Orphics: Computer Graphics and the Shaping of Time with Color

Edward Zajec

ABSTRACT

In view of the unprecedented control and flexibility now offered by computers, the author discusses ideas and techniques for the fluid articulation of color in time and illustrates his concepts with recent work. Parallels with music and mathematics (fractals) are discussed concerning such musical practices as modulation and thematic transformation. The nature of dividual as opposed to individual forms is considered from the point of view of color dynamics and dimensional upgrades. Parallels with music and film are made concerning the nature of thematic dissolves. The emergence of a hypothetical language of light and sound (Orphics) is envisioned.

This paper is mainly about asking questions, not only in the narrower sense of exploring the computer as an image generator, but also in a wider context concerning the art-technology intersection seen as a field open to experiment for new codes of communication. I present some workable ideas and techniques for the fluid articulation of color and form in time. The focus is not on the choreography of objects in motion (animation), but rather on those as yet ambiguous transitional states where the individual becomes dividual, dimensions interpenetrate, motives dissolve into patterns, and the geometric blends with the organic. Some of these techniques, such as the idea of dimensional upgrades, relate to the visual fine arts and mathematics; others, like the ideas of thematic dissolves and transformations, straddle the media of music and film. The various subjects are illustrated by my discussion of a completed work titled *Chromas* and some newer developments. Overall, the main intention behind this work was to outline and perhaps formulate some codes for a hypothetical language of light and sound (Orphics).

THEMATIC TRANSFORMATION

The actual unfolding of the images in *Chromas* is based on the rhythms and sounds of *Seconda Sonata,* a composition for piano by Giampaolo Coral [1]. Coral is one of the few contemporary Italian composers who looked to the Vienna Schooi as a model, rather than upon the Italian or French musical traditions. However, as he is also an admirer of Pierre Boulez [2], one could say that at least in part Coral's music takes sight of Vienna through French eyes.

The structure of *Seconda Sonata* is summarized briefly as follows. The first part, which has an indication of "Mosso Nervoso", besides being a complete exposition of the serial space in its sequential and textural extensions, also embodies the rhythmic and thematic blueprint for the remaining three parts of the sonata. The second part, with a "Con Grande Liberta" indication, initially comes very close to tonality in its sonorities. It starts out softly while simultaneously building a tension which climaxes several times in a very dramatic conflagration of iterative chords. The third part, which has the indication of "Vivacissimo, Scherzando", is again an outline of the serial material, but this time given in a relentless succession of rising and descending contrapuntal arpeggios. The indication of "Mosso Frenetico" already hints at the character of the fourth part, which manages to retain a crisp exactness of pitch in spite of its extreme rhythmic complexity. Complexively, Coral's *Seconda Sonata* amply fulfills Schoenberg's [3] and Webern's [4] principal concern of deriving a whole composition from one central unifying idea.

This power to develop and manipulate a theme in time has no parallel in the visual arts. *Chromas* is an attempt to tackle this problem in terms of color and form. It opens with a simple motive, a set of crossed rays (Fig. 1, top row)—this motive is a variation of a Paul Klee watercolor titled *Eros* (1923)—and develops through a continuous thematic, chromatic and rhythmic reinterpretation of this central idea. The forming principle behind this development is not shape animation but thematic transformation. This approach is radically different from traditional animation—first, because the action is shaped in real time and, second, because the action no longer consists of figures moving on a background but of color motives fluidly dissolving into their constituent components and reappearing in different configurations. In this context, to animate means to orchestrate the flow of color passages in time, rather than to choreograph the motions of objects in space.

IMAGE FORMATION

The system underlying *Chromas* consists of two parts: a drawing part in which a static composition (plate) is organized and displayed on the screen, and a dynamic part in which a composition is performed in a complex of color changes.

The important features regarding the drawing part relate to the nature of the plates, which are composite and organized by level. They are composite in the sense that each plate consists of two juxtaposed images (transparencies). It is possible to display two transparencies concurrently on the screen and to layer and unlayer them in different modes (and, or, xor). They are organized by level, in the sense that the color coding of each transparency allows two levels of control. On the micro level, the elements are recursively configured on a diamond lattice according to a given series of 16 colors. On the macro level the elements are organized to display either the main theme or two variations: a moebius strip and a diamond (Fig. 1, top row). Changing the

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series provides different chromatic or intervallic interpretations of the same transparency on a micro level (Fig. 1, columns 1 and 3), just as the overlay of different pairs of transparencies, for instance, the rays with the moebius or the moebius with the diamonds, provides thematic variations on a macro level (Fig. 2).

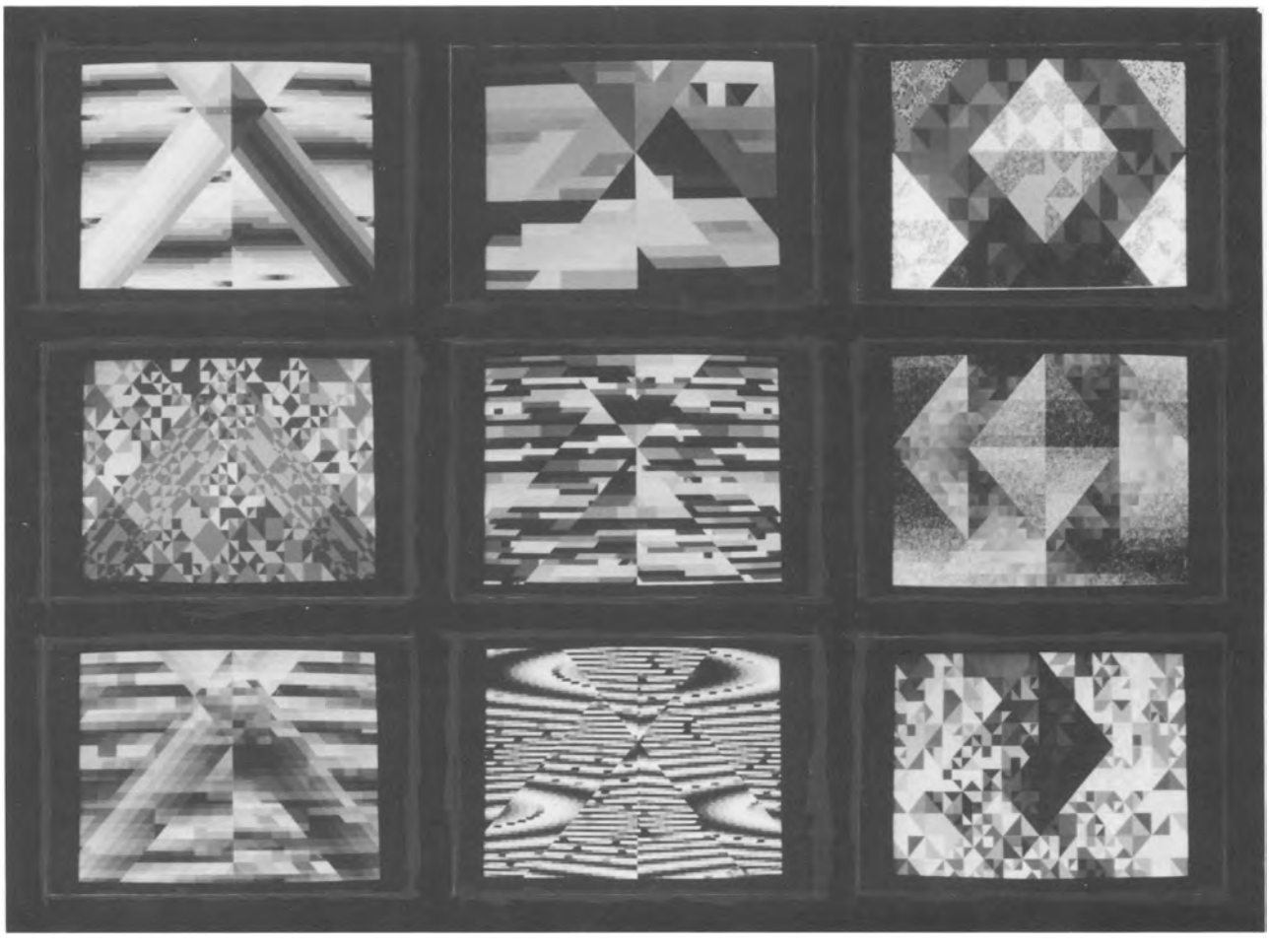
In more recent work I have been experimenting by juxtaposing fractal [5] configurations on the uniform lattice transparencies. By way of the midpoint displacement algorithm [6] it is possible to calculate a random fractal surface [7] with a relatively small amount of computation. The method consists of recursive subdivisions of a given surface, adding random irregularities at smaller and smaller scales. The resulting surface can be presented in a volumetric projection and shaded using the 16 colors of the aforementioned series (Fig. 3), or it can be flattened to the plane by viewing it from a zenith position, in which case it can function as a transparency, featuring a distinctly unique micro element configuration. (Fig. 4)

The introduction of random fractal surfaces opens up a new domain and a rich source of thematic variation possibilities. A point of note here is that the fractal midpoint displacement method causes artifacts in the form of creases along grid lines. These defects are particularly noticeable in Fig. 4, where they appear in the form of marked vertical and horizontal discontinuities in texture and gradient. Artifacts are probably most annoying to someone striving for a naturalistic surface effect, but they are a welcome feature in my work. Their gridlike character provides a common link between the fractal and Euclidean geometries, as can be seen from the overlay in Fig. 5.

There are prominent examples in twentieth-century art of such attempts at bridging the natural with the geometric. A few painters in particular made a concentrated effort towards resolving this dichotomy. Paul Klee's entire pictorial opus as well as his theoretical writings [8] testify to this concern. M. C. Escher's mastery of molding what are otherwise organic forms into subtle geometric tessellations is well known [9]. Perhaps less known, but becoming increasingly more relevant, are Pavel Filonov's dense, magmatic compositions, where the larger, naturalistic forms are simultaneously structured and atomized by a relentless swirl of suprematist-inspired microforms [10, 11].

Similarly, with fractals we now have a means of visualizing nature's more complex phenomena and, more importantly, the possibility of visualizing the morphological rules shaping these phenomena. By choice, we can visualize just these rules in themselves without necessarily intending to simulate or emulate a natural object. This is the point where the two geometries meet and can interplay with the greatest freedom. Furthermore, by blurring the distinction between figure and background and by opting for color

Fig. 1. Nine plates are shown from a computer-generated work titled *Chromas*. The whole composition, lasting 20 minutes, is derived from one central theme: a set of crossed rays and two variations (top row). The individual form (theme) is shown in different chromatic and intervallic arrangements in the first and third columns. The upgrade of elementary units into larger units is shown in the central column. The theme can be seen as an individual form if taken as a composition of shapes, or as a dividual, variable entity if considered in its color breakdown (any of the nine plates).



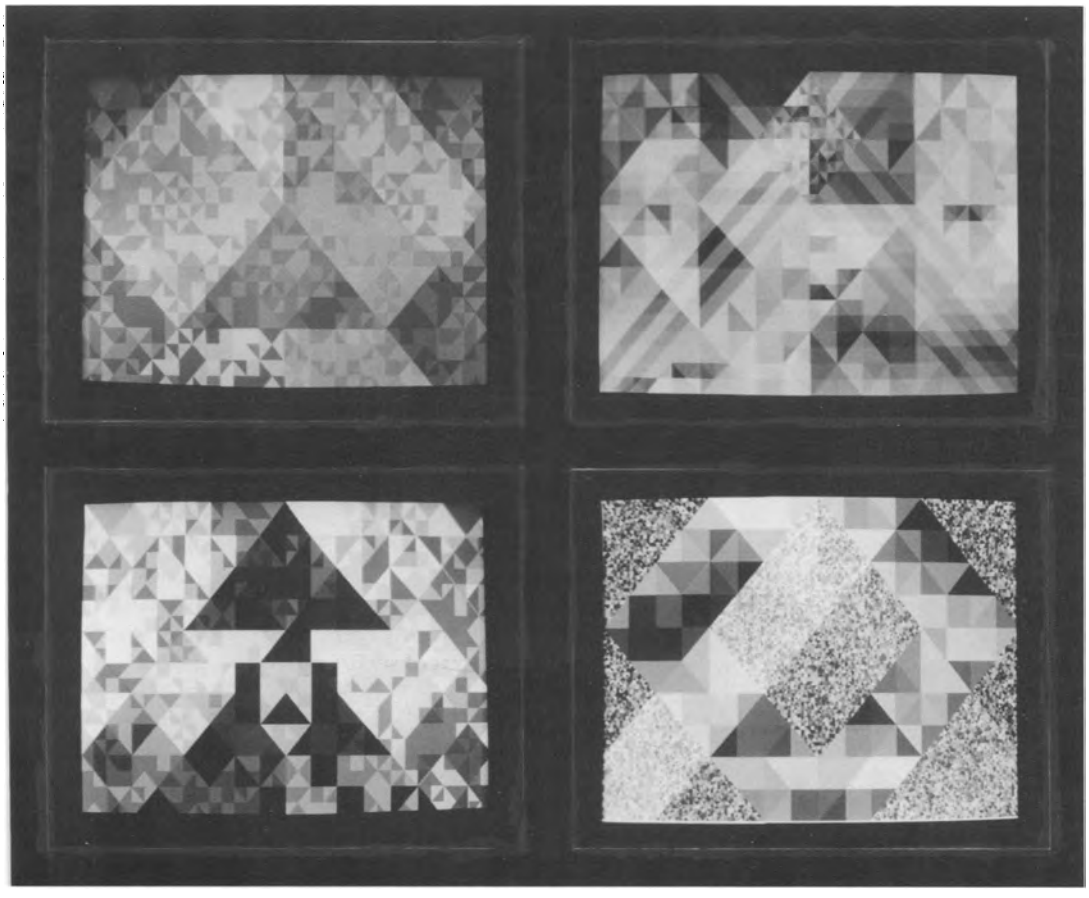


Fig. 2. Variations on an individual (theme) level are illustrated. Each of the four plates consists of a juxtaposition of two different transparencies. The transparencies can be intertwined in theme and in color, providing unlimited variation and development possibilities.

progression as a forming principle, it becomes possible to orchestrate large numbers of elements, each of which can be individually controlled like the notes in a musical composition. This is where the computer becomes essential by providing the speed and control needed to process and interrelate very large quantities of information.

DIMENSIONAL UPGRADES

The concept of dimensional upgrade bears some analogy to polyphony in music. It implies a transition from one voice, for instance a linear entity such as a series of colors, to many voices—that is, the extension of the series to the visual plane. What matters is having some rules to ensure that a particular series retains its signature, its unique progression of colors, not only in linear form but in a planar setting as well [12]. By using these rules in a recursive fashion it is possible to project a particular series on the plane at any desired upgrade level. Thus a dimensional upgrade does not involve spatial transformations such as the projection of an object from a planar to a volumetric dimension, but provides a structural framework for related changes in magnitude as well as in organization.

Contemplating such possibilities of controlled action and duration on the plane is evidence of the meagerness of our color-structuring principles in comparison to music. While the spatial aspects of color dimensionality have been codified systematically, the temporal aspects of color remain almost completely uncharted. In traditional animation, for instance, synchrony of action is determined by the unfolding story line. Beyond this, the objects follow their individual trajectories, bound in color and shape only by the constraints of naturalistic representation. In other art forms such as dance or ballet, synchronized movement does assume a prominent role. Nevertheless, color remains of marginal importance and it is not intrinsic to the action. Only in some festive or ceremonial situations, when huge crowds are gathered, can we see synchrony of action unfolding in terms of color, for instance, when one section of the performing ensemble in a stadium simultaneously displays one or another side of its multi-color uniforms. Note that each of the cited examples involves the human figure in action. It should be clear by now that the dichotomy here is not abstract versus realistic, or even two-dimensional versus three-dimensional, but dividual versus individual forms. This central antithesis starts with Cézanne, but it was systematically (and yet poetically) outlined for the first time by Klee in his theoretical writings:

> The question as to whether a thing is dividual or individual is decided by the criterion of indefinite extension or definite measure. For where there is indefinite extension, arbitrary division can be made without changing the structural style. But where an individual has definite measure, nothing can be added or subtracted without changing it into another individual [13].

He follows with a concrete example:

> For example, the fish seen as an individual, breaks down into head, body, tail, and fins. Seen dividually it breaks down into scales and the structure of the fins. The individual proportion is determined by the relation between head, body, tail and fins and can not be essentially changed; in any case, nothing can be omitted. A few scales may be missing from the body, but we cannot do without the head, the eye, or any of the fins. The dividual structure of this fish is variable in so far as it matters much less whether it has 330 or 350 scales than whether or not it has a head. Thus the distinction between dividual and individual involves a value judgment. But is the

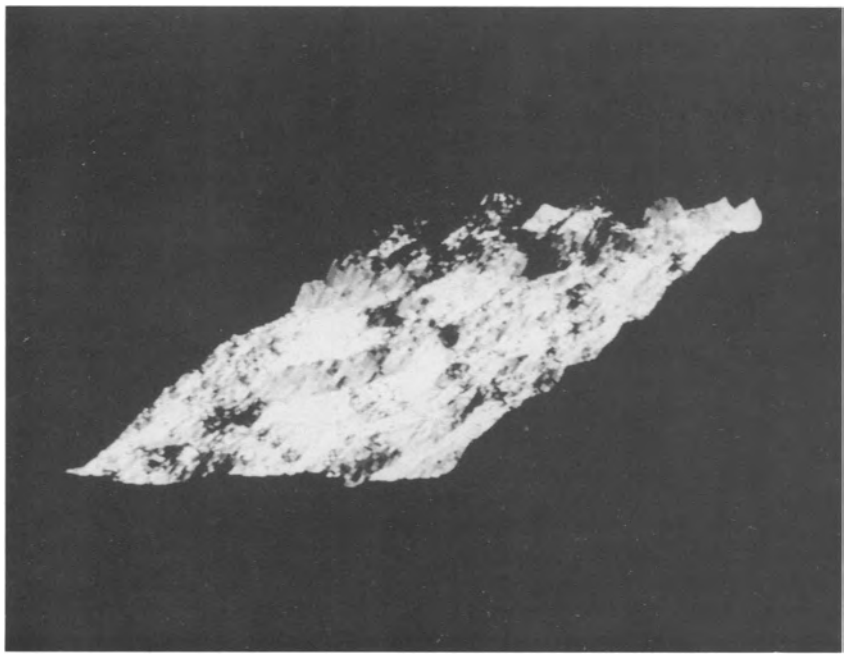


Fig. 3. Computer-generated image showing a volumetric projection of a shaded random fractal surface.

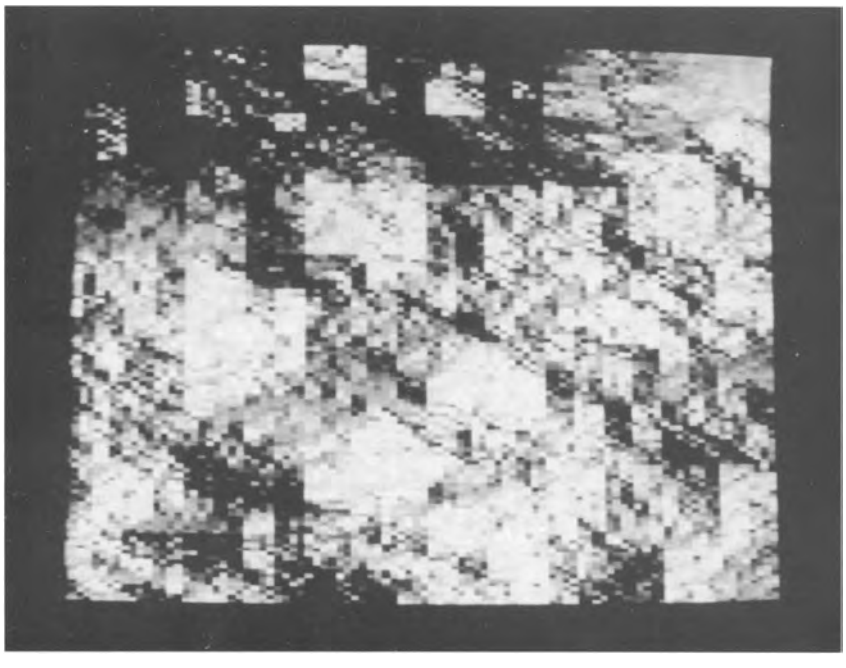


Fig. 4. The same surface used in Fig. 3, flattened to the plane and seen as a transparency featuring a unique microcomponent configuration.

> fish always an individual? No, not when it occurs in large numbers, not when "it's teeming with fish", as the saying goes. The concepts lower (or dividual) and higher (or individual) are not absolute but mutually dependent; when I broaden the conceptual field, I create a higher perceptible whole. It is good that in the course of time a certain elasticity has been achieved in regards to limits [14].

The beauty of the above passage lies in Klee's depth of insight for having resolved and unified such disparate and, in many ways, mutually exclusive concepts as measure, proportion and dimension, as well as the broader dichotomies of representation and non-representation under the wider concept of limit. When it comes to establishing limits, be it in art or science, it becomes a matter of choice, of 'value judgment' as Klee says, on how we look upon the world. These then are matters that go beyond mere perceptual or formal issues but involve a definite conceptual stance.

Dimensional upgrades fit into this picture as structuring devices determining the arrangement of elements in the formation of intermediate or higher dividual units (Fig. 1, column 2). For instance, expanding a musical motive consisting of a few notes into a phrase is a well-defined process in music. Nothing similar exists in a visual context. Besides, the very idea of a musical motive as a dynamic (dividual) nucleus charged with developmental potential stands sharply in contrast to a visual motive, which has been traditionally perceived as a fixed ornamental unit recurring at given intervals. In *Chromas*, dimensional upgrades are instrumental in the organization of the primary color constituents, the basic motive being a series of 16 colors. The main theme (Fig. 1, top row) can then be seen either as an individual form if taken as a composition of shapes, or as a dividual, variable entity if considered in its color breakdown.

I hope that the above discussion may contribute to clearing up some long-standing ambiguities regarding the role of color in some of the more established time-based art forms such as film, video and animation, as compared to the role of color in what I here call Orphics. In view of this and in light of the dividual-individual antithesis discussed above, I would venture to say that if color can assume the emotional-expressive prominence that sound has for music, we will have to learn how to shape time in terms of dividual rather than individual forms.

THEMATIC DISSOLVES

Thematic dissolves are based on the possibility of displaying two transparencies concurrently on the screen and of layering and unlayering them at will. Technically, a dissolve is an operation that allows a smooth transition from one digital image to another. The action proper is given by color mapping, a technique that allows altering the color of an image rather than the image itself [15]. For now, the advantage of color mapping is in the high speed of the action, which occurs in real time, meaning that the color changes can be seen immediately, at the same time the program is run.

The key to this layered ensemble in *Chromas* is the color climate (which is predominantly blue) and four sets of plates (six to twelve plates per set) to fit the parts of *Seconda Sonata*. Each set is matched with a distinct color atmosphere and has a unique visual texture congruent to the musical character of the part in question. The color vicissitudes for each part are played out in a basic juxtaposition of two 16-color series, one for each transparency forming a plate. The two series, in combination, group the microcomponents into various flow patterns and create rising or descending color sequences in different sections of the plate. Sometimes the microcomponents are grouped carefully and synchronized to highlight a particular section of a theme or to blur the same section into a shimmering textural mass, as is the case for certain passages in the first and second part of the sonata. At other times, the microcomponents are arranged so as to activate the whole screen, a situation that matches the relentless succession of arpeggios in the third part. Within this part the dissolves from one transparency to the other are not arrived at directly, but in a way that creates a tension between partial advances and partial recessions from each of the two transparencies. The frantic rhythm of the fourth part is visually reflected in a contrasted distribution of the microcomponents, which produces ascending sequences and immediate shifts in the opposite direction, changing intermittently from a rising to a falling motion.

The thematic character of the dissolves discussed above comes to light through the action of the underlying transparency weaving itself into the upper transparency's action (Color Plate B No. 2). The first transparency demands that the second be adjusted to suit it in color and design, and vice versa. Within this framework it is then possible to intertwine and unify different interlocking shapes that reveal hidden patterns as well as unexpected color harmonies that are not part of either transparency but surface only for the duration of a thematic dissolve (see Fig. 2)

The result of all this has similar although distinct precedents in two well-established art forms. The action of a thematic dissolve is in certain ways equivalent to the effect of a filmic dissolve where, given two scenes, we see one blending into the other. The same action is also a close visual parallel to the musical practice of modulation, where changes from key to key are accomplished smoothly, as a continuous process.

What distinguishes a thematic dissolve from both precedents is the nature of the visual flow and the duration of its enactment. Given the composite nature of the image and the separate micro-macro levels of control, it is possible, as shown above, to plan the two images in such a way that they intertwine in color and design to form a third image, visible only for the duration of the dissolve (see Fig. 2).

Furthermore, when one of the transparencies is a random fractal surface (see Fig. 5) the thematic interplay takes on completely novel dimensions that are particularly promising in a temporal context. The stochastic distribution of tones in a random surface creates a unique rhythmic entity, which is in subtle contrast to the rhythms of the more linear geometric progressions.

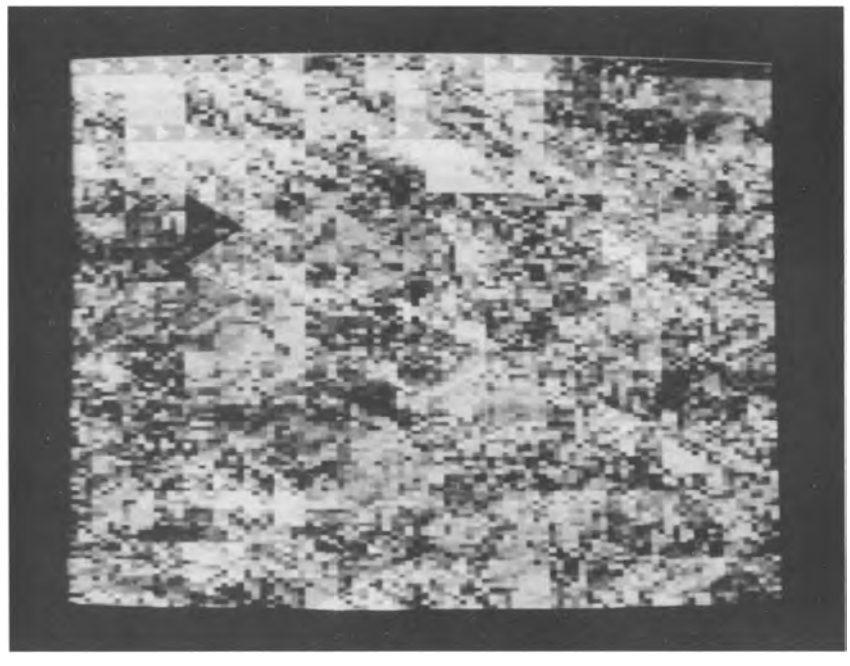
Thus the effect of a thematic dissolve merges both the filmic and the musical aspects into a single action, since the transition from one transparency to another involves structural changes that closely interrelate motive development with color modulation. In this sense, a thematic dissolve transcends the level of being a mere technique and becomes a new mode of visual communication, one that intrinsically merges the fluid qualities of sound with the radiant nature of light.

DISCUSSION AND CONCLUSION

Chromas' complexive duration is 20 minutes. It took 3 years to complete, from 1984 to 1987. Its present form leaves room for much improvement, partially because of the color distortion and the loss of resolution that occurs in transferring the images to videotape. Metaphorically, as it stands, *Chromas* is an elaborate study of an idea but not yet a finished picture. Nevertheless, I hope its worth will be judged not in terms of broadcast quality, but rather by the extent to which it might stand as a possible, even if archaic, model for the embodiment of a sound experience in visual terms.

Coral's *Seconda Sonata*, with its brilliant score, provided an excellent lead and at the same time a formidable challenge. By this I mean that the most difficult obstacle in shaping a color counterpart to *Seconda Sonata* was the disorienting lack of any frame of reference. Clearly, my intent was not to mimic the sound impulses one on one or to design a visual choreography to underscore the musical developments. I was looking for some kind of focus, a guiding principle on which to base an active autonomous visual line of development. I found it in the con-

Fig. 5. A plate showing an overlay of the random surface transparency (Fig. 4) with a regular, geometric transparency. The thematic interplay between the two images reveals new possibilities that are particularly promising in a temporal context.



cept-practice of thematic transformation. A central theme—being dividual—is built from the same color material as the smallest detail and set off in time and space in such a way that this kinship is immediately visible, closely relating the parts to the larger plan. Dimensional upgrades and thematic dissolves make sense only within this thematic perspective; indeed, they are ramifications of this basic idea. Furthermore, I strongly suspect that this type of composition is only possible in terms of dividual forms. My feeling is that a theory of dividual color-time articulation might prove to be that long-sought common ground bridging the two art forms and might provide the right focus in the ongoing search for new codes of visual communication.

This is implicitly a long-term development. We have much to learn from music, from the works of Klee, Filonov and others, and from some recent mathematical inventions, fractals in particular, but also from cellular automata and formal grammars. Obviously, this development is beyond the reach of any individual artist, and one that does not bear an immediate impact on the cultural and sociopolitical spheres, but only filters gradually into the information mainstream as new attitudes change existing conventions. With the computer we now have acquired the technical means to control time and light as music controls time and sound. In contrast to music, however, we do not have a theoretical body of rules and conventions that would allow us to communicate visual ideas unrelated to narrative and figurative representations within a temporal framework. What we do have, however, is a huge amount of experimental work attempting to bridge the sound-image-time relation [16], going back at least a few centuries, and which seems presently to be on the verge of reaching critical mass [17].

Clearly, a new art category is emerging. Efforts to name it or just to distinguish it from both traditional and computer animation have resulted in various names: abstract film [18, 19], vision in motion [20], audio-kinetic art [21], graphic music [22], color music [23], visual music [24], digital harmony [25] and, more recently, abstract dynamic visual art [26]. In seeking vividness of expression, musicians of all ages have alluded to the color of sound, as painters have told of the sound of color. Glancing backwards, I find that, for some reason or another, the name of Orpheus has been a frequent choice in indicating works tinged by metaphors of this kind. A good example, coming from the music side, is Stravinsky's and Balanchine's ballet *Orpheus*. On the opposite side, the French poet Apollinaire coined the term "Orphism" to celebrate the reappearance of color in a new art movement and in homage to Robert and Sonya Delaunay's pure color explosions in the otherwise-monochrome realm of abstract cubism. Following this tradition and in renewed homage to the ancient bard for having stolen the secrets of the gods, I here propose the appellation: Orphics [27].

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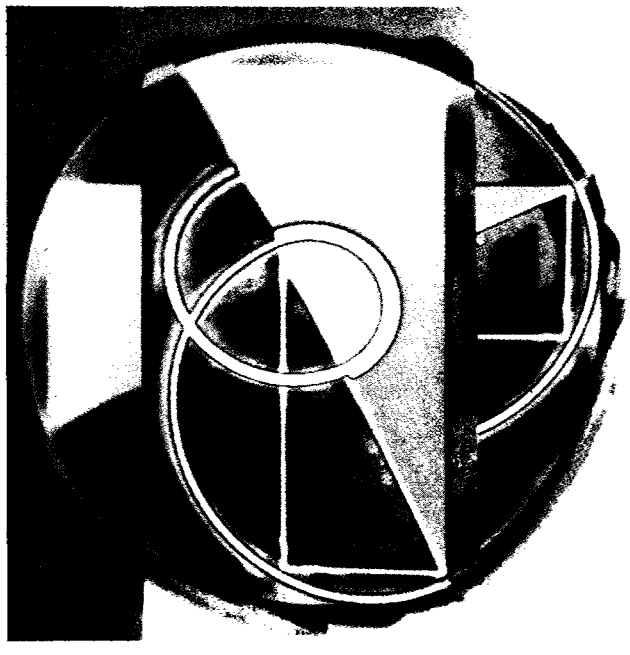
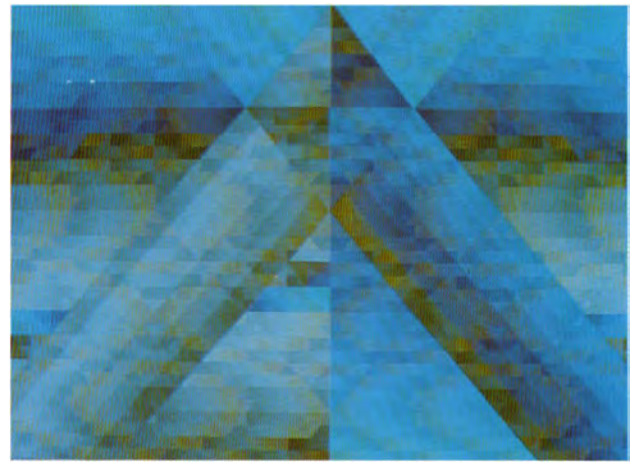
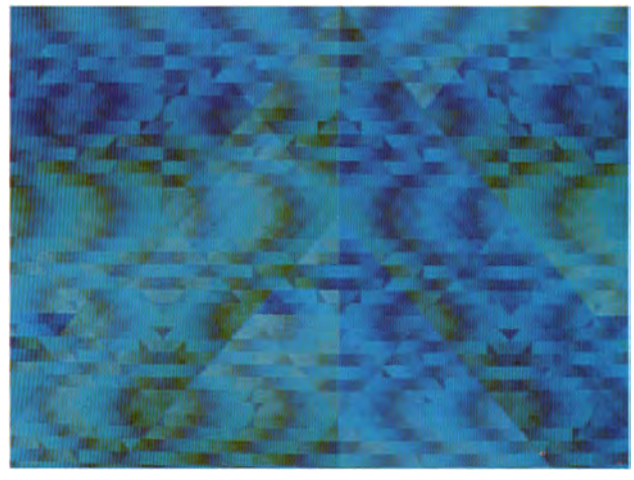
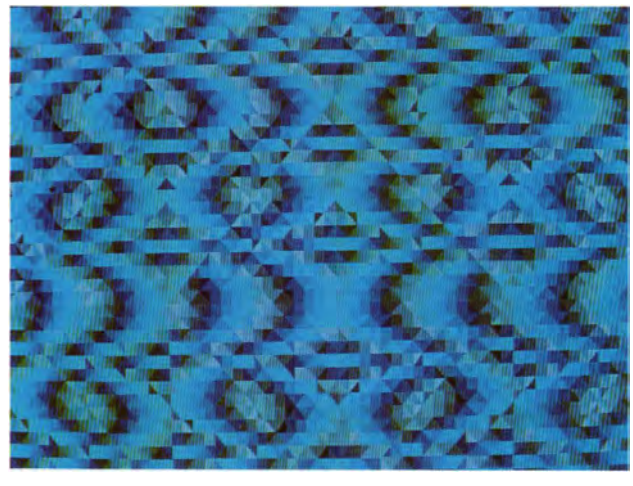
27. This proposition is a spin-off from discussions held at an ad hoc meeting on "Abstract Dynamic Art" held at the Industrial Research Institute in New York City on 20 November 1987. The meeting was organized by Hank Clauser in an attempt to bring together a number of interested people to confront and define the issues regarding a new visual art form variously indicated during the meeting as Visual Harmony, Motion Graphics, Abstract Dynamic Visual Art (ADVA), Dynamics Visual Music and Systematic Synthetic Moving Imagery. It was a useful beginning although no agreement was reached. The participants were musicians Warren Lehr and Reynold Weidenaar; computer scientists Ken Knowlton (also artist) and Herbert Maisel; visual artists Hank Clauser (also engineer), Larry Cuba, Jeffrey Horowitz, Margot Lovejoy, George Shortess (also psychologist), Bill Yarrington and Edward Zajec.









Color Plate B

No. 1. Left. John Pearson, (top) *Finale #3*, pastel and pencil on paper, 38 × 50 in, 1988; (bottom) *Fresnel Proposition: UNM Series #8*, electronic (digital) image and 35-mm slide, 1985.

No. 2. Right. Edward Zajec, (top to bottom) a thematic dissolve is shown. Two transparencies can be displayed concurrently on the screen and layered and unlayered at will. The thematic character of the dissolve comes to light when the action of the underlying transparency (the ray in this case) weaves itself into the upper transparency's action. Important here is the temporal nature of the dissolve, which involves structural changes that closely interrelate motive development with color modulation.