PROJECT MUSE

Computer-aided Multi-element Geometrical Abstract Paintings

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COMPUTER-AIDED MULTI-ELEMENT GEOMETRICAL ABSTRACT PAINTINGS

Zdeněk Sýkora* and Jaroslav Blažek**

Abstract—*The artist-author, in the first part of this paper, describes paintings he made since* 1961 *in which the composition resulted from the repeated use of one or more basic elements. These elements are characterized by unique shape (square or rectangular) and by specific internal geometrical patterns. The combinatorial complexities of arranging the elements according to specific rules led to the use of a computer.*

*The mathematician-author prepared the programs for a small computer, the LGP-*30, *made by Eurocomp GMBH, Minden, Westfalen, German Federal Republic. In the second part of the paper, he gives the basic information required in preparing computer programs for this kind of abstract painting.*

Examples of these paintings, in black and white and in color, are shown.

I

The principle of bringing elements of a structure into a precise relationship has already been applied by Cezanne. Especially his last works show that his original static solution of obtaining plastic balance was gradually changed into a 'dynamic' solution. At first, his elements were a tree, a mountain and a house. The shapes of the elements were formed of modulated warm and cool colors. In his last works, his interest is concentrated on the color relationships of elements. The development that Cezanne followed in his work is, I believe, typical of many artists of his time and of many artists today.

I began, in 1961, to make paintings of a geometrical, abstract kind in which the composition results from the repeated use of one or more *basic elements*. These elements were characterized by a unique shape (square or rectangular) and by specific internal geometrical patterns.

One of my first paintings using this scheme is shown in Fig. 1. The surface is made up of $18 \times 18 = 324$ rectangles, of which the basic element consists of four internal triangles forming a central rhomboid. The areas surrounding the rhomboid (which is usually white) may be black, light gray or dark gray. I followed, as much as possible, the rule of not having two areas of identical color in contact.

It was a surprise to find that in this composition there appeared an illusion of movement. This illusion is probably caused by the asymmetry in the

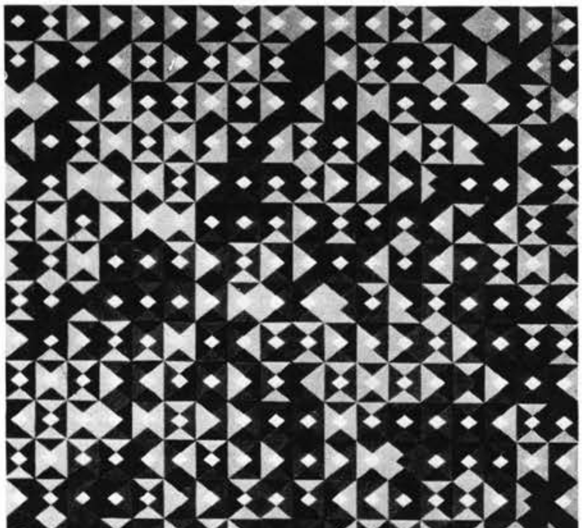

Fig. 1. *'Gray Structure', oil on canvas,* 150 × 120 cm, 1962–1963.

color patterns of some of the elements. Furthermore, there is an illusion of depth that results from particular color values dominating certain areas of the painting.

When considering other rules for making compositions from given elements, I realized that one ran into combinatorial complexities that might be more easily resolved by means of a computer. I turned to

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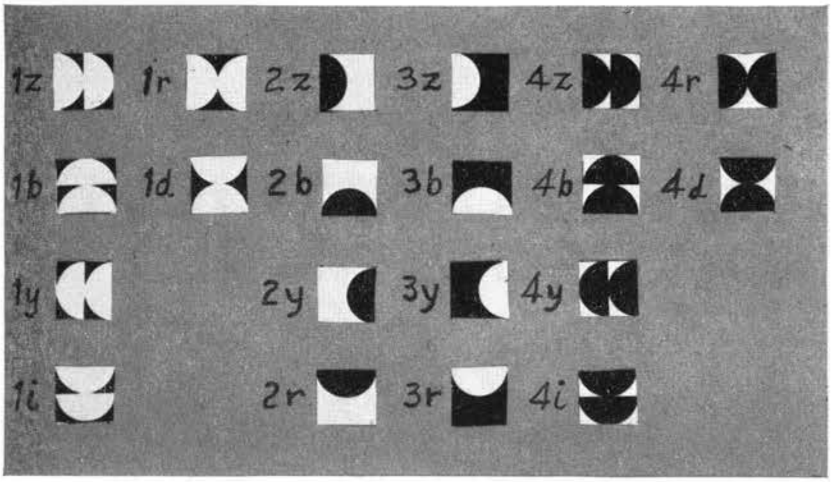

Fig. 2. Geometrical elements used in the paintings entitled 'Black-white Structure' (cf. Figs. 4 and 5).

Jaroslav Blažek, a mathematician, for help [cf. Refs. 1–15].

II

We prepared a program suitable for the small computer, LGP-30, manufactured by Eurocomp GMBH, Minden, Westfalen, German Federal Republic that was available to us.

The procedure for two-color paintings (e.g. black and white) is demonstrated by an example. First the elements to be used must be specified. Then these are grouped according to color density (cf. Fig. 2). Group 1 contains the 'lightest' elements 1z, 1b, 1y, 1i, 1r and 1d; group 2 contains elements 2z, 2b, 2y and 2r; etc. The numbers of the groups 1, 2, 3 and 4 are taken as quantitative measures of color density. Each element is related only to one other one simply by an interchange of color. Thus 1r and 4r are related, as are 1y and 4y, and 2r and 3r.

For the computer, each element is identified by code numbers designating the color (i.e. black or white) at each of the four sides and by additional code numbers designating the shape (i.e. the presence or absence of an open half circle) at each of the sides.

Then an initial diagram is prepared providing a grid for the placement of the elements (cf. Fig. 3). At the start, the artist must insert a number of initial elements of his choice and also + and − signs in locations where he desires an increase or a decrease in color density. The degree of change to a darker or a lighter density adapted for the painting is represented quantitatively by a numerical color density coefficient c, which must have a numerical value exceeding zero. In this case, the coefficient $c = 0{\cdot}75$ was chosen. Lower values for c yield less change in color density; higher values yield greater change.

One of four rules must be chosen. Before giving these, however, the terms employed must be explained. We say that the *colors continue* if the color along a side of an element is the same as that along the adjoining border of the neighboring

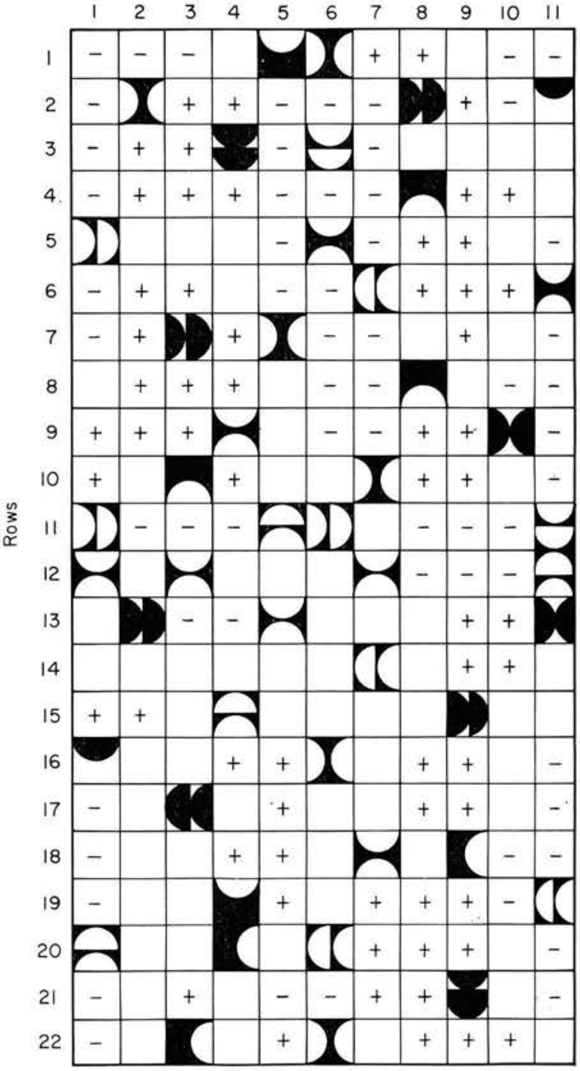

Fig. 3. The placement of initial elements and the assignment of color density ratings supplied among the instructions to the computer for the painting 'Black-white Structure' (cf. Fig. 4).

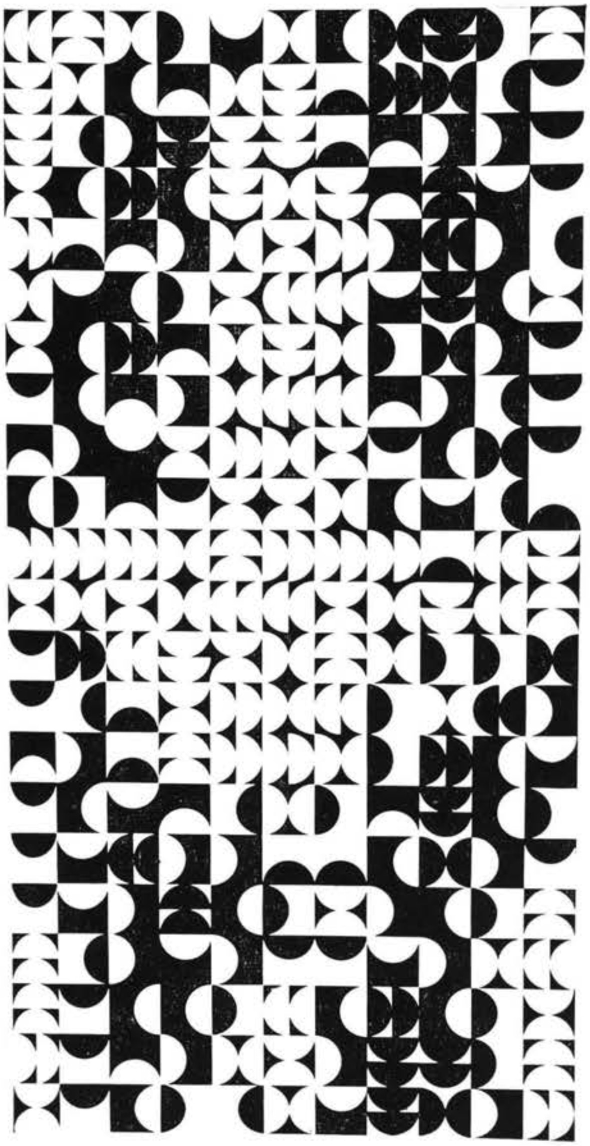

Fig. 4. *'Black-white Structure', oil on canvas,* 220 × 110 cm, 1966 (*cf. Figs.* 2 *and* 3 *and Table* 1).

element. We say that the *shapes continue* at the side of an element if each half circle open to a side joins a half circle of a bordering element to form a complete circle or if two patterns join, neither of which is a half circle open to a side. Thus, for the joining pair 2y–3r, where 3r is on the right side, the color continues at their common border but the shape does not. For the pair 2y–1r, the color does not continue but the shape does. For 2z–4d, both the color and the shape continue.

The rules have been formulated as follows:

Rule 0: Both the color and the shape at the side of an element continue across the side common to another element.

Rule 1: The color at the side of an element continues across the side common to another element but the shape does not.

Rule 2: The color at the side of an element does not continue across the side common to another element but the shape does.

Rule 3: Neither the color nor the shape at the side of an element continues across the side common to another element.

In the application of any one of these rules the condition of color is decided before that of shape. Four additional rules could be added for the situation where shape is treated first.

The given elements (cf. Fig. 2), the initial diagram (cf. Fig. 3), the density coefficient ($c = 0{\cdot}75$) and the selected rule (in this case, Rule 2) together state the problem that is presented to the computer. The computer starts with the element in the top left corner and proceeds to the right, each time deciding which element to employ. The second row is started at the right and ended at the left. Thus the rows are calculated in sequence until the bottom row is reached. The results of the complete computation are shown in Table 1. Those elements chosen initially are underlined. The final painting based on the information in Table 1 is presented in Fig. 4.

The determination of an element can be illustrated simply. The element at the position represented by row 1, column 8 (or 1:8) is typical. In such a case, the preceding positions 1:1, 1:2, 1:3, 1:4 and 1:7 were calculated previously and positions 1:5 and 1:6 had been assigned. The determination of the color density is based on an averaging procedure, employing the known color densities (assigned or calculated) of all elements whose sides or corners touch. The neighboring positions of 1:8 are 1:7 (containing an element of group 3), 1:9 (still undetermined), 2:9 (still undetermined), 2:8 (containing an element of group 4) and 2:7 (still undetermined). The average of the two known color densities is 3·5 (i.e. $(3 + 4)/2 = 3{\cdot}5$). Since the + mark at 1:8 signifies an increase in color density by the amount 0·75, the value calculated for 1:8 is 4·25 (i.e. $3{\cdot}5 + 0{\cdot}75 = 4{\cdot}25$). As the color densities are given only in whole numbers (in our present case by the numbers 1, 2, 3 and 4 (cf. Fig. 2)), the closest value is chosen, i.e. 4.

Now the computer must decide which element of group 4 should be placed at 1:8. Following Rule 2, the computer must first find all elements of group 4, for which the colors would not continue across the side common to another element, i.e. elements of group 4 which have both the left and the lower sides black. But this is impossible; therefore the computer must seek all elements which satisfy only one of these conditions, that is, 4z, 4b, 4r and 4d. Then the computer chooses from these four elements all those for which the shapes do continue across the border, that is, those which have a half circle opening on the left side but which do not have a half circle opening on the lower side, namely, 4z and 4r. The computer decides between these two elements by a random process, like the flip of a coin. Thus element 4r is selected.

The element for position 1:9 is determined next. In this case, the average is computed from the known values: 4 at 1:8 (not 4·25) and 4 at 2:8; therefore the average is 4. After applying the first part of Rule

TABLE 1. COMPUTER RESULTS*

Columns

Rows	1	2	3	4	5	6	7	8	9	10	11
1	1y	1b	1r	2z	<u>3r</u>	<u>1r</u>	3y	4r	4i	2z	1b
2	1i	<u>1r</u>	3y	3b	1r	1i	2b	<u>4z</u>	4r	2y	<u>2r</u>
3	1i	2y	3z	<u>4i</u>	1i	<u>1i</u>	2b	3b	3z	3z	2r
4	1d	3y	4z	3y	1i	1r	1i	<u>3b</u>	4b	3r	2r
5	<u>1z</u>	2b	3b	3z	1r	<u>1d</u>	1z	3z	4y	3z	2y
6	1r	3r	3y	2z	1d	1y	<u>1y</u>	3r	4i	3y	<u>1d</u>
7	1d	3y	<u>4z</u>	3b	<u>1r</u>	1i	1r	2z	4r	3z	2r
8	2r	3y	3b	3z	1r	1y	1y	<u>3b</u>	3z	2y	2r
9	3b	3z	3r	<u>1d</u>	1z	1r	1d	2r	3y	<u>4r</u>	2r
10	3y	2z	<u>3b</u>	2r	1d	1d	<u>1r</u>	3y	3r	2y	2b
11	<u>1z</u>	1z	1z	1r	<u>1b</u>	<u>1z</u>	1z	1z	2b	1y	<u>1i</u>
12	<u>1d</u>	1r	<u>1d</u>	1r	1y	1y	<u>1d</u>	1r	1i	1y	<u>1b</u>
13	2r	<u>4z</u>	1y	1i	<u>1d</u>	1r	1b	1r	2z	2z	<u>4r</u>
14	2r	2y	2b	1d	1z	1r	<u>1y</u>	2z	1r	4y	3z
15	3b	3y	2b	<u>1b</u>	1z	1z	1r	2z	<u>4z</u>	3y	3r
16	<u>2r</u>	3y	3r	3b	2y	<u>1r</u>	2z	3b	4i	3y	2z
17	<u>2r</u>	3r	<u>4y</u>	3z	3z	2b	2b	3y	4r	3z	2r
18	2r	3r	3z	4b	3y	2z	<u>1d</u>	3z	<u>3y</u>	2z	1b
19	1b	2y	3z	3r	3z	2r	2r	3r	3z	1r	1y
20	1b	2r	3y	3y	2z	<u>1y</u>	3y	4z	3y	2z	1d
21	1z	2r	3b	3z	1r	1d	3z	4i	<u>4i</u>	2z	1b
22	1d	2r	<u>3y</u>	2z	2y	1r	3r	4i	4r	3z	1z

*(Based on Rule 2, Coefficient $c = 0{\cdot}75$ and Fig. 3). Underlined numbers refer to the initial elements.

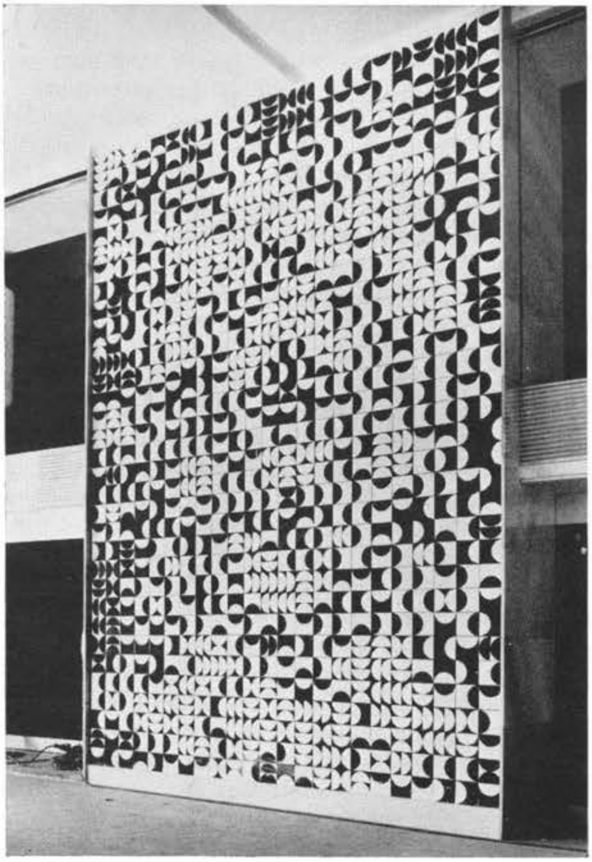

Fig. 5. 'Black-white Structure', ceramic, 530 × 350 cm, 1969.

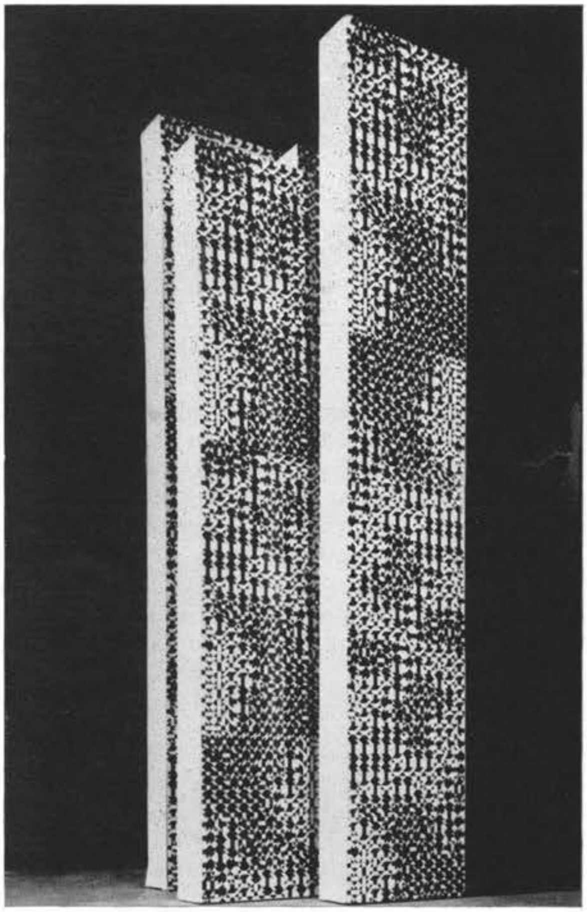

Fig. 6. Model, in glass mosaic, of 20 m *high ventilating towers for a tunnel in Prague.* Josef Koles, architect.

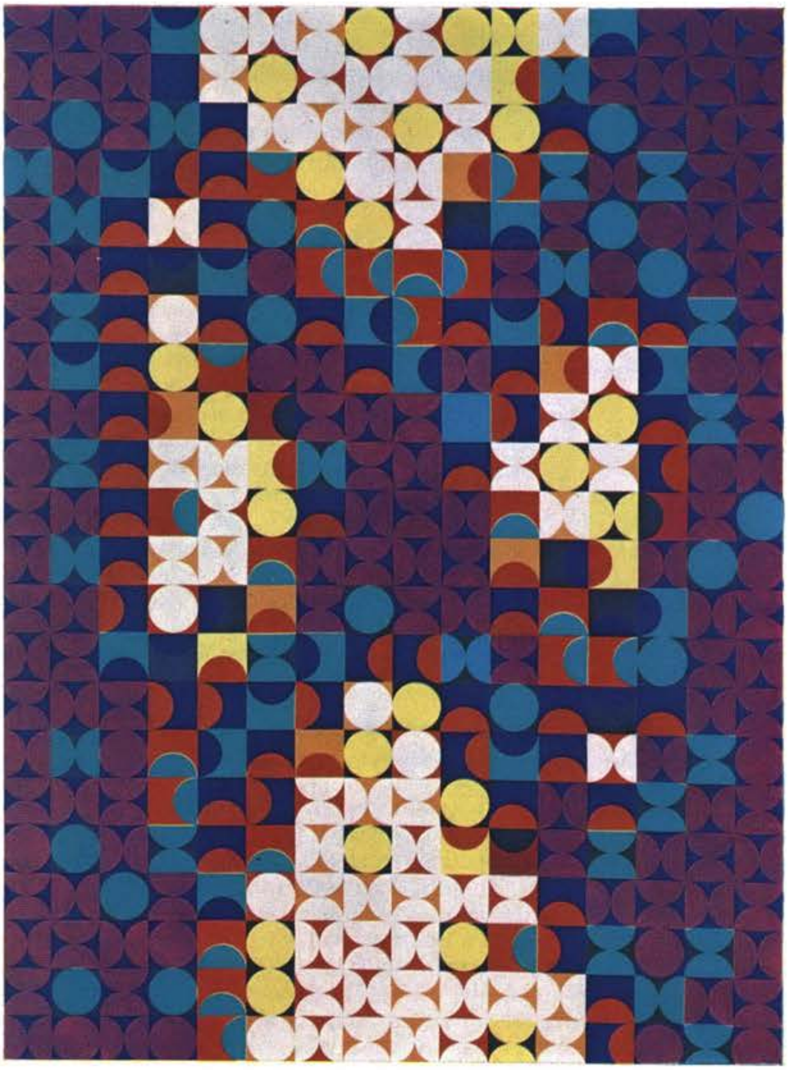

Fig. 7. *'Multi-colored Structure'*, *oil on canvas*, 200 × 160 cm, 1969.

2 'the color . . . does not continue . . .' (that is, the left side is white) the elements 4b, 4y, 4i and 4d remain and elements 4z and 4r are eliminated. Then the second part of Rule 2 '. . . the shape does (continue)' is applied. It is clear, however, that in this instance the application of the shape restriction does not lead to any further selection, because *all* elements 4b, 4y, 4i and 4d are eliminated. Therefore, the random procedure is applied to these four elements and element 4i is used.

It is clear that a different picture results if there are changes in the initial diagram or in the density coefficient or if a different rule is employed. The procedure for large paintings has been to place the initial elements at intervals of four in each row, displacing them systematically in succeeding rows. Examples of using this procedure are shown in Figures 5 and 6. In the case of the smaller paintings, a less arbitrary procedure for the placement of initial elements and density ratings is followed in order to produce specific desired effects in various parts of the composition (cf. Figs. 3 and 4 and Table 1).

Multi-colored paintings can also be designed with the aid of the same computer (cf. Fig. 7). To accomplish this, we use the computer program twice. The first calculation is done to establish the geometrical pattern, in black-and-white, as above. Then, in preparation for the second calculation, we tabulate in groups a series of color pairs (for example: white–orange, white–red, red–green, etc.). This tabulation of color pairs is analogous to the tabulation of elements in Fig. 2. We also must decide on a rule to be followed.

Finally the results of the two calculations are combined. For example, if for a given position both the element 2z and the color pair red–green are selected by the computer, then the semi-circular area of 2z is made green and the remaining portion red.

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Tableaux abstraits géométriques, composés à l'aide de plusieurs éléments et réalisés grace à un ordinateur

Résumé—Dans la première partie de cet article, celui des deux auteurs qui est l'artiste décrit certains des tableaux qu'il a faits depuis 1961, dans lesquels la composition résulte de l'usage répété d'un ou de plusieurs éléments de base. Ces éléments se caractérisent par leur forme unique, carrée ou rectangulaire, et par leur arrangement intérieur spécifique, associés à une disposition des couleurs variable. Les possibilités combinatoires complexes de ces éléments l'ont conduit à utiliser un ordinateur.

Le mathématicien a préparé, quant à lui, le programme destiné au petit ordinateur LGP-30, fabriqué par l'Eurocomp GMBH, Minden, Westphalie, en République Fédérale d'Allemagne. Dans la seconde partie de cet article, il donne les renseignements fondamentaux nécessaires à la préparation des programmes fournis à un ordinateur pour composer des tableaux abstraits géométriques comprenant plusieurs éléments.

A l'appui de ces explications, on peut voir des exemples de tableaux, en noir et blanc et en couleurs, qui font usage de tels programmes.