

ON SYMMETRY AND ASYMMETRY IN LITERATURE†

B. PAVLOVIĆ

P.E.N.-Croatian Center, Trg Republike 7, 41000 Zagreb Croatia, Yugoslavia

and

N. TRINAJSTIĆ

The Rugjer Bošković Institute, P.O.B. 1016, 41001 Zagreb, Croatia, Yugoslavia

Abstract—An attempt is made to investigate whether or not the principles of symmetry and asymmetry operate in literature. The result of the analysis is that certain (near) symmetric and/or asymmetric patterns may be found in literary works. Commonly, the authors use some convenient symmetric (asymmetric) figure, either as a descriptive means or as an underlying core around which their stories unfold. A structure of a literary work may also be interpreted in terms of symmetric and/or asymmetric objects. Sometimes a graphic shape of a work, most often of a poem, possesses symmetry. The content of a literary work may likewise be associated with some symmetric or asymmetric configuration. The citations from several literary works are included.

Symmetrisch oder nicht—
das ist die Frage.
Werner Gilde[1]

INTRODUCTION

Symmetry is an enormous subject[1–3]. The concept of symmetry is one of the most fundamental concepts in science[1–21], but also appears as a significant principle in nature, fine arts, and many human creative—and other—activities[1–3,22–27a]. Mathematics lies at its foundation. Symmetry, as an artistic conception and a medium of expression, has been with us since man's earliest attempts to communicate. Examples of symmetry in art and architecture are to be found everywhere[28]. In fact, the word symmetry[29] originated in art and is attributed to the Greek sculptor Polykleitos[2] (5th century B.C.).

Since symmetry is considered to be a universal principle[1–27,29], there is no reason why it should not be present, in some form, in literary works. Some examples can immediately be given. For instance, the following lines are taken from Chapter 1 of Daphne du Maurier's *Rebecca*[30a]:

There was Manderley, our Manderley, secretive and silent as it had always been, the grey stone shining in the moonlight of my dream, the mullioned windows reflecting the green lawns and the terrace. Time could not wreck the perfect symmetry of those walls, not the site itself, a jewel in the hollow of a hand.

In Chapter 4 of the same book we find that the perfect symmetry of Manderley could not be removed even by the crude painting of it used for a picture postcard[30b]:

It was the painting of a house crudely done of course and highly coloured, but even those faults could not destroy the symmetry of the building, the wide stone steps before the terrace, the green lawns stretching to the sea.

And again in Chapter Eleven we hear about the perfect symmetry of Manderley[30c]:

We came around the sweep of the drive and Manderley was before us, serene and peaceful in the hollow of the lawns, surprising me as it always did, with its perfect symmetry and grace, its great simplicity.

†This essay is dedicated to Zagreb, the capital of Croatia and a beautiful city with a nice blend of historical core and modern parts, rich with evidence for all aspects of urban symmetry, asymmetry, and anti-symmetry.

As the next example we give two stanzas (the first and the last) from William Blake's beautiful poem on creation "The Tyger"[31]:

Tyger! Tyger! burning bright
In the forest of the night,
What immortal hand or eye
Could frame thy fearful symmetry?

Tyger! Tyger! burning bright
In the forest of the night,
What immortal hand or eye,
Dare frame thy fearful symmetry?

As the third example we give a few lines from Anna Wickham's "Envoi"[32] in which the poetess addresses God as the Divine Being of great symmetry:

God, Thou great symmetry,
Who put a biting lust in me
From whence my arrows spring,
For all the frittered days
That I have spent in shapeless ways
Give me one perfect thing.

What is symmetry? There are several possible answers to this question[1–3,14,27]. Intuitively we may say, in concordance with the meaning of the word, that a symmetry is a beauty of form, arising from harmony of its proportions. This is a rather vague definition, but often encountered (see the above citations). Another definition is as follows: Symmetry is the characteristic of an object that allows one to say that two or more parts of it, with reference to a point, a line, or a plane, are the same. In geometry symmetry is defined as the invariance of a configuration of elements under a group of automorphic transformations[2,27]. Shubnikov and Koptsik[27] offered a very general definition of symmetry. They defined symmetry as the law of composition of structural objects, or, more precisely, as the group of permissible one-to-one transformations preserving the structural integrity of the systems under consideration (p. 308 of ref. [27]).

Symmetry may possibly be considered as a very convenient basis for relating mathematics, physics, chemistry, biology, astronomy, art, sports, architecture, music, film, dance, linguistics, philosophy, archeology, geology, literature, etc., from the same standpoint[1–3]. Whilst several of the above fields (besides mathematics and natural sciences, e.g. art and architecture) have been studied, to some extent, from the symmetry point of view[1–3,22–27], literature, save poetry[1,2,22,33–36], is a rather neglected field in discussing symmetry[37]. Apparently, most humans find exact or near exact symmetry more appealing in the visual world than in music and poetry. However, we do find rhythm (translational symmetry in time) agreeable in music and poetry, at least as a background that generally has a much lower, but not absent, symmetry.

In the present essay we will center our discussion mainly on the symmetric and asymmetric objects and patterns that we hope to detect in fiction. Examples from poetry (metrics in poetry is closely related to symmetry) will also be used. Drama will be mentioned only cursorily. The number of examples will be rather limited because each of these fields (fiction, poetry, drama) would require separate lengthy studies. We will also attempt to interpret the literary works in terms of symmetric and/or asymmetric configurations. We will be concerned much more with the symmetry (and asymmetry) of the structure[38] and the content of a literary work than with that of its form. However, the symmetry or asymmetry of the form of literary works, especially poetry, is also an interesting problem to consider[39].

Let us point out at the end of this section that mathematics has enchanted artists since Egyptian and Greek times. Polykleitos, Plato (427–347 B.C.), Aristotle (384–322 B.C.), da Vinci (1432–1519), and Dürer (1471–1528) considered mathematical laws and symmetry (though not necessarily using the latter word) in art (and other fields of human interest). Poets and

prose-writers have also been interested in mathematics. Let us just mention in this respect the essay by Musil entitled "The Mathematical Man"[40] (according to which mathematics is the luxury of a pure intellect) and his novel "The Man Without Qualities"[41] (for Ulrich, the main character in the novel, mathematics is the source of pleasure). A funny story by O. Henry entitled "The Chair of Philanthromathematics"[42] has little to do with mathematics, but without this word there would be no story.

Poe said, in his essay on the philosophy of the composition of a poem ("The Raven")[43]:

It is my design to render it manifest that no one point in its composition is referable to accident or intuition—that the work proceeded, step by step, to its completion with the precision and rigid consequence of a mathematical problem.

He required that the literary work be balanced: There should be a mathematical relationship (ratio) between the length of all works of literary art and their merits (although it is difficult to see how this relationship can be quantified). Talking about the poem "The Raven", there is a near translational symmetry present in it through the repetition of the word "more" alone (six times) or as a part of the words "evermore" (once) and "nevermore" (eleven times). The rhythm of "The Raven" is trochaic, whilst the metre is octameter acalectic, alternating with heptameter catalectic repeated in the refrain of the fifth verse, and terminating with tetrameter catalectic.

Let us also mention here another interesting point concerning mathematics in poetry. There are many different stanza forms in use in poetry. Let us consider the sestina. The French sestina has a fixed poetic form: 6 stanzas, 6 lines each, envoy of 3 lines; usually unrhymed, but repeating as final words of the first stanza, in the following order (each letter represents the final word of a line):

	1	2	3	4	5	6
1	A	B	C	D	E	F
2	F	A	E	B	D	C
3	C	F	D	A	B	E
4	E	C	B	F	A	D
5	D	E	A	C	F	B
6	B	D	F	E	C	A

Envoy B D F or A C E.

The above array has the structure of a quadratic (6×6) matrix where the even-labelled columns contain the first three elements, in increasing lexicographic order, from the row above, whilst the odd-labelled columns contain the last three elements, in reverse lexicographic order, from the above. The envoy consists of either the first three elements, in increasing lexicographic order, from the last row, or the second three elements, in reverse lexicographic order, from the last row of the sestina matrix. (Often the envoy uses all the final words, two a line: B E, D C, and F A).

Combinatorics is used repeatedly by poets. The use of combinatorics in fiction is much less frequent. A good example of combinatorics in the literature can be found in Joyce's *Ulysses*[44]:

What anagrams had he made on his name in youth?
 Leopold Bloom
 Ellpodbomool
 Mollpeloob.
 Bollopedoom
 Old Ollebo, M.P.†

†In this line a letter "o" is missing in the edition we had at hand[44]. The same was detected in several other English editions and in the German translation published by Suhrkamp, Frankfurt/Main, 1975, Teil II, p. 857.

What acrostic upon the abbreviation of his first name had he (kinetic poet) sent to Miss Marion Tweedy on the February 14, 1888?

Poets oft have sung in rhyme
 Of music sweet their praise divine.
 Let them hymn it nine times nine.
 Dearer far than song or wine,
 You are mine. The world is mine.

The curious interplay between the mathematics and poetry was described by Martin in his book on Tennyson[44a]:

The mathematician Charles Babbage† wrote to Tennyson after reading ‘‘The Vision of the Sin’’[44b] to say that he was bothered by the two lines:

‘‘Every minute dies a man,
 every minute one is born’’

‘‘I would therefore take liberty’’, wrote Babbage, ‘‘of suggesting that in the next edition of your excellent poem the erroneous calculation to which I refer should be corrected as follows:

‘Every minute dies a man
 and one and a sixteenth is born.’

In the next edition ‘minute’ was changed to ‘moment’.

This essay will consist of several sections. In the next section the basic concepts will be exposed in a rather elementary way. Then subsequent sections will report on symmetry and asymmetry of letters and words. The main part of the article is the section on symmetry and asymmetry in literature which will be partitioned into four subsections. The first subsection will be concerned with the symmetric and/or asymmetric objects in literary works and our attempt to assign the symmetric or asymmetric configurations to a given literary product.

The second subsection will report on symmetry characteristic of the content of literary works. In the third subsection a brief discussion about dualism in literature will be given. This section will end with some concluding remarks. The article will end with conclusions and with the list of references. The selection of references will be bounded by the availability of literature in foreign languages in Zagreb.

The quotations from a number of literary sources will be given. Note that all underlinings in quotations are the author’s own.

BASIC CONCEPTS

The basic concepts requisite for this essay will be presented only qualitatively. The precise details can be found in several excellent expositions: symmetry by Weyl[2] and Shubnikov and Koptsik[27], diagrammatic approach and topology by Harary[45] and Alexandroff[46], respectively, and information theory by Brillouin[47]. Besides, all kinds of symmetries will also be reviewed in this special issue on symmetry by a variety of qualified authors[3].

A. *Bilateral symmetry*

A kind of symmetry we expect to detect in the literature is bilateral symmetry. This is so because bilateral symmetry[2], which refers to such operations as reflections, is the most often encountered concept of symmetry. In the world around us people, animals, plants, heavenly bodies, etc. usually exhibit (near) bilateral symmetry (and some of them other kinds of symmetries such as spherical symmetry and cylindrical symmetry) in their external forms. Bilateral

†Charles Babbage (1792–1871) was analyst, statistician, and inventor. He was a prophet of the modern digital computing machines.

symmetry has also been present in the various products of human endeavours since the first stone axe made by cave-men. All around us are endless examples of man-made bilaterally symmetric shapes and patterns (chairs, tables, windows, doors, vases, lamps, bottles, earrings, coins, trademarks, plates, dishes, stamps, emblems, underwear, clothing, chandeliers, etc.). Many of these objects have such a symmetry for reasons of convenience, but numerous objects are designed bilaterally symmetric to make them attractive to the consumer. The aesthetic appeal of a given product is certainly of marketable value. The objects enumerated above possess either a vertical or horizontal plane of symmetry. Some possess both a vertical and horizontal plane synchronously.

As we have already pointed out, and as will be seen from the essays in this special issue on symmetry[3], symmetry is not restricted only to spatial objects: It has acoustical, colouristic, spiritual, etc., applications. Because of this we are allowed to employ terminology, otherwise reserved for use, say in geometry or physics, for identifying a particular (non-spatial) symmetry form in the literature. We will therefore do so just to keep the terminology uniform. However, in so doing we will run into an interesting situation. When we mention bilateral symmetry in literature it loses its precise meaning because we are not any more in the domain of physical reality. Now this bilateral symmetry is a strictly geometric and exact concept[2]: a spatial configuration is (bilaterally) symmetric with respect to a given plane σ if it is carried into itself by reflection in σ . Choose any line l perpendicular to the plane σ and any point p on l . There exists one, and only one, point p' on l which has the same distance from σ but lies on the other side of σ . Reflection in σ is that mapping of space upon itself, $S: p \rightarrow p'$, that carries the arbitrary point p into its mirror image p' with respect to σ . A mapping (symmetry operation) is defined whenever a rule is established by which every point p is associated with an image p' . The reflection in a plane is the basic operation of bilateral symmetry.

B. *Some other kinds of symmetries*

A circle and regular polygons, besides bilateral symmetry, also possess rotational symmetry. Note that a circle is carried into itself by the rotation around the center i for any angle. Similarly, regular n -polygons ($n = 3, 4, 5, \dots$) are carried into themselves by the rotations around their centers for angles $\phi_k = (360/n)k$ ($k = 1, 2, \dots$). Additionally, the reflections are carried out through symmetry planes passing through the centre and the n vertices of an n -polygon. Hence, an n -polygon possesses n -rotations and n -reflections. These symmetry operations form a group and this group determines the symmetry of the n -polygon. For example, the regular pentagon has ten symmetry operations (five rotations and five reflections) and, thus, it belongs to the group $5m$ of order 10.

In art, architecture, the organic and inorganic world appear many examples of cyclic symmetry, trigonal symmetry (the angle of rotation is 120°), tetragonal symmetry (90°), pentagonal symmetry (72°), hexagonal symmetry (60°), etc. Let us mention a few: the Roman amphitheatre in Pula, Croatia[28] (cyclic symmetry), the rosette of St. Pierre in Troyes, France (trigonal symmetry), city squares in the central Savannah, Georgia (tetragonal symmetry), the Pentagon building in Washington (pentagonal symmetry), and snow crystals (hexagonal symmetry).

Flowers are distinguished for their colour, pleasing scent, and rotational symmetry. The symmetry of 5 is very frequent amongst flowers. Families such as Caryophyllaceae or Rosaceae and many others possess pentagonal symmetry. Individual examples are *Herniaria glabra* L., *Cydonia oblonga*, etc. Some of the flower families (e.g. Papaveraceae, Cruciferae, or Rubiaceae) exhibit tetragonal symmetry, whilst others (e.g. Iridaceae or Liliaceae) possess hexagonal symmetry. Some families exhibit only bilateral symmetry such as, for example, Labiatae, whilst others like Compositae, n -gonal symmetry. Examples of this kind are *Bellis perennis* L., *Helianthus annuus* L., *Matricaria chamomilla* L., *Calendula officinalis* L., etc.

Similarly, as the regular n -polygons are connected with the finite groups of plane rotations, so the regular n -polyhedra are related to the finite groups of proper rotations around an axis in space. We should note here that there are unlimited regular n -polygons possible. But, there are only five regular n -polyhedra: the regular tetrahedron, the cube (or hexahedron), the octahedron,

the dodecahedron, and the icosahedron. Note the following regularity in polyhedra (the Euler formula)[1]:

$$V - E + F = 2$$

where V is the number of vertices, E the number of edges, and F the number of faces.

The repetition of bilaterally symmetric figures leads to the construction of two-dimensional patterns such as the regular lattices (made up from either equilateral triangles, squares, or regular hexagons) and a variety of ornaments. Examples are wallpaper patterns, diaper patterns, floor tiles, honeycomb, Chinese, Egyptian and Arabic ornamentation, etc. The kind of symmetry that can be applied to ornaments is called *ornamental symmetry*[2]. The symmetry of ornaments is concerned with discontinuous groups of congruent mappings of the plane. Ornaments will be also discussed in this special issue on symmetry[3].

Crystals represent the geometric arrangements of atoms in three dimensions. In chemistry all kinds of compounds produce crystalline forms, e.g. boron-hydride polyhedra[48,49], co-ordination polyhedra of atoms in the structure of an alloy, RhBe[50], ice, diamond, etc., all of which possess crystallographic symmetry[2,14,19].

Another type of symmetry that is encountered in nature, art, architecture, music, poetry, etc., is translational symmetry. Let us consider an infinite set of points labelled by A, B, C, D, . . . positioned on a straight line l . The distance between the points is constant and the same for all adjacent pairs. This is illustrated in Fig. 1. The transformation relating two adjacent points A and B may be represented as

$$\begin{aligned}x_B &= x_A + \Delta l \\y_B &= y_A.\end{aligned}$$

A translation carries point A into the position of B, B into the position of C, C into the position of D, etc. Since there are an infinite number of points on the line, the translation changes nothing. This symmetry is called pure translational symmetry.

C. Assymetry

In order to introduce this concept let us consider for a moment the human hands. The left hand (or the right hand) is an asymmetric object: It does not possess any built-in symmetry elements. But asymmetry is not merely the absence of symmetry, because if we put the left hand in front of a mirror, the image of the left hand is produced by the mirror. These two objects, the left hand and its mirror-image, together form a symmetric figure. The left hand is an asymmetric unit of the figure. More generally, in the case of asymmetric objects, the object

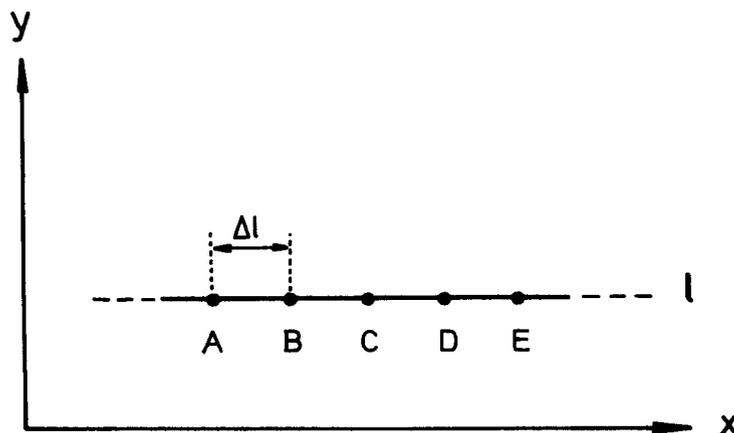


Fig. 1.

and its image together form a symmetric figure in that there is a one-to-one correspondence between any point p on the object and a twin point p' on the image (Fig. 2). Because of this objects of all kinds that bear a mirror relationship to one another are referred to as left- and right-handed objects. A mirror always converts a left-handed to a right-handed object. Asymmetry is the nonidentity of an object with its mirror image. A modern term for this property is *chirality*[51].

Objects exhibiting chirality are termed *chiral objects*. Chiral objects do not possess those symmetry elements which can superimpose the object on its mirror image. These are the reflection plane and the axis of improper rotation (or improper axis). A improper rotation (or a rotatory reflection) is a combined symmetry operation which consists of a rotation through a given angle about some axis and reflection in a plane perpendicular to this axis. (The order in which the rotation and reflection are performed is immaterial). Chiral objects may possess some elements of symmetry such as the axes of proper rotations. The objects identical to their mirror images are called *achiral objects*.

Two chiral objects like two hands or two feet, identical in shape, but not superimposable because one is right and one is left, are called *enantiomers*. Chirality is the necessary and sufficient condition for the existence of enantiomers. It is also a necessary, but not sufficient condition for optical activity.

There are many natural and hand-made objects which are chiral and which appear in two enantiomorphous forms. These are, for example, crystals of flint-stone, pine-cones, screws, snail shells, shoes, shells (though one of the forms may predominate depending on the habitat), etc. The daily rotation of our planet together with the direction of its axis from South to North pole is a right screw. Molecules of DNA, the basic material of the gene, consist of two right-handed chains and coil about each other in a helical form. Proteins present in plants and animals (man included) are made up (with rare exceptions) of only left-handed amino acids. (This fact so far lacks an explanation, though there are quite a few speculations on its origin). Modern biologists are even talking about asymmetric evolution[52].

Note that the human body is a symmetric (achiral) object, while the hands and feet are asymmetric (chiral) objects, respectively. Our left hand (left foot) and right hand (right foot) have opposite chirality. The heart of mammals is also chiral (asymmetric screw). Most people

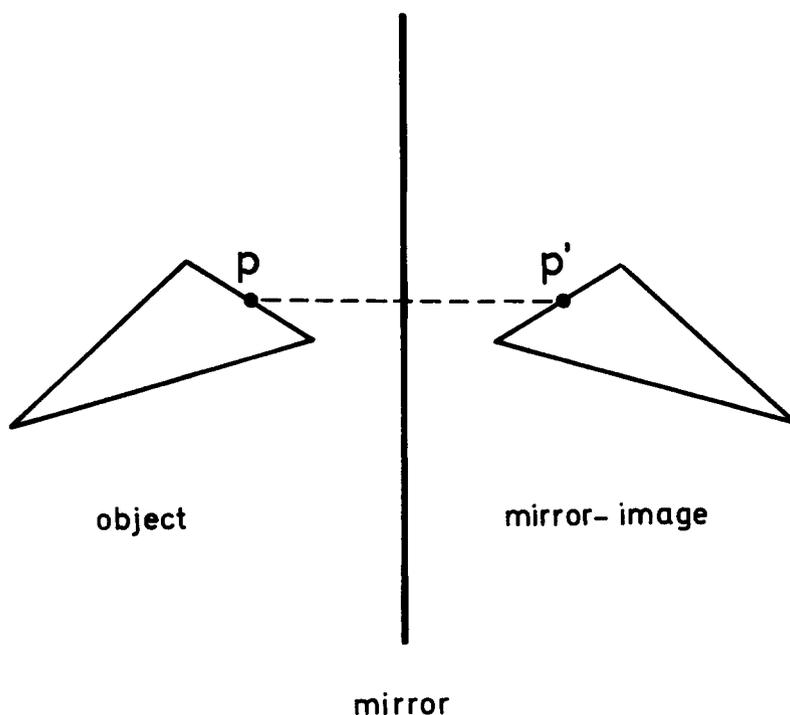


Fig. 2.

have their heart on the left side of their body. But, a few people have the heart on the right side and their intestines are inverted. This phenomenon is known in medical science as *situs viscerum inversus totalis*. When a position of only a single organ is inverted, a case which happens more often than the above, this is known as *situs viscerum inversus partialis*. When only the heart is displaced to the right, this is known as *dextrocardia* ("right" heart).

Dorothy Leigh Sayers uses a character with a "right" heart in her story "The Image in the Mirror"[53]:

Wimsey obediently moved his hand across.
 'I seem to detect a little flutter,' he said after a pause.
 'You do? Well, you wouldn't expect to find it that side and not the other, would you? Well, that's where it is. I've got my heart on the right side, that's what I wanted you to feel for yourself.'
 'Did it get displaced in an illness?' asked Wimsey sympathetically.

One way of getting the left and right sides reversed is described in the same story:

Wimsey twisted his head round so as to get a view of the page. '*The Plattner Experiment*,' he said; 'that's the one about the schoolmaster who was blown into the fourth dimension and came back with his right and left sides reversed. Well, no, I don't suppose such a thing would really occur in real life, though of course it's very fascinating to play with the idea of a fourth dimension.'

The concept of chirality has found its greatest application in chemistry[50,54].

D. Diagrams in literature

The structure of literary works may be studied by means of diagrams[55–60], i.e. topological structures. The diagrammatic approach is well-established, for example, in natural sciences, linguistics, social sciences, and anthropology[61–67]. It is believed that diagrammatic analysis is a powerful method to use for the interpretation of work of literature. For example, the diagrams may be used to visualize the relationships (sometimes very complex) between the characters in a novel or a play. A diagrammatic analysis may be used to lay bare the basic structures around which the plot of a work is interwoven. In addition, an attempt to present a given literary work in diagrammatic form may bring forth some hidden structures and add a new dimension to the interpretation and understanding of the work.

Let us consider here by way of an example, a rather simple touching story "Simon's Papa" by Guy de Maupassant[68]. There are three main characters in the story: Simon, a seven-year old schoolboy (A), La Blanchotte, his un-wed mother (B), and Phillip Remy, the blacksmith and kind man (C). The graphical interpretation of the relationship between the characters may be given by Fig. 3 (a triangle). This is a variation of the love triangle: The intensity and kind of affection between the pairs AB (mother–son), BC (man–woman), and AC (son–father-figure) are obviously different. We will not quantify these relationships (this would be extremely difficult to do, if not impossible) and will only assume that the three distances A–B, B–C and A–C in the above triangle are not the same in order to point out that there are three kinds of relationships in the story. Thus, a convenient diagram to depict the relationships between the above three characters is the scalene triangle (Fig. 4). Therefore, the structure around which the story is built is an asymmetric (chiral) triangle.

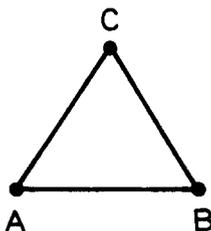


Fig. 3.

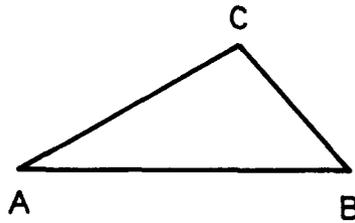


Fig. 4.

This technique of expressing diagrammatically the relationship between three people (for example, husband, wife, and lover) is used by Hercule Poirot in Christie's *Triangle at Rhodes*[69]:

Susan looked up at Poirot.

'Well?' she said. 'What do you make of this?'

Hercule Poirot did not reply in words, but once again his forefinger traced a design in the sand. The same design—a triangle. 'The Eternal Triangle', mused Susan. 'Perhaps you're right. If so we're in for an exciting time in the next few weeks.'

This simple approach will be used later in the text in an attempt to present the structure of literary works in terms of symmetric and/or asymmetric objects.

A kind of topological structure (diagram) often employed in fiction, is the genealogical tree of family chronicles. An example of such a genealogical tree is taken from Marquez's *One Hundred Years of Solitude*[70] which is a chronicle of the Buendía family (Fig. 5). Family trees are, of course, asymmetric structures.

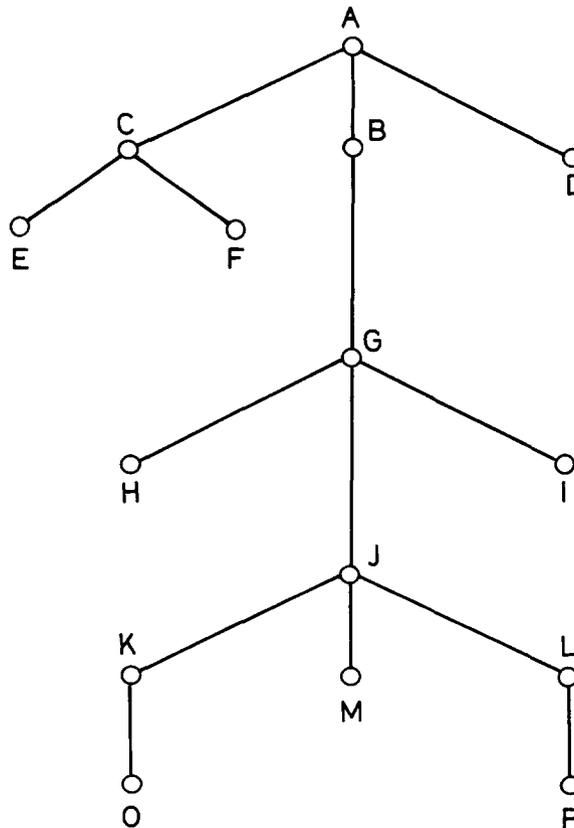


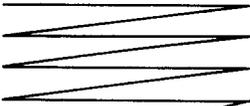
Fig. 5. The Buendía family tree. A = José Arcadio Buendía m. Úrsula Iguaran, B = José Arcadio m. Rebecca, C = Colonel Aureliano Buendía m. Remedios Moscote, D = Amaranta, E = Aureliano José (by Pilar Ternera), F = 17 Aurelianos, G = Arcadio (by Pilar Ternera) m. Santa Sofía de la Piedad, H = Remedios the Beauty, I = José Arcadio Segundo, J = Aureliano Segundo m. Fernanda del Carpio, K = Renata Remedios (Meme), L = Amaranta Úrsula m. Gastón, M = José Arcadio, O = Aureliano (by Mauricio Babilonia), P = Aureliano (by Aureliano).

Diagrams are also used by criminal story writers. At a certain point in a story they produce a diagram which should help the reader to speculate about the misdoer (see, for example, Christie's *The Murder of Roger Ackroyd*[71]). The construction of these diagrams is similar to that described earlier, though with many more additional details. The diagrams usually depict the scene of the crime and the position of the body, and sometimes the positions of characters involved in some way with the murdered person. However, these diagrams are not too helpful, because in this case the culprit would be discovered too early by the reader and the interest in the novel (and perhaps in the future works of the same author) may wane, unless the readers are true aficionados of this kind of fiction.

Poems may also be produced with graphic shapes of various kinds. A modern Croatian poet Slavko Jendričko conceived the poem "A Debatable Verse"[72] in the form of an asymmetric right-angled triangle (Fig. 6).

Croatian text	English text†
još samo idioti vjeruju u poeziju:	only idiots still believe in poetry:
samo idioti vjeruju u poeziju:	idiots still believe in poetry:
idioti vjeruju u poeziju:	still believe in poetry:
vjeruju u poeziju:	believe in poetry:
u poeziju:	in poetry:
poeziju:	poetry:

By the example of associating a graphic design with a poem, the following "zig-zag" diagram may serve to relate to the poem "Rondo" by Ante Stamać, another modern Croatian poet[73]:

Poem†	Corresponding diagram
RONDO	
Ein Nichts in den Hauch	
Ein Hauch ins Wort	
Wort in den Wind	
Wind in Gestalt	
Gestalt in Fetzen	
Fetzen in Schau	
Schau in Wort	
Wort in Hauch	

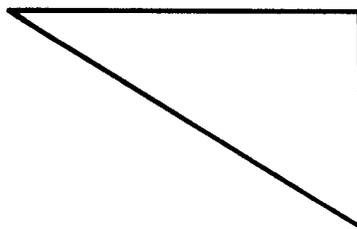


Fig. 6.

†Translation by the authors of this article.

†Translation by Ina Jun Broda.

E. Information-theoretical concepts

Information theory is a branch of probability theory[74] and was founded by Shannon[75]. The gain of information is defined by[47]

$$I = K \log_2 P$$

where I is the information (a dimensionless quantity), K is a constant (yet to be specified), and P is the total number of possibilities. As the most convenient unit, a system based on the binary digits or bits was selected. Thus, the logarithm is taken to base two for calculating the gain of information in bits. The above equation deals with equiprobable events.

The gain of information per element in the system \bar{I} is given by the Shannon formula[75]

$$\bar{I} = - \sum_{i=1}^n p_i \log_2 p_i,$$

where $p_i = (P_i/P)$. P_i is the number of elements in the i -th set of elements. The equation is applicable to the cases with different probabilities.

The information connected to a specific physical problem, i.e. bounded information[47], is related to the entropy E . The bound information appears as a negative term in the total entropy of the physical system, and since the negative of the entropy is defined as the negentropy N , the following expression connects the bound information, the entropy, and the negentropy[47]

$$\text{bound information } I = \text{decrease in entropy } E = \text{increase in negentropy } N.$$

The above represents the negentropy principle of information.

Let us now consider the limiting cases:

$$(a) P_i = 1, P = n, p_i = 1/n$$

$$\bar{I} = \log_2 n = E_{\max} = N_{\min}$$

$$(b) P_i = P = n, p_i = 1$$

$$\bar{I} = - \log_2 1 = 0 = E_{\min} = N_{\max}.$$

The entropy is a measure of disorder within the system, whilst the information is the measure of a degrees of order within the system. When the information is at a maximum, the entropy is at a minimum, and vice versa[76].

SYMMETRY AND ASYMMETRY OF LETTERS AND WORDS

Before we apply the concept of symmetry to literature we will briefly discuss the symmetry and asymmetry of the capital letters in the English alphabet and in English words, since we prepared this article in the English language. (There would be only minor differences if our native Croatian tongue were employed, because our alphabet is also based on Latin. Some of the letters of the old Croatian alphabet, called the *Glagolitic* alphabet, also possess symmetry[77]. Letters and words of other languages may also be subjected to the following analysis.) We will perform this analysis because letters make words, and many define literature as the art of words, when they want to point out that words are building-blocks of a literary work. This fact also reveals the special place of literature among the arts. Words are not physical building materials—as, for example, stone is for sculpture—but very complex mental creations with many meanings. Therefore, the understanding of the structure of words is very important for the discernment of the nature of literature. Besides, letters and words are very suitable objects to illustrate the concepts of achirality and chirality.

Let us consider the vowels ‘‘A’’ and ‘‘E’’. The first letter has a vertical plane of symmetry,

whilst the second has a horizontal plane of symmetry. The mirror-images of these letters are identical to the letters themselves. For example, the mirror-image "A" of the letter "A", can cover the original letter exactly in the plane. The same is true for the letter "E". Letters "A" and "E" are symmetric capital letters and they belong to the class of achiral objects. However, there are letters which are not symmetric and consequently they cannot be covered in the plane by their mirror-images. For example, the letter "L" belongs to this class. Its mirror-image "J" cannot cover "L". Letters like "L" are asymmetric capital letters and they belong to the class of chiral objects.

The classification of capital letters according to their symmetry or asymmetry characteristics is as follows:

(I) Achiral letters:

(I.1) Achiral letters with a vertical symmetry plane:

A, M, T, U, V, W, Y (26.9%).

(I.2) Achiral letters with a horizontal symmetry plane:

B, C, D, E, K (19.2%).

(I.3) Achiral letters with both vertical and horizontal symmetry planes:

H, I, O, X (15.4%).

(II) Chiral letters:

F, G, J, L, N, P, Q, R, S, Z (38.5%).

Note that all achiral letters possess one or more axes of proper rotation, and the axes of improper rotation. Chiral letters, of course, do not possess improper axes. Three chiral letters: "N", "S" and "Z" have a two-fold axis.

Let us mention here that the letters alone may be used in poetry. A good example to illustrate this point is the following poem by Alexei J. Kruchonikh, written in 1912[77a]:

	o	e	u	
i		e	e	i
o		e	e	e

Poem may be composed even without using letters (or words). An example of this kind is graphic poetry. One form of graphic poetry uses only punctuation marks. Below we give a graphic sonnet by the Serbian poet Dobrivoje Jevtić, prepared in 1978, in which the author made use of only slants (virgules, slashes), and which also reveals translation symmetry:

SONNET ABOUT THE RAIN

```

////////////////////
////////////////////
////////////////////
////////////////////

////////////////////
////////////////////
////////////////////
////////////////////

////////////////////
////////////////////
////////////////////
////////////////////

////////////////////
////////////////////
////////////////////
////////////////////

```

Nevertheless, most of the information that people use is communicated by language. In the spoken language the elementary symbols are the fundamental sounds. The written language consists of words spelled out in letters. Consider a sentence. The letters are symbols used to build the sentence. If these symbols were equally probable *a priori*, the information contained in the sentence of N letters would be

$$I = N \log_2 27 \text{ bits.}$$

The number 27 is made up of 26 letters and the spacing between the words as an additional symbol. The solution of the above equation is not satisfactory because we know empirically that different letters occur with different *a priori* probabilities in the language. The probability for the occurrence of the letters in the English language is given in Table 1[47]. In Croatian, the distribution is different[78]: The letters ‘‘A’’, ‘‘E’’, ‘‘I’’, ‘‘O’’, and ‘‘N’’ occur—in this order—most often. Note that the first four letters are vowels. This is one of the reasons why the Croatian language belongs to the group of ‘‘soft’’ languages.

The above analysis shows that the symmetry or asymmetry characteristics of letters apparently have little effect on the probability of their occurrence. Now that we are acquainted with achirality and chirality of letters, let us consider words. There are words in the English language that are bilaterally symmetric. These are the words that are the same when read forwards or backwards which possess a built-in vertical plane of symmetry. There are only a very few such words, usually names or acronyms: ‘‘AMMA’’ (Elmer L. Amma, Professor at Department of Chemistry, the University of South Carolina), ‘‘AMA’’ (American Medical Association), ‘‘AAA’’ (American Automobile Association), ‘‘AVA’’ (Ava Gardner, American Movie star). etc. These words belong to the class of palindromic words, words that spell the same in both directions: ‘‘ANNA’’, ‘‘HANNAH’’, ‘‘RADAR’’, ‘‘MALAYALAM’’ (the Dravidian language of the Malabar Coast of India, a branch of Tamil), ‘‘ROTATOR’’, ‘‘WASSA-MASSAW’’ (a swamp in Berkley County, South Carolina), etc. Logos that we find on the covers of the books, which are used as parts of registered trademarks of publishing companies, are either symmetric or asymmetric objects. An example of the (bilateral) symmetric logo is ‘‘BB’’ standing for Ballantine Books, Inc. of New York. The portrayal of a rooster is an asymmetric logo which is used by Bantam Books, Inc. of New York. Note that the artistic name of the Swedish singing group ‘‘ABBA’’ possesses bilateral symmetry, which would be

Table 1.

Symbol	Probability of occurrence
Spacing	0.2
E	0.105
T	0.075
O	0.0654
A	0.063
N	0.059
I	0.055
R	0.054
S	0.052
H	0.047
D	0.037
L	0.029
C	0.023
F U	0.0225
M	0.021
P	0.0175
Y W	0.012
G	0.011
B	0.0105
V	0.008
K	0.003
X	0.002
J Q Z	0.001

lost if it were to be properly spelled out as ABBA. This is, of course, another palindromic word. Entire sentences may be composed that are palindromic by words. Even a short story exists that is palindromic by words[22].

In enigmatic poetry, only one case of a Latin palindromic matrix, symmetric about both diagonals is known:†

$$\begin{bmatrix} S & A & T & O & R \\ A & R & E & P & O \\ T & E & N & E & T \\ O & P & E & R & A \\ R & O & T & A & S \end{bmatrix}$$

There are bilaterally symmetric words that possess a horizontal plane of symmetry. Some examples are as follows: "BED", "BEDE" (Venerable Bede, 673–735, English scholar, historian, and theologian), "DICK" (familiar form of the name Richard), "BEE", "BECK", "BEDECK", "DIOXIDE", "BOX", etc. Both the palindromic words with a vertical plane of symmetry and bilaterally symmetric words with a horizontal plane of symmetry are achiral. All other words are chiral. "Symmetry" itself is also a chiral word.

It is hard to imagine a literary work that would be composed in such a manner that is palindromic by words, although the attempts along these lines are recorded[22,43]. The following verse which is palindromic by words is rather interesting[79]:

Is it odd how asymmetrical is 'symmetry'?
'Symmetry' is asymmetrical how odd it is.

Both lines may be read word by word from the end to the beginning. They are invariant to the inversion: A change in the direction of reading with simultaneous change in the order of letters in the words produces no change in the meaning. Perhaps a computer will be able to perform such a task in the future. However, the "synthetic" (computerized) literary work is something that may appear sooner than we expect[80–82]. What the artistic values of such a prose (or poetry or plays) would be is highly uncertain, unless we find a machine-oriented criteria for human value of information.

Information is defined as the result of choice. It is not considered as a basis for a prediction, as a result that could be used for making another choice. The human value of information is completely ignored. Thus, a sentence of 100 letters from either "World Tennis" (leading international tennis monthly), "Hamlet", Einstein's book on relativity[83], or the text generated by a computer has exactly the same information value. In other words, "information" is defined as distinct from "knowledge" which so far has not been quantified in terms of numbers. The value of the information is completely ignored by the framework of information theory. Information is always measured by a positive quantity, whilst the value of information can, in certain cases, be regarded as negative. The idea of value refers to the possible use by an observer. Whilst information is an absolute quantity which has the same value for any observer, the human value of information is necessarily a relative quantity. It would have different values for different observers.

SYMMETRY AND ASYMMETRY IN LITERARY WORKS

Since symmetry in general and bilateral symmetry in particular have been permanent, and very visible, ingredients of man's culture from the dawn of human history, they are expected to permeate to some extent all kinds of literary works. In order to establish this, we will look for examples in a variety of works of literary art. Attention will be directed especially towards fiction.

† In English: The sower Arepo barely holds the wheel.

A. *The symmetric and asymmetric objects in literature*

It appears that in works of literature either the writer uses a symmetric and/or asymmetric objects as a descriptive means, or the basic structure of a literary product may be associated with a geometric object with some characteristic symmetry. In the first case the object possesses symmetry (or asymmetry) of some kind (bilateral, spherical, ornamental, crystallographic, etc.) and is employed as such by the author. A few examples will be mentioned. The story entitled "The Hands" by the Croatian writer Ranko Marinković[84], and the novel *Pentagram* by the Serbian writer Radomir Konstantinović[85] belong to the first category. Even poems have been written whose graphical shapes have bilateral symmetry. An example of such a poem is that produced by the German neoromantic poet Christian Morgenstern (1871–1914) entitled "Die Trichter" ("The Funnel")[86]:

Zwei Trichter wandeln durch die Nacht.
Durch ihres Rumpfs verengten Schacht
fließt weisses Mondlicht
still und heiter
auf ihren
Waldweg
u.s.
w.

The shape of the poem in print is the funnel, a bilaterally symmetric object (Fig. 7).

The second case of the use of symmetry in literature is not as simple and clear-out as the above, because here we deal with the non-spatial objects to which we ascribe spatial features. Such an analysis (and interpretation) is ordinarily highly subjective and a given non-spatial configuration may be associated with the different geometric figures depending on the aim of the person carrying out such a study.

A variety of symmetric and asymmetric objects may be encountered in literature. Some of these objects that appear with a certain frequency in literary works will be listed below. In many instances the following symmetric (and asymmetric) two- and three-dimensional objects appear or may be identified which serve as the works' foundation: cycle, cross, polygons, polyhedra, etc. We add to them a centre as one-dimensional object, because the structure of

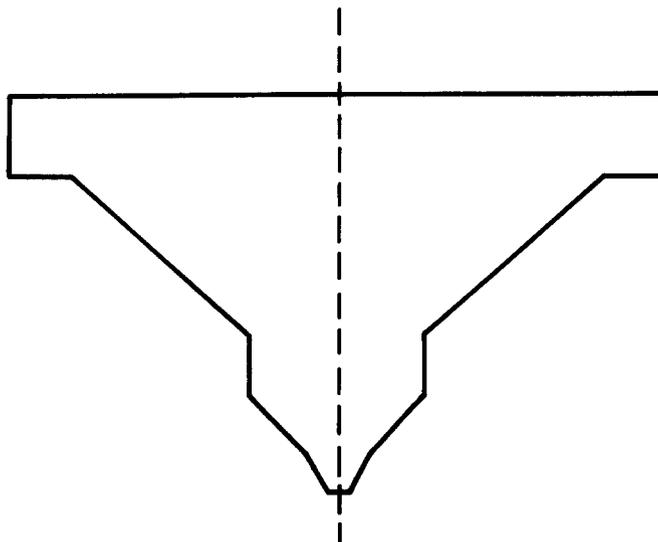


Fig. 7.

many a literary work is strongly centered. It may be considered as a centre of symmetry of such a literary work.

The centre symbolizes the starting point of all processes of efflux, emanation, and divergency, and the meeting point of all processes of return and convergency. Many writers use as a central point for their novels a (easily or not so easily recognizable, dynamic or static) place, date or idea. Let us mention here a few: Remarque's *The Arch of Triumph*[86a], Döblin's *Berlin Alexanderplatz*[87], Singer's *The Cafeteria*[88] (one cafeteria on Broadway in New York proudly displays the sign "We are the cafeteria in Singer's *The Cafeteria*), Solzhenitsyn's *August 1914*[89], Metalious's *Peyton Place*[90], Chevalier's *Clochemerle*[91], Orwell's *1984*[92], etc. Very often authors choose a character to represent the (gravity) centre of the work. Selected examples are Puškin's *Evgeny Onegin*[93], Lagerlöf's *Gösta Berling*[94], London's *Martin Eden*[95], Goldman's *Marathon Man*[96], Voinovich's *The Life and Extraordinary Adventures of Private Ivan Chonkin*[97], Dickens's *Oliver Twist*[98], Farrell's *Studs Lonigan*[99] Tolstoy's *Anna Karenina*[100], Hašek's *The Good Soldier Schweik*[101], Pasternak's *Doctor Zhivago*[102], Solzhenitsyn's *One Day in the Life of Ivan Denisovich*[103], May's *Winnetou*[104], Voltaire's *Candide*[105], Balzac's *Eugène Grandet*[106], Shakespeare's *Hamlet*[107], Hemingway's *The Old Man and the Sea*[108], etc. There are a great many novels (and other literary works) in this category.

Here belong also the autobiographies and biographies of "famous" people from all walks of life (statesmen, political and religious leaders, war heroes, movie and theatre actors and actresses, dancers, showbusiness and entertainment stars, scientists, opera singers, painters, poets, writers, artists, gangsters, band-leaders, indiscreet secretaries, composers, conductors, philosophers, murderers, executioners, kings and queens, ex-kings and ex-queens, sport stars, etc.), where by definition the central role is taken by the person who writes his/her autobiography or about whom the biography is being written. We list below some examples: Maurois's *The Life of Sir Alexander Fleming*[109], Birkenhead's *Rudyard Kipling*[110], Buckle's *Nijinsky*[111], Bonanno's *A Man of Honor*[112], La Mure's *Moulin Rouge*[113] (the life of Henry de Toulouse Lautrec, 1864–1901, French painter), Padover's *Karl Marx*[114], Louis's *Joe Louis: My Life*[115], Farago's *Patton*[116], Stone's *The Agony and Ecstasy*[117] (The life of Michelangelo), Zolotow's *Shooting Star*[118] (The biography of the movie star John Wayne), Clark's *The Life of Albert Einstein*[119], Solzhenitsyn's *The Oak and the Calf*[120] (an autobiographical account), Canneti's *Saved Tongue*[121] (the story of Elias Canneti's youth), Anne Frank's *The Diary of a Young Girl*[122], etc.

In this type of literary products one should include series of stories and novels, mostly mystery and adventure, about a single hero in a variety of situations such as the James Bond series by Ian Fleming, the Rabbi David Small series by Harry Kemelman, the Old Shatterhand series by Karl May, the C. Auguste Dupin series by Edgar Allan Poe, the Maigret series by George Simeon, the Hercule Poirot series by Agatha Christie, the Father Brown series by G. K. Chesterton, the Tarzan series by Edgar Rice Burroughs, the Sherlock Holmes series by Sir Conan Doyle, the Jeff Peters stories by O. Henry, the Nick Adams stories by Ernest Hemingway, etc. Some of these characters may have a side-kick, as Sherlock Holmes' most famous of them all: Dr. Watson. Here also qualify the numerous works about a given historical figure by various authors such as works about Alexander the Great, Gaius Julius Caesar, Charlemagne, Napoleon, etc. Similarly, in this class should be included countless narratives of Jesus Christ's life starting with the four gospels (according to St. Matthew, St. Mark, St. Luke, and St. John) in "The New Testament".

The type of novels classified as "ich (I)" novels may also be included in this group. The ultimate "ich" form of a novel is perhaps the very first novel in this genre: Rousseau's *Les Confessions*[123].

The circle possesses rotational (and bilateral) symmetry and is a symbol of unity, non-differentiable wholeness, endless time, and circular movements. It is also a symbol of protection. Example of this is the magician's circle. Before he began his conjuring, the magician would draw a circle round himself, inscribing on the periphery certain signs (of the Zodiac, for instance) and the Tetragrammaton (The four letters YHWH forming a Hebrew tribal name for the Supreme Being). So long as the circle remained unbroken and the magician stayed inside it, no evil spirit

could harm him. See, for example, the description of the magician's circle by Marlowe (1564–1593) in "Doctor Faustus"[124], Act I, Scene iii:

FAUSTUS:

⋮

Within this circle is Jehovah's name,
Forward and backward anagrammatised:
Th' abbreviated names of holy saints,
Figures of every adjunct to the heavens,
And characters of signs and erring stars,
By which the spirits are enforced to rise:

⋮

Medieval castles, for example, often have round fortifications. The "protection" against evil forces of an individual used to be contained in rings, bracelets, necklaces, etc. These objects today serve merely as adornments. The marriage is "protected" by the wedding-ring. The Japanese flag contains a red circle on a white base. Some other nation's flags also contain a circle (e.g. South and North Korea, Tunis, Zaire, Brasil, etc.), but within the circles elaborate symbols appear, and the simplicity (and beauty) such as that of Japanese banner is diminished. Five circles are symbols of the Olympic movement representing the union of all the sportsmen on our planet.

The basic notion in philosophy of Heraclitus is circular motion. The whole philosophy of the mature Nietzsche is pervaded by the idea of the eternal (circular) return. The concept of circular motion may best be visualized by the self-returning walk along the cyclic path on a given structure where the start and the end are the same points.

Many literary works either use circles as symbols in some way or their structure is circular, e.g., Homer's *The Odyssey*[125], Dante's *Divine Comedy*[126], Verne's *Around the World in Eighty Days*[127], Brecht's *Caucasian Chalk Circle*[128], Solzhenitsyn's *The First Circle*[129], Tolkien's *The Lord of the Rings*[130], Bunyon's *The Pilgrim's Progress*[131], Maugham's *The Circle*[132], Matković's *Game Around Death*[132a], etc.

In many of the above cases such as *The Pilgrim's Progress*, and in others, the structure of the novel is truly spiral, i.e. it represents a combination of circular motion and translation. The Maelstrom, a spiral movement of (sea) water (whirlpool), is used by Poe in his stories "A Descent into the Maelstrom"[133] and "Narrative of A. Gordon Pym"[134].

The life of a human being also resembles, from a distance, a journey on a circular path. A closer look at this path shows that it is circular, but irregular, because in every life there are ups and downs. The autobiographies and biographies mentioned earlier may also be included in this group.

In Plato's *Symposium*[135] Aristophanes talks about round people:

You must begin your lesson with the nature of man and its development. For our original nature was by no means the same as it is now. In the first place, there were three kinds of human beings, not merely the two sexes, male and female, as at present: there was a third kind as well, which had equal shares of the other two, and whose name survives though the thing itself has vanished. For "man-woman"[†] was then a unity in form no less than name, composed of both sexes and sharing equally in male and female; whereas now it has come to be merely a name of reproach. Secondly, the form of each person was round all over, with back and sides encompassing it every way; each had four arms, and legs to match these, and two faces perfectly alike on a cylindrical neck. There was one head to the two faces, which looked opposite ways; there were four ears, two privy members, and all the other parts, as may be imagined, in proportion. The creature walked upright as now, in either direction as it pleased; and whenever it started running fast, it went like our acrobats, whirling over and over with legs stuck out straight; only then they had eight limbs to support and

[†]i.e. hermaphrodite.

speed them swiftly round and round. The number and features of these three sexes were owing to the fact that the male was originally the offspring of the sun, and the female of the earth; while that which partook of both sexes was born of the moon, for the moon also partakes of both. They were globular in their shapes as in their progress, since they took after their parents. Now, they were of surprising strength and vigour, and so lofty in their notions that they even conspired against the gods; and the same story is told of them as Homer relates of Ephialtes and Otus, that scheming to assault the gods in fight they essayed to mount high heaven.

Thereat Zeus and their other gods debated what they should do, and were perplexed: for they felt they could not slay them like the Giants, whom they had abolished root and branch with strokes of thunder—it would be only abolishing the honours and observances they had from men; nor yet could they endure such sinful rioting. Then Zeus, putting all his wits together, spake at length and said: 'Methinks I can contrive that men, without ceasing to exist, shall give over their iniquity through a lessening of their strength. I propose now to slice every one of them in two, so that while making them weaker we shall find them more useful by reason of their multiplication; and they shall walk erect upon two legs. If they continue turbulent and do not choose to keep quiet, I will do it again,' said he; 'I will slice every person in two, and then they must go their ways on one leg, hopping.' So saying, he sliced each human being in two, just as they slice sorb-apples to make a dry preserve, or eggs with hairs; and at the cleaving on each he bade Apollo turn its face and half-neck to the section side, in order that every one might be made more orderly by the sight of the knife's work upon him; this done, the god was to heal them up. Then Apollo turned their faces about, and pulled their skin together from the edges over what is now called the belly, just like purses which you draw close with a string; the little opening he tied up in the middle of the belly, so making what we know as the navel.

Formally viewed, this story represents a nice example of the transition from spherical (round people) to bilateral symmetry (two-legged people), and possibly to asymmetry (one-legged people).

The cross is the symbol of christianity, albeit it was known in the cultures of ancient Knossos (Crete), China, India, Persia, and Egypt. Romans used to crucify the enemies of the state on them. The cross was a symbol of the crusaders. Flags of several countries contain the cross: Finland (blue cross), Greece (white cross), Iceland (red cross), Norway (blue cross), Sweden (yellow cross), Tonga (red cross), Switzerland (white cross), etc. The international charitable organization "Red Cross" has a red cross as the symbol. The cross appears in all sorts of literary works. Let us mention here Sienkiewicz's *Quo Vadis*[136], Wallace's *Ben-Hur*[137], Lagerkvist's *Barabbas*[138], Fast's *Spartacus*[139], Caldwell's and Stearn's *I, Judas*[140], Yerby's *Judas, My Brother*[141], Burgess's *Man of Nazareth*[141a], etc.

Polygons (triangle, square, pentagon, etc) are used as symmetric (achiral) and asymmetric (chiral) objects in literary works.

The triangle is used in literature in many ways, and is connected with the number three. The best example for this is Dante's *Divine Comedy*[126] with its three parts: Inferno, Purgatory and Paradise, and the repeated use of the number three. This poem shows great structural and formal symmetry. The composition is ideal: it is written in *terza rima* (strophas consisting of three hendecasyllables), each of the mentioned three parts contain 33 cantos of comparable length which together with the introductory canto make a perfect number of 100 cantos.

The most important triangle for Western civilization, the Holy Trinity, appears—depending on interpretations—as a symmetric or an asymmetric triangle. It is an asymmetric triangle if each apex of the figure is labelled by a different symbol representing the Holy Father, the Holy Son, and the Holy Spirit. But, if the Holy Trinity is interpreted as the Divine Being in three appearances, then the triangle is symmetric (i.e. equilateral triangle), because each of its apexes should be labelled by the same symbol reflecting this unity.

The triangle was important structure in Greek philosophy (see, for instance, works of Plato, e.g. *Timaeus*, or Pitagora, 482–496 B.C.). Nietzsche in *Thus Spoke Zarathustra*[142] talks about three evils, whilst Popper introduced three worlds (physical world, conscience, and world of ideas, theories, and thoughts) in his works[143].

Modern examples of the use of (asymmetric) triangles are Remarque's *Three Comrades*[144], Dos Passos's *Three Soldiers*[145], van Wyck Mason's *Three Harbours*[146], Christie's *Third Girl*[147], Greene's *The Third Man*[148], Jerome's *Three Men in a Boat*[149], Wallace's *The Three Sirens*[150], Kästner's *Three Men in Snow*[151], Uris's *Trinity*[152], etc.

A poet may see in the triangle a form of the Universe. The Croatin poet Jendričko in his poem "Triangle" mentioned the ". . . Triangular shape of Universe. . ."[153].

In some works several triangles may be found. Various asymmetric triangles may be found, for example, in *The Illiad*[154]. The basic one is made up from the three goddesses Athene, Aphrodite and Here. Another important triangle consists of Menelaus, the King of Sparta; his wife, the beautiful Helen; and Paris, the abductor of Helen, one of many sons of Priam, the King of Troy (or Illium). In *The Odyssey*[125] besides the basic triangle of Odysseus, Penelope and Telemachus, there are also several others. A particularly moving story is related to the fate of Agamemnon (the leader of Greek expeditionary force in the *The Illiad*), who is murdered on his return from Troy by Clytaemnestra, his wife, and her lover, Aegisthus. Another triangle in *The Odyssey* is concerned with Odysseus, his old father Laertes, and his son Telemachus. One of many Shakespearian love/hate triangles is given in "Othello" and consists of Othello, Desdemona and Iago[155].

Love triangles may be detected in Dreiser's *An American Tragedy*[156], Cain's *The Postman Always Rings Twice*[157], or in London's *The Sea-Wolf*[158]. A classical love triangle is a basis of Tolstoy's *Anna Karenina*[100] which is made up of Anna, her husband Alexei A. Karenin, and her lover Alexei Vronski. A love triangle may also be found in Goethe's *The Sorrows of Young Werther*[159] consisting of Werther, Lotta, and Albert, respectively. Another love triangle is clearly described by Flaubert in *Madame Bovary*[160] with Madame Bovary (*née* Rouault), Charles Bovary, the husband, and baron Rodolphe, the lover, respectively.

Many writers have been and still are interested in love/hate triangles. The reason for the interest in this kind of human entanglement is perhaps related to the fact that the love/hate triangles (made up from all possibilities) are of frequent occurrence in real life. Cain seems to be inordinately occupied with the (tragic) situations (pregnant with physical and emotional violence) induced by the love triangles (see any of his works, like *Double Indemity*[161] or *Mildred Pierce*[162]).

In some works may also be found several love/hate triangles. A good example to illustrate this point in fiction may serve du Maurier's *Rebecca*[30] where several love/hate triangles may be uncovered. The main triangle underlying the novel is made up of Maximilian de Winter, his second wife, and Rebecca (his first wife). This triangle is interesting per se because Rebecca is dead, and the reader slowly learns what kind of "real" relationship exists between these characters. Then appears the triangle from the past made up by de Winter, Rebecca, and Favell, Rebecca's lover. Finally, at the end of the novel another triangle appears, consisting of the Winter, his second wife, and Favell, offering the solution to the novel's plot. Since all these triangles are closely related, combined they lead to the three-dimensional structure: an asymmetric trigonal pyramid, which reveals another triangle depicting a relationship of de Winter's second wife, Rebecca (dead), and her former lover (alive) because both these characters caused her a lot of emotional trouble. However, there is another important character in the novel. This is Mrs. Danvers, the housekeeper. She is a part of triangles consisting of Rebecca, the second Mrs. de Winter, and her, then Rebecca, Mr. de Winter, and her, and finally the second Mrs. de Winter, Mr. de Winter, and her. Since, she was practically interacting very little with Favell, they may be assigned to the opposite vertices of the asymmetric trigonal bipyramid by which we may depict the relationship of the characters in *Rebecca* (Fig. 8).

The case of Dumas's *The Three Musketeers*[163] is interesting because here the basic figure is not the triangle, as one might assume from the title of the novel, but an asymmetric quadrangle consisting of three musketeers (making up a friendship triangle before the time of the novel): Aramis, Athos, and Porthos, and young Gascon (later to become a Musketeer) D'Artagnan.

The quadrangle (square) symbolizes fourfold division and is connected with the number four. According to the Aristotelian view the matter is differentiated into four primary elements: Earth, Air, Fire, and Water. With the four elements go four primary qualities: Hot, Cold, Wet, and Dry. The Corpuscularian philosophers (e.g. Newton, Boyle, Locke, Galileo, Decartes) considered that the corpuscles are wholly defined by their four features: size, shape, texture, and motion[164]. William Blake was preoccupied in his work with the four-fold man[34, 165a,b]. A year is divided into four seasons. The Moon exhibits four phases. Many sacral, military, industrial, residential, etc., structures are shaped as quadrangles. Good examples of this struc-

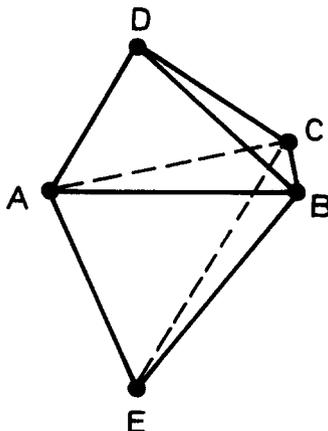


Fig. 8. A = Mr. de Winter, B = Mrs. de Winter, C = Rebecca, D = Favell, E = Mrs. Danvers.

ture, with different meanings, in literature are de Vinci's "Quadrifolium"[165c], Dumas's *The Three Musketeers*[163], Ibañez's *The Four Horseman of the Apocalypse*[166], Slavica's *The Fourth Horse*[167], Christie's *The Big Four*[168], Reymont's *Peasants*[169] (the novel is divided in four parts: each part is connected with one season of the year).

The pentagram appears in two forms: the pentagon and the five-pointed star and is an object of mani-fold symbolism related to the number five. In Greek times it was the Pithagorean sign of identification. The five-pointed star is the symbol of a human being. The five-pointed star was the symbol of the Third International, because it symbolizes the union of workers from all five continents. The (red, yellow, blue, or white) five-armed star is a symbol of many (socialistic) countries. Fifty white stars representing fifty states of the Union appear on the American flag. A number of five-armed stars is also a sign of good quality and excellence (see, for example, the ranking of walks and sights by Michelin, a tourist guide) and, by coincidence, of the ranking of generals in the American army.

An example of the direct use of a symmetric object in literature, i.e. pentagon, may be found Michener's *Poland*[170a]:

. . . . , instead they came up with a chain made of woven hair from a cow's tail on which was suspended a curious pentagon-shaped medal dating back to some pre-Christian time.

'What's this?' a soldier asked, and Biruta said truthfully:

'We've always had it.'

'Why was it hidden?'

'It's our good-luck charm.'

This was too complex, for the men, so they summoned Krumpf, and as soon as he saw it he surmised that it must be some early Germanic medallion, a souvenir of the time when Teutonic greatness began, and he snatched it from the soldier. As he stomped off with his prize, Biruta thought: 'How strange. A man from this village, centuries ago, took that medal from a pagan. Now the pagans have reclaimed it.'

The use of an asymmetric pentagon represents, for instance, the structure of Christie's *Five Little Pigs*[171].

The hexagon is also sometimes employed by writers, but much more by designers judging from the hexagonal patterns we see everywhere in our daily lives. Many naturally-occurring structures are built, entirely or partially, from hexagonal units (e.g., honey-comb, steroids, etc). It is interesting to note that one of the first scientific studies about hexagonal structures was performed by the Croatian scientist Rugjer Bošković (1711–1787). He studied the structure of the honey-comb and proved that the choice of a hexagonal structure was not by chance: Using such a structure, the bees economize on building material. Bošković published this in the study entitled "*De apium cellulis*" in 1760 in his commentaries on Volume II of Benedict Stay's (Stojković, 1714–1801, Croatian philosopher, poet, and orator) *Ten Books of Recent*

Philosophy in Verse. In this unique work Stay presented Newton's natural philosophy in verse[172,173].

An example of the use of hexagonal symmetry in the literature is provided by Mann's *Magic Mountain*[174], when he describes the disorder of the snow storm in which Hans Castorp, the hero of the novel, well-nigh dies. An hour before Hans Castorp goes skiing, he enjoys the play of the snow flakes "And among these myriads of enchanting little stars," so he philosophizes,

in their hidden splendor, that was too small for man's naked eye to see, there was not one like unto another; an endless inventiveness governed the development and unthinkable differentiation of one and the same basic scheme, the equilateral, equiangular hexagon. Yet each in itself—this was the uncanny, the antiorganic, the life-denying character of them all—each of them was absolutely symmetrical, icily regular in form. They were too regular, as substance adapted to life never was to this degree—the living principle shuddered at this perfect precision, found it deathly, the very marrow of death—Hans Castorp felt he understood now the reason why the builders of antiquity purposely and secretly introduced minute variation from absolute symmetry in their columnar structures.

Polyhedra and crystal structures also appear in literary works. The regular polyhedra, often referred to as the Platonic solids, are prominent objects in Plato's philosophy. Plato, in *Ti-maeus*[175] associated the regular tetrahedron, octahedron, cube, and icosahedron with four elements: fire, air, earth, and water. In the dodecahedron he saw, in some sense, the image of the universe.

Ferdinand Baldensperger, in his capital work *La Littérature*[176], said that the contemporary philosophers like the scientific term "crystallization", because it well illustrates the transition from the saturated solution (i.e., the mind ready for creation) to the geometrical assembly (i.e., the basic idea for the future work).

Guy de Maupassant gives in his story *Love*[177] the following description of the ice-hut in which two hunters found shelter in the early morning cold in marshes just before starting the hunt:

We made a pile in the middle of our hut which had a hole in the middle of the roof to let out the smoke, and when the flames rose up to the clear, crystal blocks they began to melt, gently, imperceptibly, as if they were sweating. Karl, who had remained outside, called out to me: "Come and look here!" I went out of the hut and remained struck with astonishment. Our hut, in the shape of a cone, looked like an enormous diamond with a heart of fire, which had been suddenly planted there in the midst of the frozen water of the marsh. And inside, we saw two fantastic forms, those of our dogs, who were warming themselves at the fire.

The following lines are taken from Hemingway's "*The Old Man and the Sea*"[178] in which the prisms are used a descriptive means:

He could not see the green of the shore now but only the tops of the blue hills that showed white as though were snow-capped and the clouds that looked, like high snow mountains above them. The sea was very dark and the light made prisms in the water. The myriad flecks of the plankton were annulled now by the high sun and it was only the great deep prisms in the blue water that the old man saw now with his lines going straight down into the water that was a mile deep.

A pleasing poetical description of the mystery and glory of the amber necklace (owned by Barbara Ossolinski) is given in Michener's *Poland*[170b]:

Not harsh or brilliant like a challenging diamond,
Nor stained with miner's blood like a throbbing ruby,
Nor brazenly proclaiming its work like a cube of gold. . .
You are an autumn moon rising over a field of ripened grain."

It is interesting to note that Erwin Schrödinger argued in his essay "What is Life?"[179] that aperiodic crystals are far more interesting structures than periodic crystals. This is so because

the beautifully ordered structure of a periodic crystal—in its rigidity which does not allow much change—is dull in comparison with a structure which permits variations. If we leave inorganic world and consider, for example, the societal structures, then the structure of a totalitarian society—in its inflexibility—resembles a periodic crystal structure, whilst the structure of a democratic society, in its vitality and dynamism, bear likeness to an aperiodic structure. Aperiodic structures may evolve to different levels of organization whilst periodic structures are static and dead.

B. *Symmetry characteristics of literary works*

The definition of bilateral symmetry (reflection symmetry) that concerns such symmetry operations as reflections, loses its preciseness in the literature. This is so because in the novel (novelette, story) a spatial configuration (an object) is substituted, for example, by a given character, and its mirror-image by an identical character (a twin-brother or a double). The symmetry plane is the author's phantasy by which the two germane characters are related. A lot of fiction appears with bilaterally symmetric (in the above sense) characters. Identical twins appeared in novels such as *The Twin Lottas* by Kästner[180]. A good example of a double is the novel *A Double* by Dostoyevsky[181]. The explicit case of the convergency of a character and his image (his conscience) to a common unfortunate end may be found in Poe's story *William Wilson*[182]:

At that instant some person tried the latch of the door. I hastened to prevent an intrusion, and then immediately returned to my dying antagonist. But what human language can adequately portray *that* astonishment, *that* horror which possessed me at the spectacle then presented to view? The brief moment in which I averted my eyes had been sufficient to produce, apparently, a material change in the arrangements at the upper or farther end of the room. A large mirror—so at first it seemed to me in my confusion—now stood where none had been perceptible before; and, as I stepped-up to it in extremity of terror, mine own image, but with features all pale and dabbled in blood, advanced to meet me with a feeble and tottering gait.

Thus it appeared, I say, but was not. It was my antagonist—it was Wilson, who then stood before me in the agonies of his dissolution. His mask and cloak lay, where he had thrown them, upon the floor. Not a thread in all his raiment—not a line all the marked and singular lineaments of his face which was not, even in the most absolute identity, *mine own!*

It was Wilson; but he spoke no longer in a whisper, and I could have fancied that I myself was speaking while he said:

'You have conquered, and I yield. Yet, henceforward art thou also dead—dead to the World, to Heaven and to Hope! In me didst thou exist—and, in my death, see by this image, which is thine own, how utterly thou hast murdered thyself.'

A variant of this theme is the story by Papini "Two Images in the Pool"[183] in which the character of the story appears as two identical people of differing age (the younger by seven years really represents the conscience). At the end of the story the younger counterpart is killed by the older who remains alive and thus represents the singular case of somebody who killed himself but is still alive. In these works by juxtaposing two parts the authors have transformed the inherent symmetry of left and right into something more complex and unique.

Sometimes the mirror-image is not like the character at all. This is so because the artist's creative phantasy acts as a distorting mirror that we all know from amusement parks. Examples are Stevenson's *The Strange Case of Dr. Jekyll and Mr. Hyde*[184] (this is the case of a character and his evil transformation), de Maupassant's *La Horla*[185] (the case of a character with a split-personality), Wilde's *The Picture of Dorian Gray*[186] (this is the case of a character staying young while his portrait is getting older), Poe's *The Oval Portrait*[187] (the reverse case from the above: a character is getting older fast whilst the portrait is being painted, and dies with the finishing stroke of the painter's brush), etc. The ultimate transformation of a character is described in Kafka's "The Metamorphosis"[188] though the mishap that happened to the protagonist of the story may have really occurred only in his imagination.

A (political) satire also falls into the category of a literary work with a distorted mirror-image. A good example to illustrate this is Swift's *Gulliver's Travels*[189].

The first and the best-known part of the book "A Voyage to Lilliput" describes Lemuel Gulliver's involvement with the Lilliputians. The Lilliputians are a caricature of the English

court and the government. English society is reduced below the six-inch level and its faults and flaws are made more ridiculous, more mean and foolish.

The variant of geometric symmetry which is concerned with such operations as rotations appears in fiction as a merry-go-round (a carrousel) of characters and events, real or fantastic. Many modern American novels reveal this kind of inner symmetry. Let us by way of example mention a few: Hemingway's *The Sun Also Rises*[190], Shaw's *The Young Lions*[191], Jones's *From Here to Eternity*[192], Mailer's *The Naked and the Dead*[193], Hailey's *Overload*[194], etc. In the literature of other nations this kind of novel may also be found. Examples are Kosinski's *The Painted Bird*[195], Kundera's *Joke*[196], or Škvorecký's *Armoured Battalion*[197]. A good example of this kind of novel is Hugo's *Les Misérables*[198]. All these novels treat human destiny in circumstances beyond the control of an individual.

As we have already pointed out, the concept of asymmetry may be best introduced with the help of the mirror. The mirror as a contraption which reflects reality has always fascinated writers. The mirror is an important device in fairy tales such as *Snow-white and the Seven Dwarfs*, fantasies such as Carroll's *Alice Through the Looking Glass*[199], straight fiction such as Papini's *Mirror Which Flees*[200], or in criminal stories such as Christie's *Dead Man's Mirror*[201]. Shakespeare[202] nicely said in "Hamlet":

for anything so overdone is from the purpose of playing, whose end, both of the first and now, was and is, to hold, as 'twere, the mirror up to nature; to show virtue her own feature, scorn her own image, and the very age and body of the time his form and pressure.

An interesting use of the mirror in fiction is to be found in Sayers's *The Image in the Mirror*[203]. Let us use the author's own words:

'I was going along Holborn at lunch-time. I was still at Crichton's. Head of the packing department I was then, and doing pretty well. It was a wet beast of a day, I remember—dark and drizzling. I wanted a hair-cut. There's a barber's shop on the south side, about half-way along—one of those places where you go down a passage and there's a door at the end with a mirror and the name written across it in gold letters. You know what I mean.

'I went in there. There was a light in the passage, so I could see quite plainly. As I got up to the mirror I could see my reflection coming to meet me, and all of a sudden the awful dream-feeling came over me. I told myself it was all nonsense and put my hand out to the door-handle—my left hand, because the handle was that side and I was still apt to be left-handed when I didn't think about it.

'The reflection, of course, put out its right hand—that was all right, of course—and I saw my own figure in my old squash hat and burberry—but the face—oh my God! It was grinning at me—and then just like in the dream, it suddenly turned its back and walked away from me, looking over its shoulder. . .

In nature, mirror symmetry is observed when trees and other objects are reflected in a smooth lake or river. The myth of Narcissus is related to this kind of reflection symmetry: Nemesis caused Narcissus to fall in love with his own reflection in the water. His love was not returned and Narcissus died on the bank of a brook. From his body a flower, named after him *narcissus*, has grown. On account of the Narcissus myth there is psychoanalysis the term *Narcissus's complex* for a person who always watches himself (herself) in the mirror or, when on the street, in a store window.

The exact image of reality is the photograph. There are authors who record reality with photographic accuracy, such as the great masters of the written word Flaubert[160] and de Maupassant[68,177,185]. To this category also belongs Emile Zola[204,205], though not such an accomplished stylist as the former two. They perfectly recorded their times, but their works carry a recognizable personal signet of each of them. In making the literary "photos" they employed their own, highly sensitive, lenses.

In the history of literature there are many works (poems, stories, novelettes, novels, plays) which mirror-imaged the reality of a particular time. These are the cases when the literature plays the role of a (true or distorting) mirror. Folk tales and oral epics also played the role of a mirror. The reality and its mirror-image given by an author is at best near symmetric. However, much more often reality is distorted in literature. This is so because a creative author will

always put into his work his experience or his impression of a particular historical incident in a very subjective way. Many rather critical stages in the history of mankind (war, famine, plague, revolution, the explosion of the first atomic bomb, the launching of the first man in outer space, the landing of the first man on the Moon, etc.) have been experienced by talented people, directly or indirectly, who recorded them by various means and have been concerned almost always with their impact on the fate of an individual and the inner life of his mind.

Great fiction which reflects the destiny of a man in cataclysmic incidents is rare, but it records or reconstructs a particular historical situation with the clarity of a magnifying glass. Let us here mention only several examples: *War and Peace*[206] (Russian people in the 1812 war against Napoleon), *Doctor Zhivago*[102] (Russian people in the October Revolution of 1917 and in early postrevolution days), *Chesapeake*[207] (American East, people and land, from 16th century to the present day), *The Bridge on the Drina*[208] (People of Bosnia under Turkish rule), *The Last Days of Pompeii*[209] (Pompeii in the time of the eruption of Vesuvius, 79 A.D.), *Masada*[210] (The defense of Masada by Jews against the Romans in 73 A.D.), *Goldsmith's Gold*[211] (People of Zagreb in the last quarter of 16th century), *Gone with the Wind*[212] (Georgia during the Civil War 1861–1865), etc. Why are these, broadly speaking, historical novels (distorted mirror-images, i.e. literature) and not history books ("true" mirror-images, i.e. science)? Perhaps the reason is that the author of a "historical" novel can be as careless, or as meticulous, as the historian and yet reserve the right not only to rearrange events, but, more significantly, to ascribe motive, something the scrupulous historian should never do. Hence, the historical novels represent a blend of fact and fiction and reveal the spirit and drama of a particular point in the history through the author's mind.

In between historical fiction and historical works there are memoirs of historical figures such as Casanova's *Memoirs*[213], Eisenhower's *Crusade in Europe*[214] or Montgomery's *The Memoirs of Field Marshall the Viscount Montgomery of Alamein, K.G.*[215], and chronicles such as Ryan's *A Bridge Too Far*[216], Jones's *W W II*[217], and Tuchman's chronicle about XIV century very appropriately entitled *A Distant Mirror*[218]. In these works the general history is well-reflected. However, the interpretation of certain incidents and of roles played by various historical figures varies widely. In memoirs the central figure in everything is always the author, whilst in chronicles the sympathies of the author are usually centered only on some persons and incidents, and they are given more attention than the others.

Let us now consider the case of a large family chronicle, the plot of which is built around the genealogical tree. Family trees reflect the symmetry of growth, proposed by Jung[219], besides giving a mirror-image of the rise (and decline) of a given family in a certain period of time, and in characteristic social, economic, and political circumstances. Examples of this kind of novel are Mann's *Buddenbrooks*[220], Galsworthy's *The Forsyte Saga*[221], Krleža's *Glem-bays*[222], Singer's *The Family Moskat*[223], Marquez's *One Hundred Years of Solitude*[70], Haley's *Roots*[224], Michener's *The Covenant*[225], etc.

We already mentioned that the family trees are asymmetric structures. We can see the author making them symmetric if he wishes to do so, but on the expense of credibility. However, the science fiction authors can certainly devise a family which growth follows the ramifications of the symmetric tree by means of, for example, the genetic engineering. On the other hand, there are structures around us which may be depicted by symmetric trees. For instance, a year possesses a tree-like structure which is symmetric. This structure was also used in the literature.

Michener in his historical novel *Poland*[170c] gives the following description of the future Krzyztopor palace of the Polish magnates Ossolinskis, reflecting the symmetry of a tree-like structure of a year (this palace was later destroyed by the Swedish Army (1655), after only seven years of existence):

And with that unfurled two rolls of paper on which architects had done much planning, and to his startled audience he disclosed the wild plans which preoccupied him:

'I am going to build nothing less than the grandest castle in Europe. See! It will have of one glorious tower representing the unity of God. It will have these four huge towers, each one—you will forgive me for saying, Cyprjan—larger than your castle here. They represent the four seasons of the year.

'We have inside seven major edifices—living area, guests, warehouses—representing the days of the week. We have twelve corridors for the months of the year and fifty-two separate rooms for the weeks. If you cared to count, you'd find three hundred and sixty-five windows plus this little one here for Leap Year.

The development of European literature (as well as art) itself generated a tree with roots in Greece. The development of human culture also resembles a tree-like structure (a cultural tree) with roots in the ancient civilizations of China, India, Persia, Egypt, Babylonia, Greece, Rome, South America, etc. Similarly, the growth of the Croatian culture represents a tree-like structure with roots in Dubrovnik, Split, Zadar, Šibenik, Zagreb, Varaždin, Požega, Vinkovci, Vukovar, Pula, Rijeka, and Kosinj[225a,226].

C. Dualism in literature

We now wish to discuss briefly dualism in literature. Dualism is related to opposing values such as good and evil (Christ and antichrist). The concept of dualism has been present in theology and philosophy since ancient times. The transition from unity to dualism (and later to pluralism) is described in the beginning of Lao Tsu's "Tao Te Ching"[227]:

ONE

The Tao that can be told is not eternal Tao.
 The name that can be named is not the eternal name.
 The nameless is the beginning of heaven and earth.
 The named is the mother of ten thousand things.
 Ever desireless, one can see the mystery.
 Ever desiring, one can see the manifestations.
 These two spring from the same source but differ in name;
 this appears as darkness.
 Darkness within darkness.
 The gate to all mystery.

Dualism may be related to the principle of anti-symmetry. The anti-symmetry is a fundamental principle of quantum mechanics[228]: It reflects the very basic characteristic of fermions. Fermions are particles (electrons, protons, neutrons, positrons) for which only anti-symmetric states occur in nature. The wave function is anti-symmetric if the interchange of the positions of any two particles cause the function to change sign. The state corresponding to an anti-symmetric wave function is called an anti-symmetric state. Particles for which only symmetric states occur in nature are called bosons (for example, photons are bosons). The wave function is symmetric if the interchange of the positions of any two particles do not cause the function to change sign. The state corresponding to a symmetric wave function is called a symmetric state. It appears that all particles occurring in nature are either fermions or bosons. Note also that for every particle there is an anti-particle.

A pictorial way of describing anti-symmetry is by comparing positive and negative in photography: to each white point corresponds a black point. Let us denote a black point by p^- and a white point by p^+ , respectively. (The signs, + and -, are related to colours). Then the transformation $p^+ \rightarrow p^-$ (i.e., the colour change) corresponds to the reflection through the anti-symmetry plane. The anti-symmetry plane is a symmetry element as the symmetry plane except that the reflection through it is followed by the colour change. The notion of black-white or anti-symmetry is the simplest aspect of the principle of colour symmetry[27].

The concept of dualism in literature consists of building a story around two opposing characters (Cain and Abel), values (good and evil), powers (East and West), political systems (democracy and totalitarianism), doctrines (evolution and revolution), etc. A standard strategy of a writer is to build (in as many variations as there are writers) the conflict of antagonists up to a climax and then to resolve the clash in some way, and, in so doing, to deliver a message containing a moral lesson and in many cases (e.g., especially in nationalistic historical novels such as Sienkiewicz's *With Fire and Sword*[229]) a lot of optimism. In many a criminal story the conflict usually ends in the murder which ordinarily happens early in the story, and then the writer works through some 50 to 100 pages of text until the murderer is delivered.

Dualism may be, of course, detected in almost all literary works, but some are truly built on the opposite values. A few examples of this kind are given as follows: Tolstoy's *War and Peace*[206] Dante's *Divine Comedy*[126], Guareschi's *Don Camillo*[230], Shaw's *Rich Man, Poor Man*[231], Cervantes's *Don Quijote*[232], Dostoyevsky's *Crime and Punishment*[233], Beecher Stowe's *Uncle Tom's Cabin*[234], Stendhal's *Red and Black*[235], Turgenyev's *Fathers*

and *Children*[236], Tolkien's *The Lord of the Rings*[130], etc. The socialistic realism, the state sponsored art and literature movement, is a truly good representative of the principle of black and white (anti-symmetry).

D. Concluding remarks

Finally, we wish to say a few words about entropy and symmetry, as the opposing principles, in literary works. We have already pointed out that as symmetry increases, the information content increases, whilst the entropy decreases. Many of the writers we have cited in this essay composed their works with the aim to maximize the information they wished to transmit to the reader. In other words, the literary works *in toto* possess an inner (near) symmetry which takes care that the work is well-balanced and ultimately readable. Symmetry as an aesthetic factor will be discussed in this special issue on symmetry[237]. However, there is another stream of authors whose ideas differ from the above efforts. They bring into their works a certain amount of disorder, especially in connection with communication between the characters (see, for example, Ionesco's plays, e.g., "The Lesson"[238]). The failure to communicate is an unfortunate feature of our times. This situation is mirror-imaged in literature. Thus, we have a case of an increase in entropy of a literary work, and a decrease in the related symmetry (symmetry within the language). However, the symmetry of the work as a (distorted) mirror of reality remains. Therefore, in literary work one may detect several levels of symmetry and some may be annihilated by the increasing entropy of their particular level, but some remain. Under the levels of symmetry in the literary product we consider, for example, the symmetry of a work as a whole (mirror-image of reality), order within the language, dualism, the use of symmetry objects, etc. So it may happen that a literary work with aesthetic appeal may also possess a high value of the entropy, especially concerning the communication between the characters. A very characteristic work in this respect is a story by Thomas Pynchon entitled appropriately "Entropy"[239]. In this beautiful story (sic!) entropy refers to the failure of Saul (an information scientist) and his wife to communicate with each other and indirectly, the similar failure of everyone at the lease-breaking party (in Washington). Incidentally, in the story a number of scientific terms appear, e.g. Gibbs and Boltzmann statistics, cosmic heat-death, the theorem of Casius, and references to scientific literature sources such as "Handbook of Chemistry and Physics" (CRC Press Edition) and "Scientific American". Thus, the story "Entropy" requires that the readers have a certain knowledge of modern science.

CONCLUSIONS

This study shows that symmetry and asymmetry appear in works of literature. Their appearance is in several modes: the authors either use some symmetric (and/or asymmetric) objects directly in their works or the structure of their works may be interpreted in terms of symmetric (and/or asymmetric) figures, or a literary work itself may be considered as a symmetric or an asymmetric object. An important point is also that the literary products (near) mirror-image in some way the reality (of the past and present). The authors may also predict the future and then the work plays the role of the magic mirror. This, of course, is also true for looking back into the past.

It is necessary to emphasize that the preciseness of the definition of symmetry and asymmetry is lost in literary works. When we talk about symmetry in the literature, we should do this with great care, because in this area we are dealing with the symmetry of non-physical products, i.e. psychic produce. The somewhat loose and intuitive understanding of symmetry as harmony of proportions (or beauty of form) so perceptible in the visual world, translates in the literature to spiritual harmony which is susceptible to individual sensitivity[240]. If the process of writing consists of interpreting the images that appear in the mind of the author with words, then reading is a kind of reverse process. However, the image that the reader creates in his mind may not correspond to that one originated by the author; the difference may be related to the possibility of a great number of interpretations that the work of an author offers to the creative reader. This multitude of possible interpretations makes work universal with its meaning unbounded by space and time. This may best be seen when the same play is staged by different directors as is the case with the numerous productions of classical Greek dramae or Shakespearean plays. There are as many interpretations as directors: some more, some less

successful with the public. Thus, the symmetry inherent in literary works may not always be easily discerned.

At this point we may ask it how it happens that the authors thought and wrote about the concept of symmetry in their minds. Was this done consciously or subconsciously? We are free to speculate how the artists learned about symmetry. Was it by observing symmetry in nature or did the creative artist's mind, in order to bring into being beauty, order, and perfection, intuitively follow the principle of symmetry? In other words, was the use of symmetry initiated from an empirical source or from an independent source? Perhaps the origin of symmetry in artists' works could be traced to both sources. It seems that evolution follows the symmetry rules. For example, the representatives of a given animal species in order to survive must have an optimum size and shape which is ordinarily very symmetric. The symmetry requirements for the spatial organization apparently appear indirectly in the genetic code of all living matter (see, for example, the studies in the spatial structures of viruses[241]). The artist is usually a very keen observer of nature. Thus, he surely noticed, and learnt about, many kinds of symmetries that appear in the Universe. This may be supported by simply observing the art of primitive cultures or medieval paintings. Symmetry in these works is too obvious. Order, perfection, and especially beauty are important ingredients in every work of art and literature[240]. This is particularly true for poetry according to Poe[43]. Poe's theory of poetry is based on a simple proposition. He sees the human self divided neatly into intellect, conscience, and soul. The first is concerned with truth, the second with duty, and the third with beauty. In poetry the third alone is in question. Oscar Wilde started Preface to *The Picture of Dorian Gray*[186] by stating: "The artist is the creator of beautiful things". The aesthetic effects resulting from symmetry of an object lie in the psychic process of perception, and this process is highly individualistic. However, the relationship between beauty and symmetry will be discussed by competent people elsewhere in this special issue on symmetry[3].

Acknowledgements—The authors would like to thank for their discussions and correspondence on symmetry, asymmetry, and antisymmetry in mathematics, natural sciences, arts, and literature B. M. Gimarc (Columbia, SC), Ž. Jeričević (Zagreb, Houston, TX), K. Horvatić (Zagreb), I. Hargittai (Storrs, CT), I. Bauer (Zagreb), N. Allegretti (Zagreb), J. Gašparac (Zagreb), Z. Slanina (Prague), L. Klasinc (Zagreb, Baton Rouge, LA), J. Herak (Zagreb), D. Bosanac (Zagreb), I. Mills (Reading), D. Petranović (Zagreb), V. Šunjić (Zagreb), D. Bonchev (Burgas), D. Mayer (Zagreb), V. Imper (Zagreb), M. Randić (Ames, IA), Z. Pavišić (Zagreb), Z. Trgovčević (Zagreb), and T. Cvitaš (Zagreb).

Early versions of the essay were examined by D. Bonchev, M. Randić, G. M. Gimarc, I. Hargittai, D. Jeričević, and L. Klasinc. This is a good opportunity to thank them for critical comments and many helpful suggestions.

REFERENCES

1. W. Gilde, *Gespiegelte Welt*. VEB Fachbuchverlag, Leipzig (1979).
2. H. Weyl, *Symmetry*. University Press, Princeton (1952).
3. See other contributions on symmetry in this special issue of *Computers & Mathematics with Applications*, edited by István Hargittai.
4. E. P. Wigner, *Group Theory and Its Applications to Quantum Mechanics of Atomic Spectra*. Academic, New York (1959).
5. M. Hamermesh, *Group Theory and Its Application to Physical Problems*. Addison-Wesley, Reading, Mass. (1967).
6. F. A. Cotton, *Chemical Applications of Group Theory*. Wiley, New York (1963).
7. L. Pauling and R. Hayward, *The Architecture of Molecules*. Freeman, San Francisco (1964).
8. R. McWeeny, *Symmetry: an Introduction of Group Theory and Its Applications*. Pergamon, Oxford (1964).
9. M. Tinkham, *Group Theory and Quantum Mechanics*. McGraw-Hill, New York (1964).
10. H. H. Jaffe and M. Orchin, *Symmetry in Chemistry*. Wiley, New York (1965).
11. R. M. Hochstrasser, *Molecular Aspects of Symmetry*. Benjamin, New York (1966).
12. R. B. Woodward and R. Hoffmann, *The Conservation of Orbital Symmetry*. Verlag-Chemie, Weinheim (1970).
13. D. S. Schonland, *Molecular Symmetry*. Van Nostrand & Reinhold, London (1971), reprinted.
14. I. Bernal, W. C. Hamilton and J. S. Ricci, *Symmetry*. Freeman, San Francisco (1972).
15. A. D. Boardman, D. E. O'Connor and P. A. Young, *Symmetry and Its Applications in Science*. McGraw-Hill, London (1973).
16. D. B. Chestnut, *Finite Groups and Quantum Theory*. Wiley, New York (1974).
17. J. Rosen, *Symmetry Discovered*. Cambridge University Press, London (1975).
18. L. Klasinc, Z. B. Maksić and N. Trinajstić, *Symmetry of Molecules* (in Croatian). Školska knjiga, Zagreb (1979).
19. I. S. Dmitriev, *Symmetry in the World of Molecules*. Mir Publishers, Moscow (1979).
20. H. Primas, *Chemistry, Quantum Chemistry, and Reductionism*, Lecture Notes in Chemistry, No. 24. Springer, Berlin (1981).
21. J. Maruani and J. Serre (eds.), *Symmetries and Properties of Non-Rigid Molecules*. Elsevier, Amsterdam (1983).
22. M. Gardner, *The Ambidextrous Universe*. Basic Books, New York (1964); see also H. E. Huntley, *The Divine Proportion*. Dover, New York (1970) and *Patterns of Symmetry*, edited by M. Senechal and G. Fleck, University of Massachusetts Press, Amherst (1977).

23. C. H. MacGillivray, *Symmetry Aspects of M. C. Escher's Periodic Drawings*, 2nd Edn. Bohn, Scheltema & Holkema, Utrecht (1976).
24. V. A. Koptsik, *Shubnikov Groups*. University Press, Moscow (1966).
25. G. Kepes (ed.), *Module, Proportion, Symmetry, Rhythm*. Braziller, New York (1966).
26. M. C. Escher, *The Graphic Work of M. C. Escher*. Meredith, New York (1967).
27. A. V. Shubnikov and V. A. Koptsik, *Symmetry in Science and Art*. Plenum, New York (1974); (a) p. 308.
- 27a. I. Hargittai and M. Hargittai, *Szimmetria egy kémikus szemével*, Akadémiai Kiadó, Budapest (1983). Its revised English version will be published by Verlag Chemie, Weinheim, under the title *Symmetry through the Eyes of a Chemist*.
28. S. Batušić, *Pictorial History of Art* (in Croatian). Matica Hrvatska, Zagreb (1967).
29. The word "symmetry" is of Greek origin: It is constructed from the root $\mu\epsilon\tau\rho\omega\nu$ (to measure) and the prefix $\sigma\nu\nu$ (along or together) becoming $\sigma\nu\nu\mu$ before the letter μ in the root. The meaning of the word $\sigma\nu\nu\mu\epsilon\tau\rho\alpha$ is commensurable, well-proportioned, well-balanced.
30. D. du Maurier, *Rebecca*. Avon, New York (1979); (a) p. 2; (b) p. 23; (c) p. 133.
31. W. Blake, "The Tyger" in *The Portable Blake*, p. 109. Penguin, Harmondsworth, Middlesex (1974).
32. A. Wickham, "Envoi", in *Selected Poems*. Chatto and Windus, London (1971).
33. S. Lanier, *The Science of English Verse*. Scribner's, New York (1894).
34. N. Frye, *Fearful Symmetry*. University Press, Princeton (1972) third printing. The analytical study of the poet and the painter William Blake (1757-1827).
35. M. Franičević, *Some Problems of Our Rhythm* (in Croatian). Rad JAZU, No. 313, Zagreb (1958).
36. I. Slamnig, *Croatian Versification* (in Croatian). Liber, Zagreb (1981).
37. B. Pavlović and N. Trinajstić, *Mathematical Structures in Literature*, in preparation. Dr. Danail Bonchev (Burgas, Bulgaria) in his letter of November 8th, 1984, in which he commented on our essay, pointed out that 12 Cand. Sci. Theses have been produced on this topic in the U.S.S.R. Unfortunately, we were unable to obtain copies of any of these works.
38. See, for example, a discussion about meanings and uses of the term structure in M. Glucksman, *Structural Analysis in Contemporary Social Thought*. Routledge & Kegan Paul, London (1974), Chapter 2.
39. B. Pavlović and N. Trinajstić, "Symmetry in Croatian Art and Poetry" (in Croatian), preprint.
40. R. Musil, "Der mathematisch Mensch", in *Prosa und Stücke*, p. 1004. Rowohlt, Reinbek bei Hamburg (1978).
41. R. Musil, *Der Man ohne Eigenschaften*. Rowohlt, Reinbek bei Hamburg (1978).
42. O. Henry, "The Chair of Philanthromathematics", in *Gentle Grafter*, p. 443. Octopus, London (1983).
43. E. A. Poe, "The Philosophy of Composition", in *Prose and Poetry*, p. 311. Raduga, Moscow (1983).
44. J. Joyce, *Ulysses*, p. 598. Penguin, Harmondsworth, Middlesex (1975).
- 44a. R. B. Martin, *Tennyson—The Unquiet Heart*, p. 462. Clarendon, Oxford (1980).
- 44b. A. Lord Tennyson, "The Vision of the Sin", in *Poems*, Vol. II, p. 124. Macmillan, London (1908).
45. F. Harary, *Graph Theory*. Addison-Wesley, Reading, Mass. (1971) second printing.
46. P. Alexandroff, *Elementary Concepts of Topology*. Dover, New York (1961).
47. L. Brillouin, *Science and Information Theory*. Academic, New York (1963) second printing.
48. W. N. Lipscomb, *Boron Hydrides*. Benjamin, New York (1963).
49. E. L. Muetterties and W. H. Knoth, *Polyhedral Boranes*. Dekker, New York (1969).
50. Q. Johnson, G. S. Smith, O. H. Krikorian and D. E. Sands, The crystal structure of $RhBe_{6.6}$. *Acta Cryst.* **B26**, 109 (1970).
51. V. Prelog, "Chirality in Chemistry", Nobel Lecture, December 12 (1975), Stockholm. Reprinted in *Croat. Chem. Acta* **48**, 195 (1976) and *Science* **193**, 17 (1976). The term "chirality" is derived from the Greek word $\chi\epsilon\iota\rho$ for hand. Therefore, "chirality" means handedness in reference to a pair of non-superimposable objects we constantly have before us: our two hands. This term was proposed by Lord Kelvin (W. H. Thompson) in 1884. In the contemporary chemical literature the term chirality has largely replaced the older terms "dissymmetry" and "asymmetry".
52. e.g. D. M. Lambert, Specific-mate recognition systems, phylogenies, and asymmetrical evolution. *J. Theoret. Biol.* **109**, 147 (1984).
53. D. L. Sayers, "The Image in the Mirror", in *Great Tales of Detection*, p. 266. Everyman, London (1976).
54. K. Wiberg and J. Siegel, Stereoisomerism and local chirality. *J. Am. Chem. Soc.* **106**, 3319 (1984).
55. M. Rose, *Shakespearean Design*. Belknap, Cambridge, Mass. (1972).
56. T. J. Reed, *Thomas Mann—The Uses of Tradition*. Clarendon, Oxford (1974).
57. S. E. Grace, *The Voyage That Never Ends*. University of British Columbia Press, Vancouver (1982). The study of Malcolm Lowry's fiction.
58. S. Lasić, *The Structure of Krleža's 'Banners'* (in Croatian). Liber, Zagreb (1974).
59. V. Pavletić, *Ujević* (in Croatian). Liber, Zagreb (1978).
60. D. Suvin, Dramatic works of Ivo Vojnović in the European context (in Croatian), in *Croatian Literature in the European Context* (edited by A. Flaker and K. Pranjić), p. 413. Liber, Zagreb (1978).
61. C. Flament, *Applications of Graph Theory to Group Structure*. Prentice Hall, Englewood Cliffs (1963).
62. C. Lévi-Strauss, *Structural Anthropology*. Basic, New York (1963). Structural analysis in linguistics and anthropology.
63. F. Harary, Editor, *Graph Theory and Theoretical Physics*. Academic, London (1967).
64. P. Hage, A graph theoretic approach to the analysis of alliance structure and local grouping in highland New Guinea. *Anthropological Forum* **3**, 280 (1973).
65. P. Doreian, On the connectivity of social networks. *J. Math. Sociology* **3**, 245 (1974).
66. L. W. Beineke and R. J. Wilson, Editors, *Selected Topics in Graph Theory*, Academic, London (1978).
67. N. Trinajstić, *Chemical Graph Theory*. CRC Press, Boca Raton (1983).
68. G. de Maupassant, "Simon's Papa", in *The Great Short Stories of Guy de Maupassant*, p. 8. Pocket, New York (1959) 6th printing.
69. A. Christie, *Triangle at Rhodes*. Dell, New York (1971).
70. G. G. Marquez, *One Hundred Years of Solitude*. Avon Bard, New York (1971).
71. A. Christie, *The Murder of Roger Ackroyd*, P. 83. Pocket, New York (1974).

72. S. Jendričko, "A Debatable Verse", in *Title* (in Croatian), p. 17. Izdavački centar, Rijeka (1983).
73. A. Stamač, Rondo. *The Bridge* (Yugoslav Review of Croatian Literature) 1984, 142.
74. A. Rényi, *Probability Theory*. North-Holland, Amsterdam (1970).
75. C. E. Shannon and W. Weaver, *The Mathematical Theory of Communication*. University of Illinois Press, Urbana, Illinois (1949).
76. I. Prigogine and G. Nicolis, *Symmetry and Thermodynamics*, Ref. 3.
77. B. Fučić, *Glagolitic Epigraphics* (in Croatian). Kršćanska sadašnjost, Zagreb (1982), see also *The First Croato-Glagolitic Primer—1527*. Grafički zavod Hrvatske, Zagreb (1983), reprint.
- 77a. Kruchonikh (b. 1883) told this poem, in 1964, to the Croatian poet Josip Sever when he visited him in Moscow. Sever later edited a collection of poems of Vladimir Mayakovsky (1893–1930) and there he told about this visit to, and his discussions with, Kruchonikh. See this recorded in V. Mayakovsky, *The Thirteenth Apostle* (translation into Croatian and comments by J. Sever), p. 239. Mladost, Zagreb (1982).
78. I. Škarić, Cybernetics and Language (in Croatian with the extended abstract in English). *Suvremena lingvistika* 5–6, 17 (1973).
79. Ref. 27, p. 360.
80. e.g., L. T. Milic, *A Quantitative Approach to Style of Jonathan Swift*. Mouton, The Hague (1967).
81. See, for example, the issue of *bit international* 7 (1971) entitled "Dialogue with the Machine" containing papers reported at the International Symposium on Computers and Visual Research (Zagreb, May 5–6, 1969).
82. L. M. Branscomb and J. C. Thomas, Ease of use: a system design challenge. *IBM Systems J.* 23, 224 (1984).
83. A. Einstein, *Relativity*. Bonanza, New York (1961).
84. R. Marinković, "Hände", in: *Erzählungen*, Steingrüben, Stuttgart (1961).
85. R. Konstantinović, *Pentagram* (in Serbian). Forum, Novi Sad (1966).
86. C. Morgenstern, "Die Trichter", in *Galgenlieder Gingsanz und Horatius Travestitus*, Zbinden, Basel, 1972, p. 34.
- 86a. E. M. Remarque, *The Arch of Triumph*. Signet, New York (1984).
87. A. Döblin, *Berlin—Alexanderplatz*. Schleber, Kassel (1947).
88. I. B. Singer, "The Cafeteria" in *A Friend of Kafka and Other Stories*, p. 83. Fawcett Crest, New York (1980).
89. A. I. Solzhenitsyn, *August 1914*. Bantam, New York (1974).
90. G. Metalious, *Peyton Place*. Pan, London (1965) 15th printing.
91. G. Chevalier, *Clochemerle*. Penguin, Harmondsworth, Middlesex (1976).
92. G. Orwell, 1984. Signet, New York (1961).
93. A. S. Puškin, *Eugene Onegin*. University Press, Princeton (1981).
94. S. Lagerlöf, *Gösta Berling*. Langen, München (1912).
95. J. London, *Martin Eden*. Penguin, Harmondsworth, Middlesex (1980).
96. W. Goldman, *Marathon Man*. Dell, New York (1974).
97. V. Voinovich, *The Life and Extraordinary Adventures of Private Ivan Chonkin*. Penguin, Harmondsworth, Middlesex (1978).
98. C. Dickens, *Oliver Twist*. Penguin, Harmondsworth, Middlesex (1971).
99. J. T. Farrell, *Studs Lonigan*. Signet, New York (1965).
100. L. N. Tolstoy, *Anna Karenina*. Progress, Moscow (1982).
101. J. Hašek, *The Good Soldier Schweik*. Penguin, New York (1946) fourth printing.
102. B. L. Pasternak, *Doctor Zhivago*. Collins, London (1961).
103. A. I. Solzhenitsyn, *One Day in the Life of Ivan Denisovich*. Penguin, Harmondsworth, Middlesex (1963).
104. K. May, *Winnetou*. Continuum, New York (1977).
105. Voltaire, *Candide*, in *Romans et contes*. p. 145. Gallimard, Paris (1979).
106. H. de Balzac, *Eugénie Grandet*. Garnier, Paris (1965).
107. W. Shakespeare, "Hamlet", in *The Works of William Shakespeare* (edited by W. A. Wright), Vol. VII, p. 379. Macmillan, London (1904).
108. E. Hemingway, *The Old Man and the Sea*. Granada, London (1984).
109. A. Maurois, *The Life of Sir Alexander Fleming*. Cape, London (1959).
110. Lord Birkenhead, *Rudyard Kipling*. Star, London 1980.
111. R. Buckle, *Nijinsky*. Penguin, Harmondsworth, Middlesex (1980).
112. J. Bonanno with S. Lalli, *A Man of Honor*. Simon & Schuster, New York (1983).
113. P. La Mure, *Moulin Rouge*. Signet, New York (1954).
114. S. K. Padover, *Karl Marx*. Mentor, New York (1980).
115. J. Louis with E. Rust and A. Rust, Jr., *Joe Louis: My Life*. Berkeley, New York (1981).
116. L. Farago, *Patton*. Dell, New York (1976).
117. I. Stone, *The Agony and the Ecstasy*. Signet, New York (1961).
118. M. Zolotow, *Shooting Star*. Pocket, New York (1979).
119. R. W. Clark, *The Life of Albert Einstein*. Hodder and Stoughton, London (1973).
120. A. Solzhenitsyn, *The Oak and the Calf*. Harper and Row, New York (1980).
121. E. Canneti, *Die Gerettete Zunge*. Hanser, München (1977); *Die Jackel in Ohr*, Hanser, München (1980).
122. A. Frank, *A Diary of a Young Girl*. Cardinal, New York (1960).
123. J.-J. Rousseau, *Les Confessions*. Gallimard, Paris (1951).
124. C. Marlowe, *The Tragical History of the Life and Death of Doctor Faustus*, p. 15. Benn, London (1983).
125. Homer, *The Odyssey*. Greenwich, New York (1982).
126. Dante Alighieri, *Divine Comedy*. Pantheon, New York (1948).
127. J. Verne, *Around the World in Eighty Days*. French, London (1875).
128. B. Brecht, "Der kavkasische Kreidekreis", in *Gesammelte Werke*, Vol. 5, p. 1999. Suhrkamp, Frankfurt/Main (1967).
129. A. I. Solzhenitsyn, "The First Circle" (in Russian), *Collected Works*, Vol. 3. Posev, Frankfurt/Main (1969).
130. J. R. R. Tolkien, *The Lord of the Rings*. Unkin, London (1974).
131. J. Bunyon, *The Pilgrim's Progress*. Penguin, Harmondsworth, Middlesex (1979).
132. W. S. Maugham, *The Circle*. Heinemann, London (1932).

- 132a. M. Matković, *Game Around Death* (in Croatian). Zora, Zagreb (1955).
133. E. A. Poe, "A Descent in the Maelstrom", in *The Fall of the House of Usher and Other Tales*, p. 32. Signet, New York (1960).
134. E. A. Poe, "Narrative of A. Gordon Pym", ref. 133, p. 200.
135. Plato, "Symposium", in *Plato in Twelve Volumes*, Vol. III, p. 73. Heinemann, London (1967); cited lines are taken from pp. 134–139.
136. H. Sienkiewicz, *Quo vadis*. Airmont, New York (1968).
137. L. Wallace, *Ben-Hur*. Pocket, New York (1959).
138. P. Lagerkvist, *Barabbas*. Four Square, London (1960).
139. H. Fast, *Spartacus*. Panther, London (1959).
140. T. Caldwell and J. Stearn, *I, Judas*. Signet, New York (1978).
141. F. Yerby, *Judas, My Brother*. Mayflower, St. Albans, Herts (1976).
- 141a. A. Burgess, *Man of Nazareth*. Bantam, New York (1982).
142. F. Nietzsche, *Thus Spoke Zarathustra*. Schlechta, Munschen (1955).
143. K. R. Popper, *La connaissance objective*. Editions Complexe, Bruxelles (1982).
144. E. M. Remarque, *Drei Kameraden*. Desch, Munchen (1951).
145. J. Dos Passos, *Three Soldiers*. Doran, New York (1921).
146. F. van Wyck Mason, *Three Harbours*. Cardinal, New York (1952).
147. A. Christie, *Third Girl*. Fontana, Glasgow (1977) seventeenth impression.
148. G. Greene, *The Third Man*. Heinemann, London (1976).
149. J. K. Jerome, *Three Men in a Boat, To Say Nothing of the Dog*. Collins, London (1957).
150. I. Wallace, *The Three Sirens*. Signet, New York (1964).
151. E. Kästner, *Drei Männer im Schnee*. Rascher, Zurich (1934).
152. L. Uris, *Trinity*. Doubleday, Garden City (1976).
153. J. Jendričko, *Triangle* (in Croatian), see Ref. 72, p. 20.
154. Homer, *The Iliad*. Greenwich, New York (1982).
155. W. Shakespeare, "Othello". Methuen, London (1969).
156. T. Dreiser, *An American Tragedy*. Constable, London (1928).
157. J. M. Cain, *The Postman Always Rings Twice*. Avenel, New York (1982).
158. J. London, *The Sea-Wolf*. Avenel, New York (1980).
159. J. W. Goethe, *Leiden des jungen Werthers*. Bibliographisches Institut, Leipzig (1902).
160. G. Flaubert, *Madame Bovary*. Greenwich, New York (1982).
161. J. M. Cain, *Double Indemnity*. Avenel, New York (1982).
162. J. M. Cain, *Mildred Pierce*. Avenel, New York (1982).
163. A. Dumas, père, *The Three Musketeers*. Penguin, Harmondsworth, Middlesex (1983).
164. See the criticism of the Corpuscularian philosophy in R. Bošković, *Theoria Philosophiae Naturalis*. Remondini, Venice (1763); reprint, Liber, Zagreb (1974).
- 165a. W. Blake, *The Portable Blake*, (Edited by A. Kazin). Penguin, Harmondsworth, Middlesex (1974).
- 165b. C. A. Abrahams, *William Blake's Fourfold Man*. Bouvier, Bonn (1978).
- 165c. L. da Vinci, *Quadrifolium*. (translation into Croatian). Grafički zavod Hrvatske, Zagreb (1981).
166. V. B. Ibáñez, *The Four Horsemen of the Apocalypse*. Four Square, London (1962).
167. T. Slavica, *The Fourth Horse* (in Croatian). Grafički zavod Hrvatske, Zagreb (1982).
168. A. Christie, *The Big Four*. Dell, New York (1968).
169. W. S. Reymont, *Die Bauern*. Diederichs, Düsseldorf (1975).
170. J. A. Michener, *Poland*. Corgi, London (1984) (a) p. 685, (b) p. 186, (c) p. 171.
171. A. Christie, *Five Little Pigs*. Fontana, Glasgow (1981).
172. Ž. Marković, *Rude Bošković* (in Croatian), part I, pp. 123–128. Yugoslav Academy of Sciences and Arts, Zagreb (1968).
173. Ž. Dadić, *History of Exact Sciences by Croats* (in Croatian), part I, pp. 296–300. Liber, Zagreb (1982).
174. T. Mann, *Magic Mountain*, p. 480. Vintage, New York (1969).
175. Plato, "Timaeus", in "Plato in Twelve Volumes, Vol. IX, Heinemann, London (1966).
176. F. Baldensperger, "La Littérature" (translation into Croatian), Chapter 1. HIBZ, Zagreb (1944).
177. G. de Maupassant, *Love*, in Ref 68, p. 1.
178. Ref. 108, p. 32.
179. E. Schrödinger, *What is Life?*. Cambridge University Press, London (1967).
180. E. Kästner, *Das doppelte Lottchen*. Atrium, Zürich (1949).
181. F. M. Dostoyevsky, *A Double* (in Russian), p. 109. Collected Works, Vol. 7. Nauka, Leningrad (1972).
182. E. A. Poe, "William Wilson—A Tale", in *The Unabridged Edgar Allan Poe*, p. 549. Running Press, Philadelphia (1983).
183. G. Papini, "Due immagini in una vasca", in *Poesia e Fantasia*, p. 571. Mondadori, Milano (1958).
184. R. L. Stevenson, "The Strange Case of Dr. Jekyll and Mr. Hyde", in *The Great Short Stories of Robert Louis Stevenson*. 6th printing, p. 1. Pocket, New York, (1959).
185. G. de Maupassant, *La Horla*. D'Art H. Piazza, Paris (1972).
186. O. Wilde, *The Picture of Dorian Gray*. Keller-Farmer, London (1907).
187. E. A. Poe, *Life and Death (The Oval Portrait)*. in Ref. 182, p. 734.
188. F. Kafka, "Metamorphosis", in *German Stories and Tales* (edited by R. Pick) p. 266. Pocket, New York (1955).
189. J. Swift, *Gulliver's Travels*. Blackwell, Oxford (1965).
190. E. Hemingway, *The Sun Also Rises*. Scribner's, New York (1970).
191. I. Shaw, *The Young Lions*. Pan, London (1958) fourth printing.
192. J. Jones, *From Here to Eternity*. Avon, New York (1975).
193. N. Mailer, *The Naked and the Dead*. Signet, New York (1976).
194. A. Hailey, *Overload*. Bantam, New York (1980).
195. J. Kosinski, *The Painted Bird*. Bantam, New York (1979) 11th printing.

196. M. Kundera, *Joke* (in Czech). Československý spisovatel, Praha (1967).
197. J. Škvorecký, *Armoured Battalion* (in Czech). Československý spisovatel, Praha (1969).
198. V. Hugo, *Les Misérables*. Hetzel & Quantin, Paris (1881).
199. L. Carroll, "Through the Looking-Glass and what Alice found There", in *The Penguin Complete Lewis Carroll*, p. 121. Penguin, Harmondsworth, Middlesex (1983).
200. G. Papini, *Lo specchio che fugge*. Ricci, Milano (1975).
201. A. Christie, *Dead Man's Mirror*. Dell, New York (1981).
202. Ref. 107: The cited lines were said by Hamlet in Act III, Scene II, lines 19–24.
203. Ref. 53, p. 275.
204. E. Zola, *Germinal*. Bernouard, Paris (1928).
205. E. Zola, *Nana*. Bernouard, Paris (1928).
206. L. N. Tolstoy, *War and Peace*. Penguin, Harmondsworth, Middlesex (1984).
207. J. A. Michener, *Chesapeake*. Random, New York (1978).
208. I. Andrić, *The Bridge on the Drina*. University of Chicago Press, Chicago (1977).
209. E. G. Bulwer-Lytton, *The Last Days of Pompeii*. Rutledge, London (1850).
210. E. K. Gann, *Masada*. Coronet, London (1980).
211. A. Šenoa, *Goldsmith's Gold* (in Croatian) Globus, Zagreb (1978).
212. M. Mitchell, *Gone with the Wind*. Macmillan, New York (1948).
213. Casanova, *Mémoires*. Gallimard, Paris (1958).
214. D. D. Eisenhower, *Crusade in Europe*. Heinemann, London (1948).
215. B. Montgomery, *The Memoirs of Field Marshall the Viscount Montgomery of Alamein*, K. G. Collins, London (1958).
216. C. Ryan, *A Bridge Too Far*. Coronet, London (1977), sixth impression.
217. J. Jones, *W W II*. Ballantine, New York (1977).
218. B. W. Tuchman, *A Distant Mirror*. Penguin, New York (1978).
219. C. G. Jung, *Alchemical Studies*, Chapter 5. University Press, Princeton, 1976, third edition.
220. T. Mann, *Buddenbrooks*. Fischer, Berlin (1960).
221. J. Galsworthy, *The Forsyte Saga*. Heinemann, London (1935).
222. M. Krleža, *Glembays* (in Croatian). Zora, Zagreb (1950).
223. I. B. Singer, *The Family Moskat*. Farrar, Straus, & Giroux, New York (1950).
224. A. Haley, *Roots*. Doubleday, Garden City, N.Y. (1976).
225. J. Michener, *The Covenant*. Corgi, London (1982).
- 225a. Z. Črnja, *Cultural History of Croatia* (in Croatian, but there is also an English translation available). Epoha, Zagreb (1965).
226. J. Horvat, *Croatian Culture through 1000 Years* (in Croatian), Vol. I, Vol. II. Globus, Zagreb (1980).
227. Lao Tsu, *Tao Te Ching*. Vintage, New York (1972).
228. P. A. M. Dirac, *The Principles of Quantum Mechanics*, reprinted fourth edition, Chapter 9. Clarendon, Oxford (1962).
229. H. Sienkiewicz, *With Fire and Sword* (translation in Slovenian). Državna založba Slovenije, Ljubljana (1975).
230. G. Guareschi, *Don Camillo*. Rizzoli, Milano (1965).
231. I. Shaw, *Rich Man, Poor Man*. Delacorte, New York (1970).
232. M. de Cervantes Saavedra, *El ingenioso hidalgo don Quijote de la Mancha*. Espasa—Calpe, Madrid (1967).
233. F. M. Dostoyevsky, *Crime and Punishment* (in Russian), *Collected Works*. Nauka, Leningrad (1973).
234. H. Beecher Stowe, *Uncle Tom's Cabin*. Penguin, New York (1983).
235. Stendhal, *Le Rouge et le Noir*. Kraus, Nendeln, Liechtenstein (1968).
236. I. S. Turgenev, *Fathers and Children* (in Russian). Nauka, Moscow (1981).
237. H. Osborne, *Symmetry as an Aesthetic Factor*, Ref. 3.
238. E. Ionesco, *La Leçon*. Gallimard, Paris (1975).
239. T. Pynchon, "Entropy", in *12 from the Sixties* (edited by R. Kostelanetz), fifth printing, p. 22. Dell, New York (1974).
240. A. Haler, *The Experience of Beauty* (in Croatian). Matica Hrvatska, Zagreb (1943).
241. R. W. Hendrix, J. W. Roberts, F. W. Stahl and R. A. Weisberger (eds.), *Lambda II*. Cold Spring Harbor Laboratory, Cold Spring Harbor (1983).