures

As it was already mentioned in the theoretical part, the scientific and technical texts are well-known for their nature of impersonal objectiveness. According to this statement, the text analyzed here may be considered as the typical technical/scientific writing. The impersonality is achieved above all, by the use of passive voice in combination with infinitives, gerunds and participle structures.

Examples from the source text:

a) ***There had been*** *some doubts about this geocentric world view even in ancient Greece, but… - Dokonce již ve starověkém Řecku* ***se vyskytly*** *určité pochybnosti o tomto geocentrickém pohledu na svět, ovšem…*

b) ***It can be expected*** *when a full moon position occurs near the dragon pointer. -* ***Lze jej očekávat****, když se poloha úplňku vyskytne v blízkosti dračího ukazatele.*

c) ***Being*** *a device for determing the time mainly during the night hours, the astrolabe enjoyed a heyday in mediaval times, and… -* ***Tím, že je to*** *přístroj určující čas hlavně v nočních hodinách, (pomocí měření astronomických nadmořských výšek), se astroláb těšil rozkvětu ve středověku a…*

d) *Nowadays the South point* ***is considered to be*** *the zero point of the (astronomical) azimuth count. - V současnosti* ***je*** *jižní bod* ***považován*** *za nultý bod (astronomického) výpočtu azimutu.*

e) *The measuring principle* ***can be*** *easily* ***explained****. - Měřící princip* ***lze*** *jednoduše* ***vysvětlit****.*

In the examples *a)* and *b)* above is illustrated how the sentences can be expressed in the impersonal way by the use of expletive “it” and “there”. Expletive “there” in sentence *a)* has no locative meaning as the “adverbial there” and expletive “it” in sentence *b)* does not refer to anything as the “referential it” which can not be replaced in the sentence. They are used to introduce new information in a rather indeterminate and impersonal way.

The verbal structures that occur in the source text are, above all, “bare infinitives”, “infinitives + to”, “gerunds” and “participle structures”. The example of “gerund” is shown in the sentence *c)*. In this case, gerund is the structure formed from the bare infinitive “be” + the inflectional suffix “ing”, and it serve as a noun in the sentence. Other examples of the verbal structure forms are not included, because to exemplify them would be redundant.

The examples *d)* and *e)* illustrate the sentences written in the form of “passive voice”. “Passives” are formed by the form of the verb *be* + *ed* participle. The “passive voice” is frequently used in the technical/scientific texts for both reasons, to demote or delete the agent (doer) from the text or to rhematize the agent. The “semantic valency” of the sentence is changed due to the use of “passive voice”, since the “agent” of the passive sentence is different as it would be in the same sentence written in “active voice”.

All of these grammatical methods i.e. *the use of expletive it and there, various verbal structures and the passive voice* are used to achieve the impersonal nature of the text which is, without no doubts, one of the most typical features of the modern technical and scientific writing.

6 TERMINOLOGICAL DICTIONARY

alidade	/ˈælɪdeɪd/	alhidáda (část měřícího přístroje s odečítacím a zaměřovacím zařízením)
altitude	/ˈæltɪˌtjuːd/	nadmořská výška
angle	/ˈæŋgəl/	úhel
angular distance	/ˈæŋgjʊlə ˈdɪstəns/	úhlová vzdálenost
antiquity	/ænˈtɪkwɪtɪ/	antika, starověk
arc	/ɑːk/	oblouk
archaic	/ɑːˈkeɪɪk/	archaický, prastarý
arrow	/ˈærəʊ/	šipka
astrolabe	/əˈstrɒləb/	astroláb (historický astronomický přístroj)
astrolabe Award	/əˈstrɒləb əˈwɔːd/	menší verze astrolábu *Harmonices Mundi*
astrological houses	/ˌæstrəˈlɒdʒɪkəl haʊzɪs/	astrologické části oblohy
astronomical clock	/ˌæstrəˈnɒmɪkəl klɒk/	astronomické hodiny, orloj
astronomical twilight	/ˌæstrəˈnɒmɪkəl ˈtwaɪˌlaɪt/	astronomický soumrak
astronomy	/əˈstrɒnəmɪ/	astronomie
axis	/ˈæksɪs/	osa
axle	/ˈæksəl/	osa
azimuth	/ˈæzɪməθ/	azimut
belt	/belt/	pás, pásmo, zóna
calculating disc	/ˈkælkjʊˌleɪtɪŋ dɪsk/	počítací disk
calendar	/ˈkælɪndə/	kalendář
celestial	/sɪˈlestɪəl/	nebeský
celestial bodies	/sɪˈlestɪəl ˈbɒdiːs/	nebeská tělesa
celestial equator	/sɪˈlestɪəl ɪˈkweɪtə/	nebeský rovník
central eclipse	/ˈsentrəl ɪˈklɪps/	centrální zatmění
chronometry	/krəˈnɒmətrɪ/	chronometrie
civil time	/ˈsɪvəl taɪm/	místní čas
civil twilight	/ˈsɪvəl ˈtwaɪˌlaɪt/	občanský soumrak

clock-builder	/klɒk ˈbɪldə/	hodinář
clock hand	/klɒk hænd/	hodinová ručička
clockwork mechanism	/ˈklɒkˌwɜːk ˈmekəˌnɪzəm/	hodinový mechanismus, ústrojí
constellation	/ˌkɒnstɪˈleɪʃən/	souhvězdí
coordinates	/kəʊˈɔːˌdɪˌneɪts/	souřadnice
coordinate grid	/kəʊˈɔːˌdɪˌneɪt grɪd/	souřadnicová síť
cotter pin	/ˈkɒtə pɪn/	závlačka
crescent moon	/ˈkresənt muːn/	půlměsíc, srpek měsíce
crystallography	/ˈkrɪstəlˌgræfɪ/	krystalografie
current time	/ˈkʌrənt taɪm/	aktuální čas
dead moon	/ded muːn/	fáze měsíce, při které není měsíc viditelný
declination	/ˌdeclɪˈneɪʃən/	deklinace (úhlová vzdálenost hvězdy od rovníku)
derive	/dɪˈraɪv/	derivovat, odvodit, čerpat
deviation	/ˌdiːvɪˈeɪʃən/	odchylka
diameter	/daɪˈæmɪtə/	průměr
dodecahedron	/ˌdəʊˌdekˌəˈhiːˌdr ə n/	dvanáctistěn
dragon pointer	/ˈdrægən ˈpɔɪntə/	ukazatel draka
earth	/ɜːθ/	země
eclipse	/ɪˈklɪps/	zatmění
ecliptic	/ɪˈklɪptɪk/	ekliptika (zdánlivá dráha slunce)
ecliptic plane	/ɪˈklɪptɪk pleɪn/	ekliptická rovina
ecliptic longitude	/ɪˈklɪptɪk ˈlɒŋgɪˌtjuːd/	ekliptická délka
equation	/ɪˈkweɪʒən/	rovnice
equatorial coordinates	/ˌekwəˈtɔːrɪəl kəʊˈɔːˌdɪˌneɪts/	rovníkové souřadnice
equivalence	/ɪˈkwɪvələns/	ekvivalence, rovnocennost
firmament	/ˈfɜːməmənt/	nebeská klenba
four-stage gear	/ˈfɔːˌsteɪdʒ gɪə/	čtyřstupňový převod
full moon	/fʊl muːn/	úplněk
full moon pointer	/fʊl muːn ˈpɔɪntə/	ukazatel úplňku
glockenspiel	/ˈglɔkə nˌʃp iːl/	zvonkohra

gear	/gɪə/	převod, převodové ústrojí
gearwheel	/gɪəˌwi:l/	ozubené kolo
geocentric	/ˌdʒi:ˌəʊˈsenˌtrɪk/	geocentrický (názor)
gravitation	/ˌgrævɪˈteɪʃən/	gravitace
gravity	/ˈgrævɪtɪ/	gravitace
heavenly bodies	/ˈhevənlɪ ˌbɒdi:s/	nebeská tělesa
heliocentric	/hi:lɪə ˈsenˌtrɪk/	heliocentrický (teorie, v níž je slunce středem vesmíru)
hemisphere	/ˈhemɪˌsfɪə/	hemisféra, polokoule
hexagon	/ˈheksəgən/	šestiúhelník
hexahedron	/heksə ˈhi:ˌdr ə n/	šestistěn
horizon	/həˈraɪzən/	horizont, obzor
hour-drive	/aʊəˈdraɪv/	hodinový pohon
hub	/hʌb/	centrum, střed
icosahedron	/ɪkɔsəˈhi:ˌdr ə n/	dvacetistěn
indication	/ˌɪndɪˈkeɪʃən/	indikace, údaj
indicator	/ˈɪndɪˌkeɪtə/	ukazatel, indikátor
intersection	/ˌɪntəˈsekʃən/	průsečík
Jupiter	/ˈdʒu:pɪtə/	Jupiter
limb	/lɪm/	rameno
line	/laɪn/	dráha, linie
local time	/ˈləʊkəl taɪm/	místní čas
location	/ləʊˈkeɪʃən/	poloha, místo, lokace
longitude	/ˈlɒndʒɪˌtju:d/	zeměpisná délka
lunar	/ˈlu:nə/	měsíční, lunární
lunar eclipse	/ˈlu:nə ɪˈklɪps/	zatmění měsíce
lunar node	/ˈlu:nə nəʊd/	měsíční, (lunární) uzel
Mars	/mɑ:z/	Mars
mass-energy	/ˌmæsˈenədʒɪ/	hmota a energie
mater	/ˈmeɪˌtə/	matka
Mercury	/ˈmɜ:kjʊrɪ/	Merkur
meridian	/məˈrɪdɪən/	poledník

millennium	/mɪˈlenɪəm/	tisíciletí
moon	/muːn/	měsíc
moon ball	/ˈmuːn ˌbɔːl	kulička znázorňující měsíc
moon phase	/ˈmuːn ˌfeɪz/	fáze měsíce
moon pointer	/ˌmuːn ˈpɔɪntə/	měsíční ukazatel, ukazatel měsíce
nautical twilight	/ˈnɔːtɪkəl ˈtwaɪˌlaɪt/	námořní soumrak
Neptune	/ˈneptjuːn/	Neptun
new moon	/njuː muːn/	nov, novolunní
night zone	/ˈnaɪt ˌzəʊn/	noční pásmo
nomogram	/ˈnəʊməˌgræm/	nomogram (speciální graf)
noon	/nuːn/	(pravé) poledne
noon line	/nuːn laɪn/	poledník
observer	/əbˈzɜːvə/	pozorovatel
octahedron	/ˌɒktəˈhiːˌdrən/	osmistěn
orbit (noun)	/ˈɔːbɪt/	oběžná dráha
orbit (verb)	/ˈɔːbɪt/	kroužit
orbit node	/ˈɔːbɪt ˌnəʊd/	okružní uzel
outer edge	/ˈaʊtə ˌedʒ/	vnější okraj
perturbation	/ˌpɜːtəˈbeɪʃən/	odchylka
plan-of-creation	/plæn ɒv kriːˈeɪʃən/	plán stvoření světa
planet	/ˈplænɪt/	planeta
planetary motion	/ˈplænɪtərɪ ˌməʊʃən/	planetární pohyb
planetary orbit	/ˈplænɪtərɪ ˈɔːbɪt/	planetární dráha
planetoid	/ˈplænəˌtɔɪd/	planetka
planisphere	/ˈplænɪsfɪə/	vkládací talíře, planisféra (otáčivá mapa hvězdné oblohy)
Platonic solid	/pləˈtɒnɪk ˈsɒlɪd/	platónské těleso
Pluto	/ˈpluːtəʊ/	Pluto
pointer	/ˈpɔɪntə/	ukazatel, ručička (přístroje)
pointer rod	/ˈpɔɪntə rɒd/	tyčinka ukazatele
pointing rod	/ˈpɔɪntɪŋ rɒd/	směrovací tyčinka

prime number	/praɪm ˈnʌmbə/	prvočíslo
processor-controlled	/ˈprəʊsesə kənˈtrəʊld/	procesorem řízené
radio clock	/ˈreɪdɪəʊ ˌklɒk/	rádiové hodiny
radio-controlled	/ˈreɪdɪəʊ kənˈtrəʊld/	rádiově řízený
rete	/riːt/	(anatomická) síť
rete pointer	/riːt ˈpɔɪntə/	ukazatel sítě
retrograde motion	/ˈretrəʊˌgreɪd ˈməʊʃən/	zpětný pohyb
right ascension	/raɪt əˈsenʃən/	rektascenze
rim	/rɪm/	rám
rotation	/rəʊˈteɪʃən/	rotace
Saturn	/ˈsætɜːn/	Saturn
scale	/skeɪl/	měřítko
sidereal day	/ˌsaɪdˈrɪəl deɪ/	hvězdný den
sidereal time	/ˌsaɪdˈrɪəl taɪm/	hvězdný čas
sight	/saɪt/	hledí
sky	/skaɪ/	obloha, nebe
solar	/ˈsəʊlə/	solární, sluneční
solar eclipse	/ˈsəʊlə ɪˈklɪps/	zatmění slunce
space-time	/speɪs taɪm/	časoprostor
spectacle	/ˈspektəkəl/	podívaná, výjev
spherical angle	/ˈsferɪkəl ˈæŋgəl/	sférický úhel
star	/stɑː/	hvězda
starry sky	/ˈstɑːrɪ skaɪ/	hvězdná obloha
stepper motor	/stepə ˈməʊtə/	krokový motor
stereographic projection	/ˌsterɪəʊˈgræfɪk prəˈdʒekʃən/	stereografický průmět
sun	/sʌn/	slunce
sun pointer	/sʌn ˈpɔɪntə/	ukazatel slunce
sunrise	/ˈsʌnˌraɪz/	východ slunce
sunset	/ˈsʌnˌset/	západ slunce
synodic month	/ˌsɪnədɪc ˈmʌnθ/	synodický měsíc (čas od jednoho novolunní k dalšímu)
telescope	/ˈtelɪˌskəʊp/	dalekohled, teleskop

temporal hours	/ˈtempərəl ˌaʊərs/	pozemské hodiny
temporal time	/ˈtempərəl taɪm/	pozemský čas
tetrahedron	/ˌtetrəˈhiːdrən/	čtyřstěn
theory of relativity	/ˈθɪərɪ ɒv ˌreləˈtɪvɪtɪ/	teorie relativity
transcendence	/trænˈsendəns/	nadřazenost
tropic	/ˈtrɒpɪk/	obratník
true solar time	/truːˈsəʊlə taɪm/	pravý sluneční čas
true sun	/truː sʌn/	jasné slunce
tunned bars	/tjuːnəd bɑːs/	laděné takty
twilight	/ˈtwaɪˌlaɪt/	stmívání, soumrak
twilight lines	/ˈtwaɪˌlaɪt laɪns/	linie soumraku
twilight phases	/ˈtwaɪˌlaɪt feɪzɪs/	fáze soumraku
two-stage gear	/tuːˈsteɪdʒ gɪə/	dvou stupňový převod
universal time	/ˌjuːnɪˈvɜːsəl taɪm/	světový čas
universe	/ˈjuːnɪˌvɜːs/	vesmír
Uranus	/jʊˈreɪnəs/	Uran
Venus	/ˈviːnəs/	Venuše
vernal point	/ˈvɜːnəl pɔɪnt/	bod jarní rovnodennosti
vertex	/ˈvɜːˌteks/	vrchol, nejvyšší bod
waning moon	/wɒnɪŋ muːn/	ubývající měsíc
waxing moon	/wæksnɪŋ muːn/	dorůstající měsíc
zenith	/ˈzenɪθ/	zenit, vrchol
zodiac	/ˈzəʊdɪˌæk/	zvěrokruh
zodiac ring	/ˈzəʊdɪˌæk rɪŋ/	prstenec zvěrokruhu

CONCLUSION

In the theoretical part were defined the style of technical and scientific writing and the subject of translation. The information about these two technical fields was paraphrased exclusively from the printed literary works which served as valuable sources during the whole process of writing of this bachelor thesis. Firstly, the theory about technical and scientific writing was determined. The information about the technical and scientific style of writing was further analyzed according to various lexical, grammatical and logical features and according to the form in which the technical texts are ordinarily produced. Secondly, the subject of translation, translator and tools utilized at the process of translation were described. Thirdly, the theoretical part was summarized and some definite conclusions were made.

In the analytical part, the translation was rendered from the original text *Astrolabium Award* into Czech language. The translation was subsequently analyzed from the different perspectives to provide the general information about the translated text and about the techniques used in the process of translation. Furthermore, the terminological dictionary was created to facilitate the process of translating.

In the course of work it was found out that the individual theories about the translation are interconnected and despite the fact that the information technology has begun to substitute increasingly the human translator, the human assistance is during the translation process still indispensable.

The main contribution of this thesis is the translation itself. After the translation of the second original text *Horologium Award*, which supplements the text contained in this thesis, will be finished, both Czech translations will be send to the Marketing Department of Festo, Ltd. in Prague. There the texts will be edited and published. The finished brochures will be used, above all, for the Festo customers who visit Festo HQ in Germany during regular VIP tours.

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APPENDICES

APPENDIX P I: ASTROLABIUM AWARD

FESTO

astrolabium
award

These two clocks (approx. 4'7" x 4'7", 1.40 x 1.40 m) of the Festo Harmonices Mundi stand in the Technology Center of Festo AG & Co. KG in Esslingen like non-identical twins.

Contents

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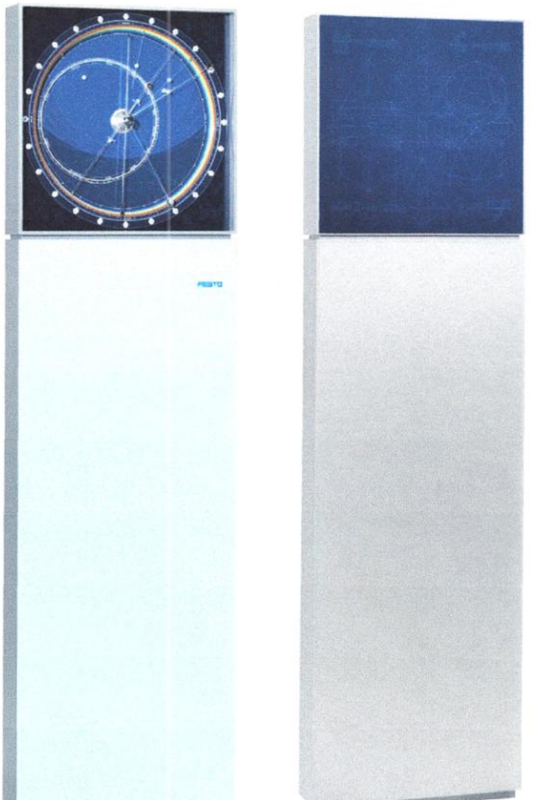


Astrolabium Award –
The Festo astrolabe

Preface

In the Astrolabe Award, Festo has created an exceptional prize for very special occasions and for outstanding achievements. Festo's Astrolabe Award is a smaller copy of the Festo Harmonices Mundi astrolabe, which is situated in Festo's TechnologyCenter in Esslingen. At the core of the astrolabe is an astronomical clock which precisely shows the movements of the sun, moon and stars. Using the golden ratio, and retaining the same level of functionality as the original, a masterpiece has been produced which is identical to its archetype in appearance, aesthetics and harmony.

The Festo Harmonices Mundi represents a synthesis of modern astronomy, mechanics, melody and electronics, implemented as a tripartate technical artwork using the latest technology. The original version in Esslingen includes, alongside the calendar clock, an astronomical clock in the form of an astrolabe, and an attractively designed glockenspiel with 76 bells, 40 tuned bars and a claviature. It is a symbol of innovation, and was calculated, designed and constructed in years of after-hours work by Professor Dr. Ing. Hans Scheurenbrand, former director of research and development at Festo AG. In 2003 the German Society for Chronometry (DGC) awarded Professor Scheurenbrand the Philipp Matthäus Hahn Medal in recognition of his work.

A project that was begun as a private hobby finally grew into an overall system that powerfully symbolises not only Festo's global corporate network but also this networks underlying principle of harmonious interpersonal co-operation.

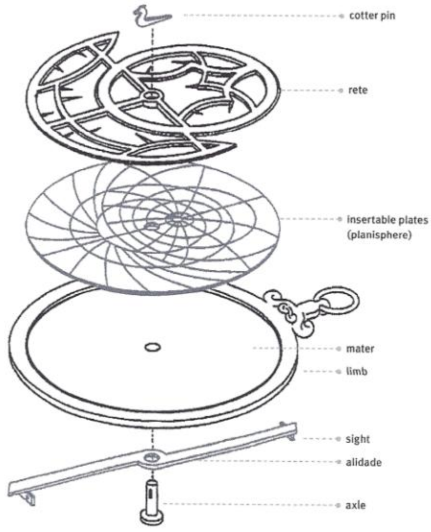
Using the Esslingen original as a basis, Prof. Scheurenbrand later created smaller versions of the astrolabe and calendar clock.

The Astrolabe Award symbolically conveys the scientific and technical achievements of Festo from company HQ to the wider world. In its new locations, the award will serve as an ambassador of Festo, and as a visible expression of the close connection with the company.

I hope that the fascination which the technology and harmony this award exerts will inspire the readers of this brochure with enthusiasm for time and eternity, and that their encounter with the Festo Harmonices Mundi calendar clock will be a star-studded experience!

Dr. Wilfried Stoll

The Astrolabe
History and Fundamental Principles



The astrolabe is one of the oldest portable instruments for observing the sky. Being a device for determining the time mainly during the night hours (by measuring the celestial altitudes), the astrolabe enjoyed a heyday in medieval times and at the beginning of the modern age in civilizations influenced by Islam, for it enabled the experienced user to easily determine the prayer times and later also the Qibla (the direction towards Mecca to which Muslims must turn for prayer), which was very important especially for travellers.

The Sky as a Clock

The measuring principle can be easily explained. Since the earth rotates once about its axis every 24 hours and at constant speed, the sun, moon and most stars rise above the horizon in the East, attain their highest altitudes in the South and set in the West. By measuring a star's altitude and azimuth (a measure of direction), one can accordingly determine how much time has passed since the rising of the star or how long it will take until it reaches the North-South line (the meridian or noon line). These values, however, depend on the observer's geographical latitude as well as the current date, so that in each individual case comprehensive tables or appropriate calculations must be used to evaluate a measurement.

Such calculations were generally rendered superfluous by the astrolabe's special design because it provided a direct conversion of the measured local altitude and azimuth angles into the (geocentric) coordinate grid, the respective orientation of which is only determined by the current time (more exactly: the sidereal time). From a mathematical point of view, an astrolabe is nothing else but a calculating disc for converting the so-called spherical angles.

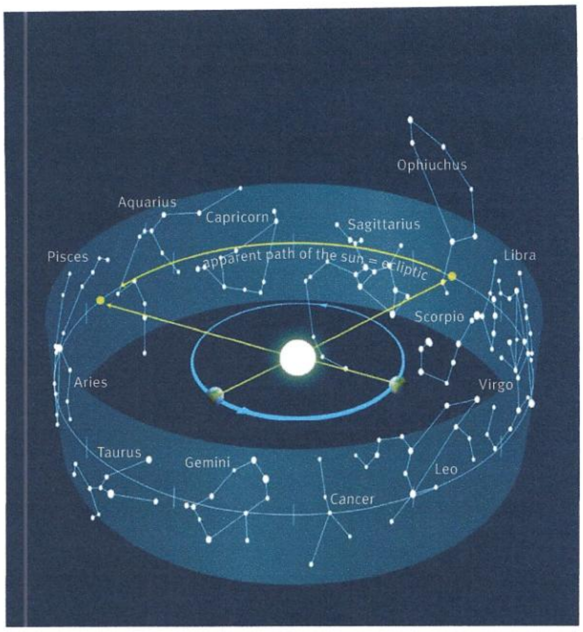
A Conformal Image of the Sky

The correct functioning of such a calculating disc requires that the spherical angles measured in the sky are projected flawlessly (i.e. preserving the angles) onto a flat surface. This is quite a challenge when considering how easily an orange peel will tear if you try to flatten it using a heavy weight. In this case mathematicians and geographers use conformal projections, one of which is the especially appropriate stereographic projection, the principles of which were already known to the Greek astronomer Hipparchos over 2200 years ago.

Astrolabes therefore include two discs which can be rotated towards each other: a planisphere (meaning literally "flattened sphere", i.e. a flat representation of the vault of the sky with its altitude and direction angles) and a usually very elaborate and filigreed rete featuring the positions of selected stars. Moreover, they comprise a rotatable measuring and pointing rod (alidade) for measuring the altitudes of the celestial bodies. The necessary supporting structure, the so-called mater, is both the housing and an additional carrier of information because its back provides space for several scales and nomograms. The parts of the instrument are held together and secured by an axle and a cotter-pin.

To determine the time of day, it is enough to measure a star's altitude and direction and to turn the rete until its corresponding star pointer points at the planisphere's correct altitude and direction lines. Then the rim of the mater indicates how long it will take for this star to reach the South line (or when the passage through the South line occurred). This reading and the knowledge of the date, which can be derived from the sun's position in the zodiac, finally provide the local time.

Celestial Motions
in the Changing World view



When the first astrolabes were designed, it was generally believed that the Earth rested in the centre of the universe and that every day the earth was surrounded by moving celestial bodies. The wandering stars (the sun, moon and planets) seemed to move at different speeds in front of the background of the fixed stars. The fastest – and therefore nearest to the earth – was the moon that moved through the constellations of the zodiac once every 27.32 days. Orbiting further out were Mercury, Venus and the sun, which completed one passage through the zodiac in approximately 365.25 days. To reach the same position of the zodiac again, Mars needed 687 days, Jupiter just under twelve years and Saturn nearly 29.5 years. The fact that the planets changed their direction of motion at regular intervals and travelled backwards for a while led to some confusion and provided the reason for the term planet (which derives from the Greek word meaning "to wander about"), but this was finally explained to some extent by a complex overlapping of several circular motions.

The Sun and Moon as "Clocks"

Since the sun with its light and heat had a substantial effect on people's everyday lives and particularly influenced the natural environment by the changing seasons, its period of orbit (the solar year) became the decisive calendar period. Similar importance was attached to the moon, the regular phase change of which seemed to be a link between the transitory nature of human life and the eternally unvarying, heavenly world of the gods. Such a change of phases from one new moon to the next lasts 29.53 days on average. The first appearance of the slender crescent moon in the evening sky ended several days of invisibility (the "dead moon") and was called "new moon" even in those times.

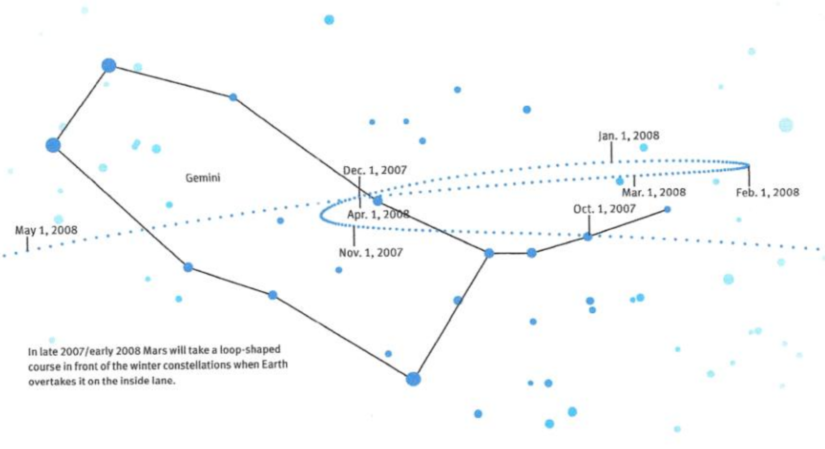
There had been some doubts about this geocentric world view even in ancient Greece, but these ideas did not gain acceptance. It was Klaudios Ptolemaios (Ptolemy) who established, so to speak, this world view in his work "Almagest" in the middle of the 2nd century. It was not until the 16th century that increasing doubts finally revolutionized this concept of the world.

Johannes Kepler (1571 – 1630)

Celestial Theories

Nicolaus Copernicus, born in what is now Poland, initiated a change when his book "De revolutionibus orbium coelestium" was published in 1543 and advocated a new world view. He placed the sun at the centre of planetary motion, whereas the earth now orbited the sun along with the other planets, but still in artistically overlapping circular orbits according to the teachings of the Greek natural philosopher Aristotle. Above all, Copernicus wanted his worldview to be seen as an improved model for easier and more precise calculations of planetary motion, but his model met this special requirement only under certain circumstances. The tables of the planets actually became more accurate when Johannes Kepler, of Weil der Stadt in Württemberg, Germany, recognised the elliptical nature of the planetary orbits at the beginning of the 17th century and, as a result, delivered the final deathblow to the ancient world view.

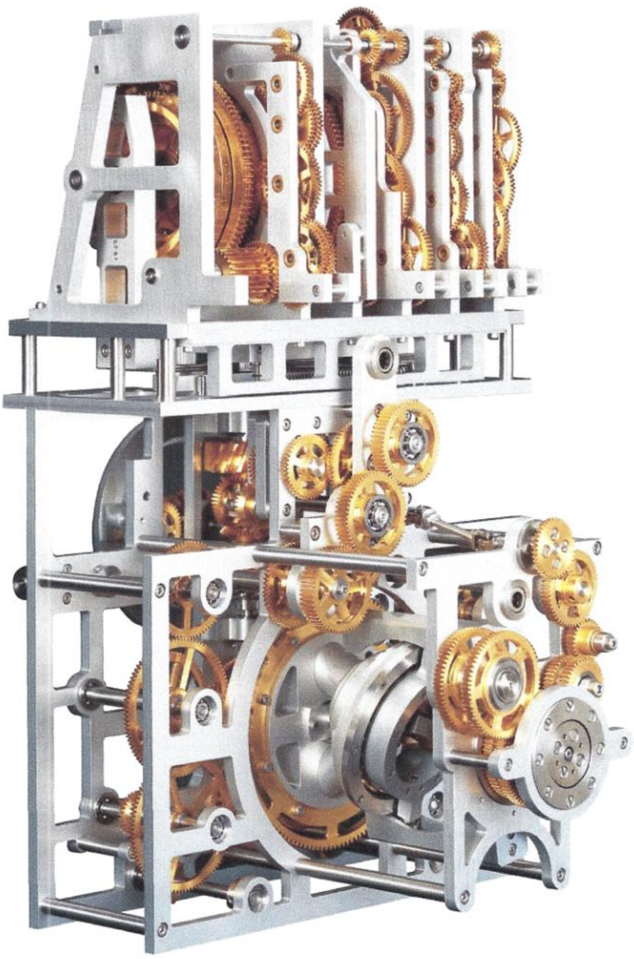
At about the same period, the newly invented telescope provided the first "close images" of the planets, which supported the novel Copernican or heliocentric worldview. This opened up the way for a new view of nature, which, only a few decades later, led to the formulation of the universal law of gravitation by Isaac Newton.



In late 2007/early 2008 Mars will take a loop-shaped course in front of the winter constellations when Earth overtakes it on the inside lane.

The Amazing Features of the Astronomical Clock

Sun, Moon, Planets and Eclipses



Moon gear with inclined moon wheel.

Soon after the invention of clockwork mechanisms in the 13th century clockmakers made the sequence of celestial events the subject of their art. For millennia the determination of time had been characterized by the celestial movements (particularly those of the apparent daily change in the fixed star sphere), but now clockmakers were able to reverse the situation and imitate the sequence of celestial events. Since they thus also modelled the celestial "plan of creation" at the same time, churches were frequently the clients who ordered such astronomical clocks, though worldly rulers were also interested in such symbols of power, as many a town hall and art gallery demonstrate today.

Over the course of time the design and precision of astronomical clocks changed constantly. The oldest preserved and still functioning large clock of this kind can be found in St. Mary's Church in Rostock. It was built in 1379-80, restored around 90 years later and not only shows the time, but also the position of the sun on the ecliptic (and thus the date), the position of the moon and its phase as well as the day of the week and indicates the dates for Easter until the year 2017 on an additional calendar disc.

The Clock as a Celestial Model

Later clocks also incorporated a representation of the planetary movements as well as of the so-called lunar node, which served as an indicator of imminent solar and lunar eclipses. At the same time clock-builders attempted to derive the different times of revolution of the individual pointers from the already existing hour-drive of the clock by means of extremely simply designed gears. However, because the individual periods of revolution could not be represented as small, whole-number ratios, more or less significant inaccuracies had to be accepted. A synodic month, for instance, i.e. the time from one new moon to the next, lasts 29.53059 days on average. If one wishes to derive this period of revolution directly from the daily rotation, the rotational speed of the moon pointer has to be reduced to 1–1/29.53059 or, rounded off to five places, 0.96614. Often the designers then contented themselves with a rotational speed of 1–1/29.5 or 0.96610 per day, which could be derived, for example, from the daily rotation through the gear combination 114/118 (or 57/59). However, they thus accepted that, after approximately 3 years, the moon was one day ahead of its target position in front of the constellations.

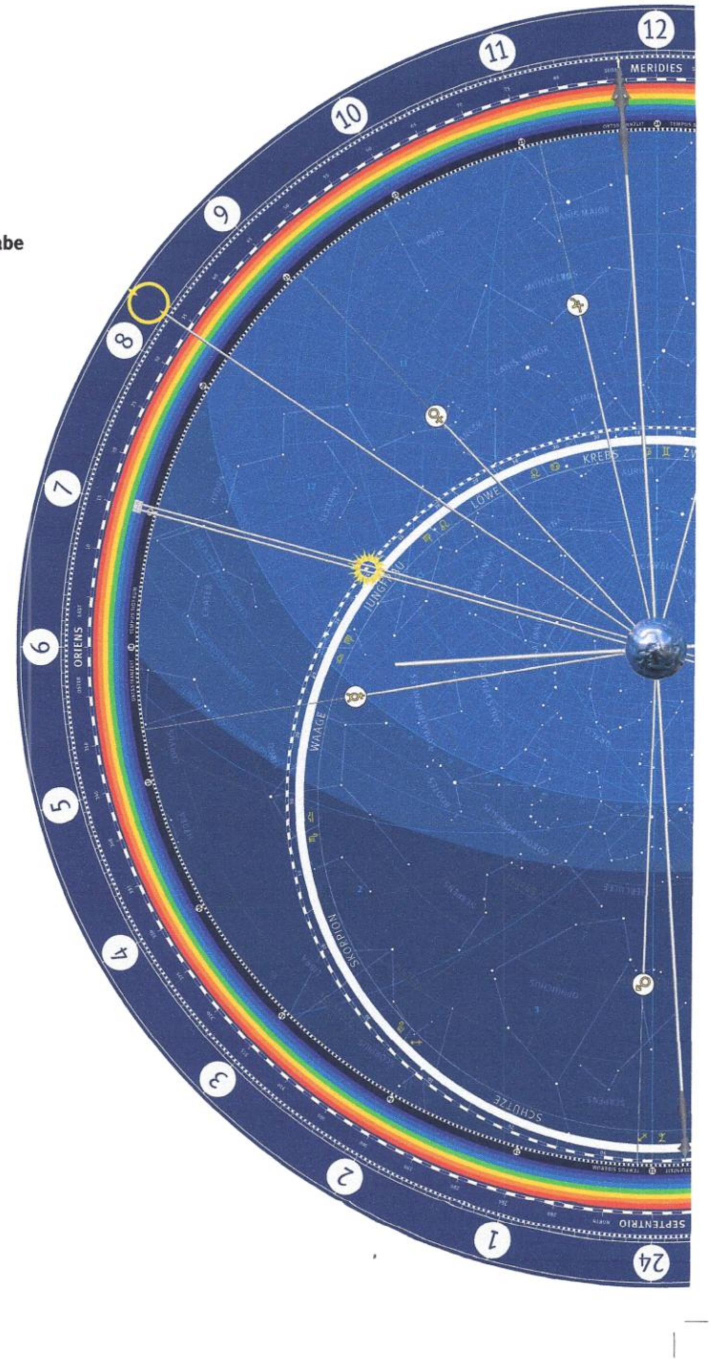
The Limits of Accuracy

A two-stage gear 22/54 · 83/35, for instance, which would not have led to a corresponding deviation of the moon until after 130 years, would have resulted in a significantly better representation of the moon, and a literally astronomical accuracy would have been achieved with a four-stage gear 11/13 · 23/16 · 23/18 · 23/37, which would have left the moon one day behind only after 95,000 years!

However, such extremely precise representations would be worthless unless one also wanted to represent obvious irregularities in motion as a countermeasure. Such perturbations caused by the gravity of other celestial bodies become noticeable in particular in the motion of the earth and moon. They were first taken into account in the third astronomical clock in the Strasbourg Cathedral built by Jean Baptiste Schwilgué between 1838 and 1842, is considered to be exceptionally precise.

General View of the Festo Astrolabe

Showing the Individual Components

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STEINBOCK

Reading the Astrolabe

Rising and Setting Times of the Celestial Bodies

The new moon and the true sun are in the sky together.

The pointer of the waxing moon is to the left of the true sun.

The full moon is opposite the true sun.

The pointer of the waning moon is to the right of the true sun.

The symbol of the true sun is decisive for determining sunrise and sunset. When the sun is on the horizon, it is just rising (in the morning) or setting (in the evening).

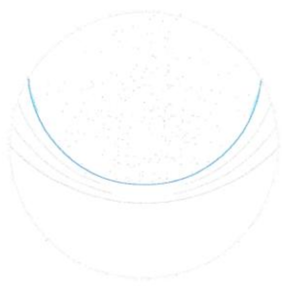
The three phases of twilight are determined by the sun's depth below the horizon.

Civil Twilight
Reading outdoors without any additional light is possible during civil twilight (the Linea crepusculi civilis indicates the beginning and end).

Nautical Twilight
The brightest stars and the horizon line are visible during nautical twilight. Navigators can perform the astronomical determination of their locations (the Linea crepusculi nautici indicates the beginning and end).

Astronomical Twilight
Real darkness only exists before or after astronomical twilight (the Linea crepusculi astronomici indicates the beginning and end).

The altitude and azimuth lines.



The horizon line with twilight lines.

The zenith of the Festo Astrolabe.

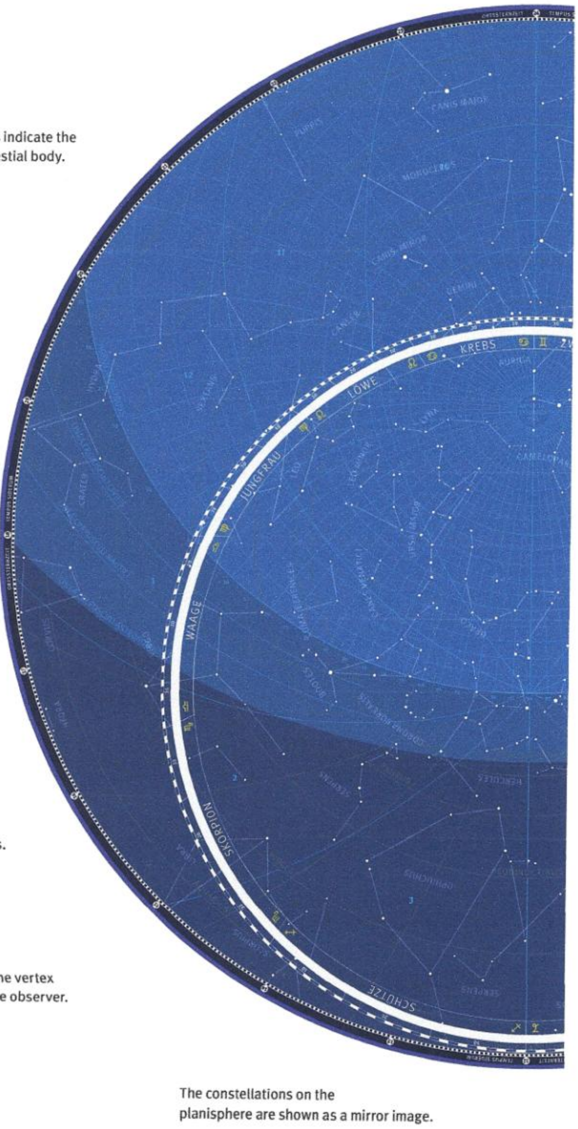
The signs of the zodiac divide the ecliptic into twelve equal parts.

The azimuth lines indicate the direction of a celestial body.

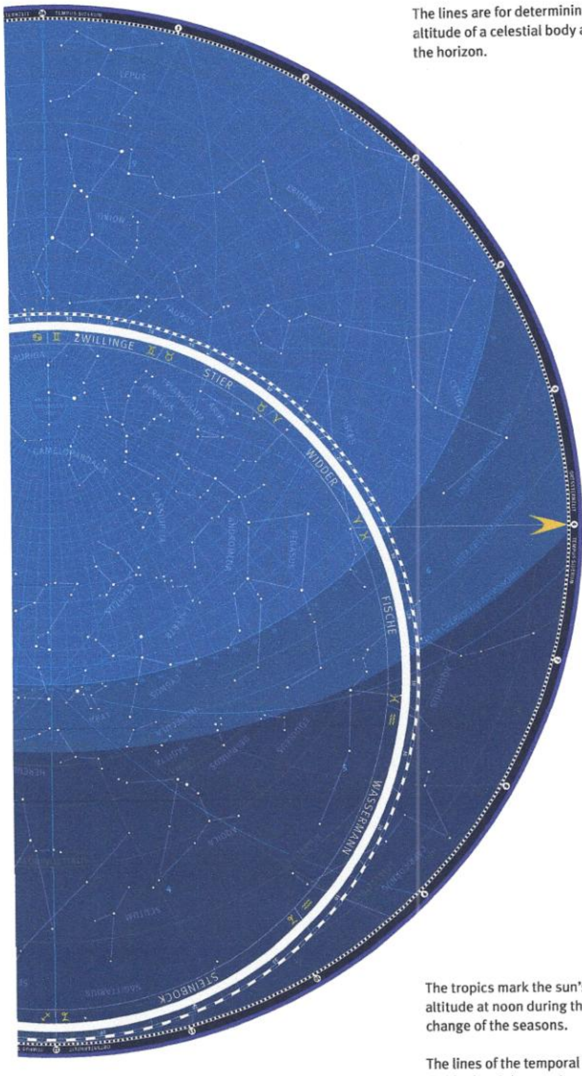
The horizon line (Horizon obliquus) surrounds the currently visible part of the sky like a frame.

The twilight lines (Linea crepusculi civilis, nautici and astronomici) mark the twilight phases.

The zenith marks the vertex of the sky above the observer.



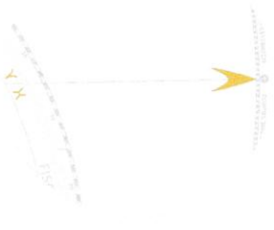
The constellations on the planisphere are shown as a mirror image.



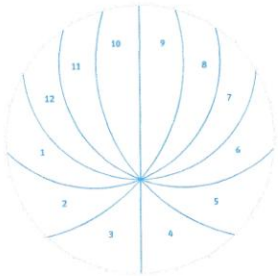
The lines are for determining the altitude of a celestial body above the horizon.

The tropics mark the sun's altitude at noon during the change of the seasons.

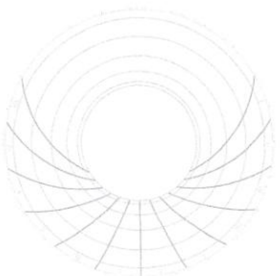
The lines of the temporal hours divide the night zone into twelve equal segments.



The rete pointer indicates sidereal time.



The astrological houses.

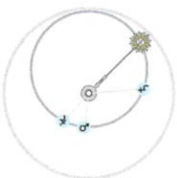


The lines of the tropics and temporal hours.

Azimuth and Altitude, Sidereal and Temporal Time and the Astrological Houses

The inner planets Mercury and Venus can never move far away from the sun: Mercury by a maximum of 28 degrees and Venus by 47 degrees at most. Their positions on the ecliptic are indicated by the intersection between the planet rod and the scale on the outer edge of the ecliptic.

Solar eclipse: the new moon pointer and the true sun are positioned together near the dragon pointer.



The outer planets Mars, Jupiter and Saturn can be positioned in the sky opposite the sun ("opposition"). Their positions on the ecliptic are also indicated by the intersection between the planet rod and the scale on the outer edge of the ecliptic.

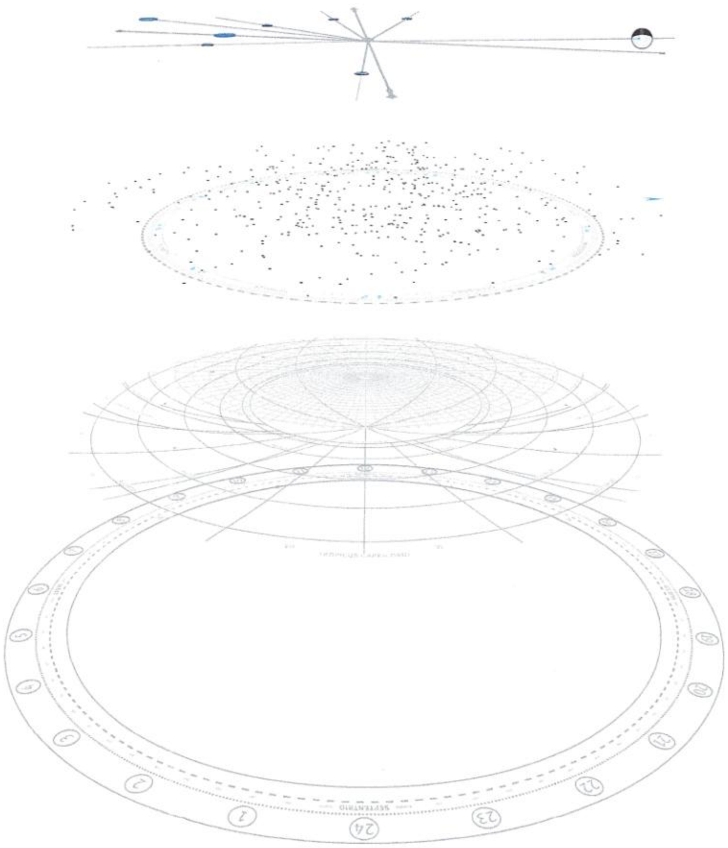
Lunar eclipse: the full moon pointer and the true sun are opposite each other near the dragon pointer.

The position of the true sun relative to the grey circular arcs on the planisphere is very important for determining the temporal time, in which every night is divided into twelve sections of equal length.

The temporal hours are longer in summer (above) than in winter (bottom).

The Design of the Festo Astrolabe

Rete, Planisphere and Pointers



The Astronomical Clock

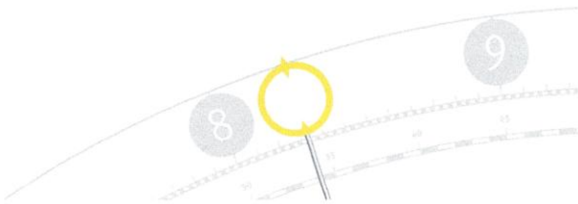
The Astrolabe of the Festo Harmonices Mundi adopts the classical form of geocentric representation and takes it to an unparalleled level of precision thanks to new calculation methods for the gears. It begins with the planisphere and rete, which are striking due to their unusual degree of completeness. The planisphere, for instance, shows the local coordinate grid (azimuth and altitude), the different twilight lines, the division for the so-called temporal hours as well as the borders of the astrological houses, while the rete reproduces the (mirror-image) view of the starry sky with all brighter stars and the constellation lines, the zodiac and the tropics of the individual zodiac constellations. The pointers for the true sun, the moon, the five planets visible to the naked eye and the lunar node, which serves as an indicator of imminent solar or lunar eclipses, move in front of this celestial model stage as if by magic.

The whole is framed by several time and longitude scales used to read off the various times or the coordinates of the individual celestial bodies as well as by a rainbow regarded as a bridge between heaven and earth. Unlike in the original, the Festo Harmonices Mundi, the movements of the various pointers are derived from the minute drive of a radio-controlled quartz clock via numerous gears, some of which have a very complex design. In the smaller Festo Award stepper motors provide the control for the individual pointers. So-called long-term orbit data, that also take into account mutual perturbations of the planets as mean values over a century, form the basis for calculation of the gears and/or of the processor-controlled movement of the stepper motors. This ensures that the positions of the individual pointers, including the rete as the representation of the firmament (and thus indirectly the pointer of the earth's rotation), deviate to a virtually negligible degree from the positions of the "natural models" in the earthly sky even over many centuries.

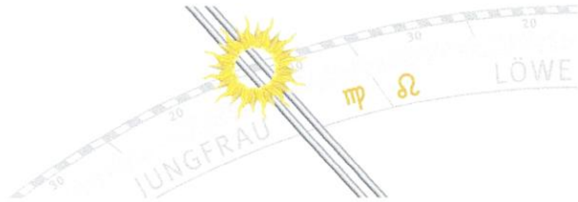
In the original, which is located at the Technology Centre of Festo AG & Co. KG in Esslingen, about 300 gearwheels, grouped into numerous gear assemblies, ensure the most precise possible representation of the motions of the sun, moon and stars. In the award version eleven stepper motors provide for exact positioning of the pointers. They are controlled by a processor that calculates the respective current position angle for the rete as well as the pointers of the sun, moon, dragon and planets from the time signals of a radio clock at minute intervals via a stored program. If required, the indication of the time can also be influenced and altered specifically such that the view of the sky can be adjusted to freely selectable dates in the past and future.

Reading Times

The Time Displays



Clock hand



Sun pointer

Rete pointer

The Astrolabe enables reading of different times, precise to the minute, all of which are determined by the daily rotation of the earth under the sun. They comprise

- civil time,
- true solar time and
- sidereal time.

The Sun Brings It to Light

Civil time is derived from the universal time transmitted via the satellites of the Global Positioning System (GPS) and is indicated by the golden ring at the tip of the "pointer" on the outer, 24-hour scale. The hour can be read directly from the position of the ring; the minutes, by contrast, have to be counted off with the help of the pointer rod on the minute ring adjoining it on the inside – each black or white field corresponds to a minute and five minutes are combined in each case into a longer mark on the scale.

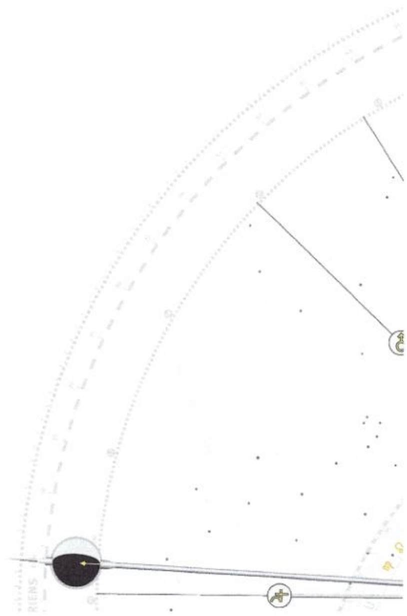
True solar time is represented by the striking golden symbol of the sun on the zodiac ring and can be read in its – imagi-nary – extension on the outer scale. It differs more or less distinctly from civil time. On the one hand, this is due to the fact that civil time is divided into so-called time zones, each of which comprises a strip of the earth that is 15 degrees longitude wide, while true solar time represents the position of the sun in the local horizon system, i.e. the horizon system based on the respective location. The difference in longitude from the reference degree of longitude of the local time zone is therefore responsible for a constant difference between civil time and true solar time. In addition, a periodically varying deviation results from the elliptic orbit of the Earth around the sun and the inclination of the earth's axis. Due to these effects, true solar time additionally deviates by as much as plus or minus 15 minutes from civil time in the course of a year.

Sidereal Time Clocks Work Differently

Sidereal time can be read on the rim of the innermost scale with the help of the golden arrow. It indicates (measured in sidereal time hours and minutes) how long ago the last transit of the vernal point through the meridian (the North-South line) was. Accordingly, this scale also begins in the meridian or South position of the Astrolabe, which corresponds to the 12 noon position of an ordinary clock. Since a sidereal day is about four minutes shorter than a solar day, the visible section of the starry sky shifts by approximately one degree to the East every day, given the same civil time. The sidereal time therefore indicates to the knowledgeable observer what part of the sky is currently in the meridian and what section of the sky is thus visible.

The age of the moon, i.e. the time that has passed since the last new moon position, is shown by the small moon ball at the tip of the moon pointer. It has one bright and one dark hemisphere as well as a day scale that ranges from 0 to 29.53 days. At new moon the moon ball presents its dark side and indicates a moon age of 0 days; at full moon one only sees the bright side with a moon age of about 14.75 days – between them all other values are possible.

Reading the Coordinates
The Positions of Celestial Bodies



Apart from indicating the time, the Astrolabe also provides the determination of various positions of celestial bodies:

- ecliptic longitude,
- right ascension and declination as well as
- azimuth and altitude.

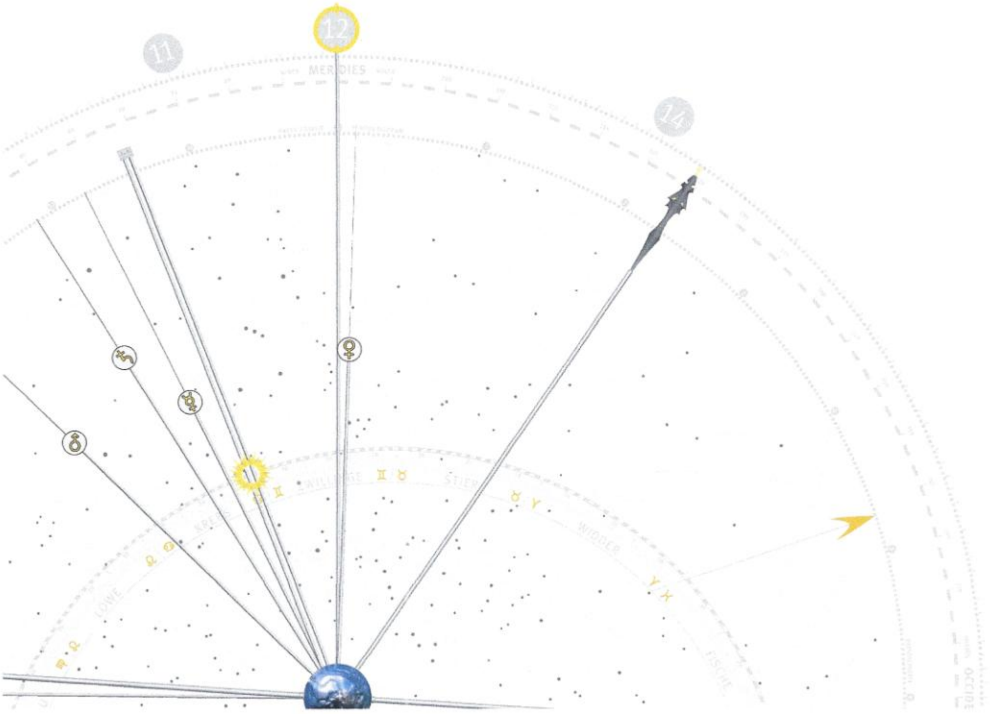
The Position on the Ecliptic
The ecliptic longitude of a celestial body (the sun, moon and planets) indicates its distance from the vernal point when measured on the ecliptic. Since these objects travel on or near the ecliptic plane, the intersection between the corresponding pointer and the zodiac ring marks the celestial body's location on the planisphere. The ecliptic longitude can be read on the scale on the outer edge of the zodiac ring.

For 23 June, 2004, 10 a.m. Universal Time, the following ecliptic longitudes were indicated (rounded off to 0.5°):

Pointer	Degr.
Vernal point	0.0°
Lunar node	39.0°
Venus	71.0°
Sun	92.5°
Mercury	97.0°
Saturn	102.0°
Mars	115.0°
Moon	155.5°
Jupiter	159.0°

A Place on the Cosmic Stage
The equatorial coordinates (right ascension and declination) indicate the positions of celestial bodies on the celestial sphere relative to the vernal point. The right ascension on the celestial equator is counted from West to East (counterclockwise) and indicated in hours, minutes and seconds (15° correspond to 1 hour), while the northern or southern declination describes the angular distance of the celestial body from the celestial equator.

The current right ascension values of the sun, moon and planets basically result from the angular difference between the pointer positions of the vernal point and the object (measured on the scale on the planisphere's outer edge). The specific position of the scale's zero point (at the East point) is of no importance. The following angles can be



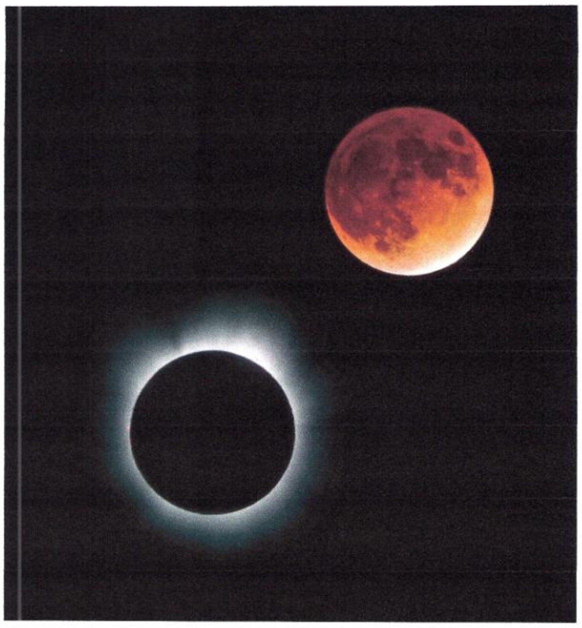
read on the specified hour (the right ascension values calculated from that are given in brackets):

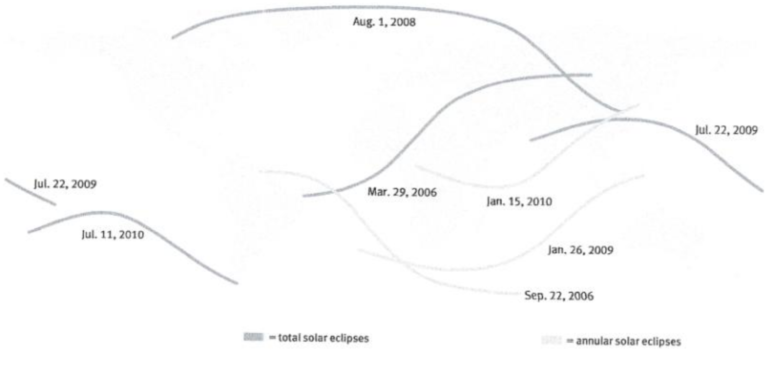
Pointer	Degr.	Calc. right asc.
Rete pointer	161.0°	0.0° = 00:00
Lunar node	124.5°	36.5° = 02:26
Venus	92.0°	69.0° = 04:36
Sun	69.0°	92.0° = 06:08
Mercury	63.5°	97.5° = 06:30
Saturn	58.0°	103.0° = 06:52
Mars	44.0°	117.0° = 07:48
Moon	3.5°	157.5° = 10:30
Jupiter	0.5°	160.5° = 10:42

The Sky as Seen by the Observer

The local coordinates azimuth and altitude indicate the position of a celestial body relative to the South point of the respective observer. The azimuth (lines going through the zenith) and altitude (circles centred on the zenith) of all visible objects can be determined with the help of the coordinate grid on the planisphere. Since – as was customary in the past – the azimuth values are indicated according to quadrants (from the East or the West (0°) to the North or South (90°) respectively), the respective quadrant (SE, SW, NE, NW) is also part of the indication of the azimuth. Nowadays the South point is considered to be the zero point of the (astronomical) azimuth count. The altitude is measured from the horizon (Horizon obliquus) at an altitude of 0°. On the specified date the following azimuths (in brackets the "modern" values) and altitudes of the sun, moon, planets and several selected stars were indicated in Esslingen (rounded off to 0.5° each):

Pointer	Azimuth	Altit.
Venus	SW 87.5° (2.5°)	62.5°
Sun	SE 49.5° (-40.5°)	60.0°
Mercury	SE 40.0° (-50.0°)	56.0°
Saturn	SE 33.5° (-56.5°)	54.0°
Mars	SE 19.0° (-71.0°)	42.5°
Moon	NE 4.0° (-94.0°)	10.0°
Jupiter	NE 5.0° (-95.0°)	6.0°
Sirius/C.Major	SE 59.5° (-30.5°)	19.5°
Capella/Auriga	SE 24.0° (-66.0°)	84.0°
Rigel/Orion	SE 81.5° (-8.5°)	32.5°




Aug. 1, 2008
Jul. 22, 2009
Jul. 22, 2009
Mar. 29, 2006
Jan. 15, 2010
Jul. 11, 2010
Jan. 26, 2009
Sep. 22, 2006
= total solar eclipses
= annular solar eclipses

The Display of Solar and Lunar Eclipses

No Fear of Eclipses

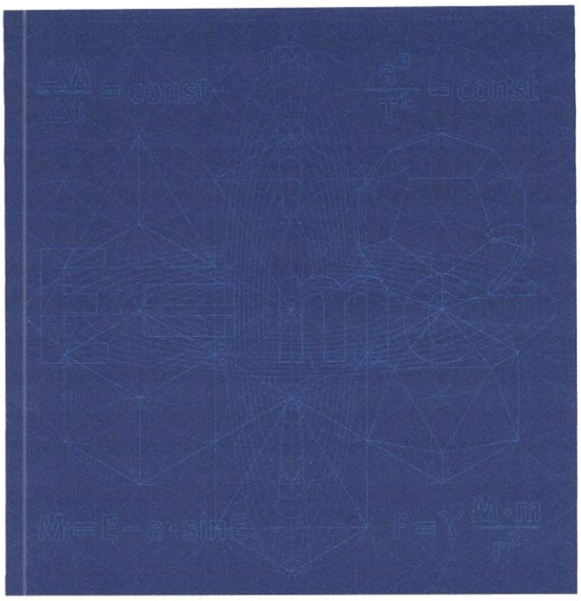
Eclipses are among the most fascinating spectacles the sky can offer. However, their apparently irregular occurrence was a repeated cause of unrest and fear among people in the past. On the Astrolabe, by contrast, one can see when a solar or lunar eclipse is expected.

Solar eclipses can only occur at new moon, lunar eclipses only at full moon. However, not every new moon brings about a solar eclipse by any means, nor does a lunar eclipse take place every full moon. Since the orbit of the moon is inclined by slightly more than 5 degrees towards the ecliptic, the new moon usually moves past above or beneath the sun while the full moon correspondingly moves above or beneath the earth's shadow. For a solar or lunar eclipse to occur, the new moon or full moon position must be near one of the two points of intersection between the moon's orbit and the ecliptic. These points of intersection are designated as orbit nodes or dragon points.

The dragon pointer of the Astrolabe indicates the position of the orbit nodes or dragon points on the ecliptic. If, therefore, the pointers of the true sun and of the moon move closer towards the new moon position in immediate proximity to the dragon pointer, a solar eclipse occurs somewhere on the earth. It depends on the angular distance to the dragon pointer whether this eclipse is central or partial. For a central eclipse, i.e. an annular or a total solar eclipse, the new moon must not be positioned more than 11.6° from the dragon pointer, for a partial eclipse the maximum is 18.8° – no matter whether relative to the dragon head or to the dragon tail. Since the shadow zone of the moon is very small (a maximum of around 270 km in diameter), a solar eclipse can always be followed only from a very small part of the Earth's surface – it may remain completely unnoticed at the location of the Astrolabe!

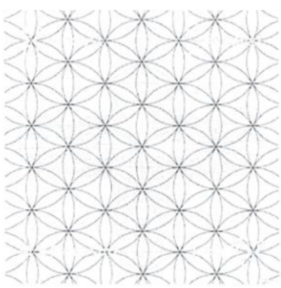
By contrast, a lunar eclipse can be observed wherever the moon is just above the horizon at the time of the eclipse. It can be expected when a full moon position (true sun and moon pointer are positioned opposite each other) occurs near the dragon pointer. Here again limits are defined. For the full moon to disappear entirely in the shadow of the earth the distance to the dragon pointer must not be greater than 5.4 degrees, whereas for a partial eclipse the full moon may not be more than 12 degrees from the dragon pointer.

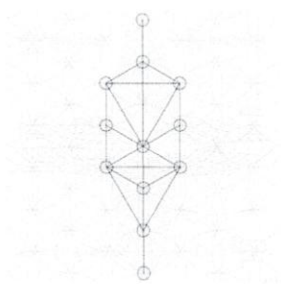
The Decorative Details



The roots of the astrolabe reach back into antiquity, so its overall design is also based on the archaic geocentric conception of the universe, with the "observer" at the hub. In former times, seven planets were known, moving against a backdrop of seemingly immobile stars: these were the sun, the moon, Mercury, Venus, Mars, Jupiter and Saturn. They are all shown on the astronomical clock of the Festo Harmonices Mundi Award as moving objects (indicators).

The Copernican revolution altered our understanding of the universe. Today we know the sun to be the centre of the solar system, with the earth being only one of its planets. After the invention of the telescope in the early 17^{th} century, a further three planets were discovered, Uranus, Neptune and Pluto, which cannot be seen by the naked eye. Together with the earth, counted as one of the planets ever since Copernicus, these latter three are shown in symbolic form on the four corner panels of the astrolabe. The numerous planetoids between the belts of Mars and Jupiter are represented by the symbols for the first four asteroids to be discovered, Ceres, Pallas, Juno and Vesta, together with some important symbols used in astronomical calendar notation.





These are

- in the top left corner, Uranus with Juno (underneath) and Vesta (to the right),
- in the top right corner Neptune with Pallas (to the left) and Ceres (underneath),
- in the bottom right corner, Pluto with the symbol for an opposing position (above) and for the retrograde motion of a planet (to the left), as well as
- in the bottom left corner, the earth with the symbols for the rising lunar node (to the right) and for the moon (above).

The Harmony of Forms and Formulas

The rear face of the astronomical clock of the Festo Harmonices Mundi Award shows a collection of ancient "sacred" shapes that occur in almost all early, highly developed cultures, together with formulas which have changed the world. The underlying pattern depicts the "Flower of Life", which is created from the merging of a perfect circle and a regular hexagon – a pattern which can be continued infinitely in all directions. Certain points in this "sea of flowers" can be connected to make a "Tree of Life" which until quite recently formed the fundamental architectural pattern of many sacred buildings.

Also derived from the "Flower of Life" are the five Platonic solids (tetrahedron, hexahedron, octahedron, icosahedron and dodecahedron), which are the basis of crystallography, as well as a representation of the squared prime number cross, an example of the modern geometry of numbers – in the simple prime number cross, all the prime numbers are arranged so that the lines connecting them create a cross.

Against this intricately woven backdrop appear five important equations, to represent modern astronomer's view of the universe:

- Kepler's Second Law (top left), which describes the relationship between distance from the sun and the speed of a planet on its elliptical orbit
- Kepler's Third Law (top right), which determines the harmony between distance from the sun and the orbital period of a planet
- Newton's Law of Gravity (bottom right), which describes the mutual influence of heavenly bodies from a classical (non-relativistic) perspective, and
- Kepler's Equation (bottom left), which in its mathematical transcendence is not strictly solvable, but can only be "cracked" by processes of approximation,
- Einstein's mass-energy equivalence equation (centre), which reveals the relationship between energy and matter, and is also the starting point for the General Theory of Relativity as a modern description of the structure of space-time.