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"THEY HAVE ALL DREAMT OF THE MACHINES—AND NOW THE MACHINES HAVE ARRIVED"

New Tendencies—Computers and Visual
Research, Zagreb, 1968–1969

Margit Rosen

Many followers of the NT [New Tendencies] have tried to give their work the habit of the machine or else they have based their procedures on the use of mechanical or electrical devices; they have all dreamt of the machines—and now the machines have arrived. And they have arrived from a direction which was somewhat unexpected, and accompanied by people who were neither painters nor sculptors.
RADOSLAV PUTAR, ART CRITIC, 1970

The machines arriving on the Yugoslavian art scene in 1968 were of a specific kind. They were quite unlike the mechanical or electrical devices addressed so far in twentieth-century art. These were symbol-processing machines: computers. The organizers of *Tendencije 4*, the fourth exhibition and meeting of an international art movement called New Tendencies,[1] welcomed these machines and their human companions not as mere strangers, but as welcome and somehow expected visitors. Their arrival was staged as a logical piece of the development of New Tendencies since 1961.

As the opening statement demonstrates, Putar created a historical model, suggesting that the movement's different strands—which could be labeled more or less precisely by the terms concrete art, neo-constructivist art, op art, kinetic art, and *arte programmata*—had laid the groundwork for the introduction of the computer to the art world within the context of New Tendencies: the New Tendencies artists had all "dreamt of the machines."

In spring 1968, artists, writers, engineers, natural scientists, and humanities scholars from around the world were invited to present work under the unifying rubric "computers and visual research." Consistent with the New Tendencies' vision of "art as research," the computer was added not to establish a new style, but to introduce a new research tool. The mandate was to explore the new aesthetic and social horizons afforded by a machine that processed signs rather than manipulating physical matter. The New Tendencies exhibitions, publications, and conferences dedicated to computers and visual research represent a historically unique enterprise programmatically integrating the theory and practice of computing within an existing art movement, thereby effectively engaging the art world in the definition and implementation of a new technology that they believed would change the future.

ZAGREB, 1961–1963

In 1961, the first New Tendencies exhibition opened at the Gallery for Contemporary Art in Zagreb, then one of the primary centers of artistic life in Yugoslavia. The art world benefited from the specific political position of Yugoslavia as a nonaligned socialist nation belonging neither to the USA and its allies nor to the Soviet Union and the member states of the Warsaw Pact. The Yugoslav Communist Party had been expelled from the Cominform, the official forum of the international communist movement, on June 28, 1948, after Josip Broz Tito defied Joseph Stalin's leadership of the association. According to art critic Jerko Denegri, the Yugoslavian art system "functioned outside both the rigid ideological pressures prevalent in the countries of real socialism and the advantages and the demands of the art market in the countries of liberal capitalism."[2] The evolution of the art world in Yugoslavia mirrors its political history. A brief period of social realism after the Second World War was in the early 1950s gradually supplanted by a modernist visual language that was increasingly officially tolerated, ultimately becoming the representative form of a new political identity. The exhibition series of New Tendencies can be seen as paradigmatic of the successful diffusion of abstract art in Yugoslavia by major public institutions.

The idea for the first New Tendencies exhibition was born in the autumn of 1960, when the Brazilian artist and designer Almir Mavignier, then living in Germany, visited Zagreb. Mavignier, who had studied under Max Bill at the renowned German design academy Hochschule für Gestaltung Ulm, was introduced to the young art historian and critic Matko Meštrović in Zagreb. Both Mavignier and Meštrović were gravely disappointed by the 1960 Venice Biennale and agreed on the need to organize an exhibition that presented new tendencies that were not yet legitimated by established venues such as the Biennale. Meštrović

arranged an invitation for Mavignier from Božo Bek, the director of the Galleries of the City of Zagreb, to curate just such an exhibition.

When the exhibition *Nove tendencije* opened in August 1961 at the Gallery of Contemporary Art,[3] visitors could admire works in the tradition of concrete art.[4] Whereas a few artworks remained within the established traditions of easel painting, the majority of artifacts were characterized by the transgression of the boundaries between painting and sculpture. While Mavignier and François Morellet presented works which might be described as "programmed painting," artists such as Günther Uecker (Zero), Enrico Castellani, Gerhard von Graevenitz, and Rudolf Kämmer experimented with the light effects of monochrome surfaces. Toni Costa, for example, built structures that changed visually when the observer passed by, while other works were actually kinetic: Julio Le Parc's *Probabilité du noir égal au blanc n° 4* consisted of plastic mobiles that moved with the air in the gallery space, and Karl Gerstner's and Paul Talman's objects could be actively manipulated by visitors to the gallery. Other artists chose contemporary industrial materials: Marc Adrian, Heinz Mack, and Uli Pohl used aluminum, plastics, and glass. While not present in this first show, motor-driven objects would characterize later New Tendencies exhibitions. With this new variability of form, the artworks' relation to the observer was transformed. But the artists promoted a different concept of the creative process itself. The works exhibited defied romantic notions of artistic creation by implementing a strictly systematic or rule-based method. The artists of this exhibition and the following events were, with individual differences, unified in taking a self-consciously "rational" contraposition versus expressive art forms such as *tachisme, art informel,* and abstract expressionism, which still dominated the art scene in the early 1960s.

The first exhibition brought the young Western European avant-garde to Zagreb, revealing that like-minded artists from Germany, Italy, France, Switzerland, Argentina, Brazil, Austria, and Croatia were all following similar lines of inquiry independently. Though a number of the artists had been in contact before, the Croatian capital became a nexus for the formation of a movement, a group of artists and theorists who would exhibit together and strive to promote their common goals for years. Meštrović and Bek successfully launched an exhibition with an international group of not-yet-established artists in a public institution. Together with Putar, these savvy theorists embedded these artistic approaches into the Croatian context, associating them with activities in Czechoslovakia, Hungary, Poland, and the Soviet Union in the tense atmosphere of the Cold War.

After the first exhibition in Zagreb in 1961, a number of group exhibitions in Zagreb, Venice, Leverkusen (Germany), and Paris followed. Between 1961 and 1965, approximately 130 artists participated in the New Tendencies exhibitions, coming from Europe and North and South America. In 1965, in *Nova tendencija 3,* artists from both sides of the Iron Curtain participated for the first time: the American Anonima Group[5] as well as Dviženije[6] from the Soviet Union and a number of artists from Czechoslovakia, Hungary, and Poland. What had started as a platform for new developments in art quickly took the form of a movement that strove for coherence. Not surprisingly, factions developed and started to compete for influence. As a consequence, several artists were threatened with exclusion in 1963.[7] The increasing international success of several New Tendencies artists didn't improve the cohesion of the movement either. In 1965, a large number of them participated in the 1965 exhibition *The Responsive Eye* at the Museum of Modern Art in New York, an exhibition that triggered an international op art boom. This success, however, turned out to be a pyrrhic victory. The op art artifacts were consumed with glee as decorative objects, while the revolutionary claims of the artists were ignored. Marc Adrian commented laconically on the effects: "Second- and third-rate fashion decorators have usurped the forms of expression of NT and replicated them ruthlessly, but formally meaninglessly."[8] Indeed, op art motifs appropriated and applied to dresses, plates, and carpets did not seem to be linked to the artists' aspirations for a "larger spiritual movement that is directly connected with the general conversion of a humanistic world view and its ultimate secularization."[9]

A NEW SYMBIOSIS WITH MACHINES, 1965–1969

The crisis culminated in 1965. In August, after the opening of *Nova tendencija 3* in Zagreb, the participants met at Brezovica Castle near Zagreb to discuss the state of New Tendencies. They debated whether the concept of "art as research" as a way to overcome traditional modes of artistic creation was actually viable and whether new modes of production and distribution could resist the demands of the art market for unique originals and promotable stars. One of the speakers at the meeting was Abraham A. Moles, professor at Strasbourg University, who had in 1958 published his *Théorie de l'information et perception esthétique* (Information theory and aesthetic perception), an early work on information aesthetics. Though a discussion of the computer did not enter the minutes of the meeting,[10] it was presumably Moles who inspired the integration of the computer into the project of "visual research" in 1968. In his article "Cybernétique et œuvre d'art" (Cybernetics and the work of art), published in the *Nova tendencija 3* catalogue, Moles emphasized that society had to take the technological transformation of the human condition by information-processing machines seriously: they "are discretely conquering our world, that is to say, the world of our thoughts."[11] Moles's suggestion was one of several factors behind the Yugoslavian New Tendencies organizers' decision in December 1967 to embrace computing technology.[12] One member of the *Tendencije 4* organizational board, Boris Kelemen,

retrospectively identified three main causes, all related to the year 1965: (1) the "beginning of a crisis for NT"; (2) "the first exhibitions of 'computer art' were held (in January Georg Nees exhibited his works in Stuttgart, and three months later Bela Julesz and Michael Noll in New York)";[13] and (3) the participation of Moles in *Nova tendencija 3* and the publication of *Aesthetica* by German philosopher Max Bense in the same year.[14] Both of the latter factors revealed the establishment of information aesthetics as a theoretical basis for computer-aided artistic research.

In summary, the optimistic embrace of computing technology in 1967 by the Croatian organizers of *Tendencije 4* must be seen as a reaction to the crisis within the movement that culminated in 1965. Some of the central aims of the movement seemed to remain unattainable: to demystify the concept of art and artistic creation by a substantially rational approach that denied romanticism and subjectivism; to overcome individualism by collective work; to make art accessible to all social classes by applying industrial principles of reproduction; and to unmask the dominating influence of the art market. The strong forces of art commerce in Western Europe, in particular, appeared to undermine any radical change.[15] For these artists and theorists, the computer appeared as a manifestation of hope descending from the purified world of distant laboratories, untainted by art commerce and fashion. The computer was seen as a means to push artistic research beyond insidious aesthetic traditions and to resist the art market's rules.

The integration of computer technology promised to affect the movement's past and future: by demonstrating that New Tendencies' methods and aims had already been engaged with the foundations of the emerging field of artistic use of computing technology, the organizers legitimized their specific approach and activities before 1968. By engaging with the newest technology, they staked out their avant-garde status. The organizers decided to leap into "a new, lively, fruitful stage of symbiosis with machines."[16] Machines—more precisely, electrified kinetic artifacts—had indeed been present in their exhibitions since 1963, even though the electronic apparatuses had not been addressed on a theoretical level. In 1968, these machines of light and motion found their successors in machines that had yet to be liberated from the air-conditioned halls of computing centers. The computers remained hidden from the public; only their products entered the Zagreb gallery space in the form of graphics, films, texts, and drafts for sculptures.

THE COLLOQUY AND THE INFORMATIVE EXHIBITION, 1968

By the end of the spring of 1968, the Croatian New Tendencies organizers had systematically evaluated all available publications about computer art, computer

graphics, and information aesthetics. In April, the key figures in the development of the program—Božo Bek, director of the Galleries of the City of Zagreb, and Boris Kelemen, custodian of the Gallery of Primitive Art—sent letters to individuals, universities, corporations, and governmental research institutes around the world (and on both sides of the Iron Curtain) asking for information and contributions. From that moment forward, English superseded French, Italian, and German as the main language of communication within New Tendencies.

On August 3, 1968, one day after the beginning of Jasia Reichardt's watershed *Cybernetic Serendipity* exhibition at the Institute of Contemporary Arts in London, an international colloquium headed by Moles convened artists, theorists, and scientists from across Europe at the Centre for Culture and Information, Zagreb. Only two of the artists who had participated in former New Tendencies manifestations were demonstrably present at the colloquium to welcome the new arrivals and start the dialogue: the Italian artist Alberto Biasi and the Croatian architect Vjenceslav Richter. The Austrian artist Marc Adrian couldn't participate, and sent his contribution by mail. Present, however, were the initiators of the new program, the Zagreb-based theorists Bek, Kelemen, Meštrović, Putar, and, as moderator, Moles. Among the new participants were Kurd Alsleben, a German artist who had generated—together with his friend Cord Passow—drawings by means of an analog computer in 1960; Frieder Nake, the German mathematician who became involved in computer graphics in 1964; Herbert W. Franke, the Austrian physicist and author of science fiction novels who had realized aesthetic visualizations by the means of oscilloscopes in the mid-1950s; the Czech artist and theorist Jiří Valoch, who presented an exhibition with computer-generated drawings in Brno (Czechoslovakia) in February 1968; and a number of engineers and natural scientists from Zagreb. With their wide range of professional backgrounds, the new arrivals broadened the disciplinary expertise of New Tendencies to include computer science, physics, electrical engineering, and semiotics, to name a few. This diverse group of participants discussed the contents of the program "Computers and Visual Research," debated at length whether the computer was a creator or a tool, and assessed the possible roles of computing technology in social development. The accompanying small "informative exhibition" that opened on August 2 showed computer graphics and films by a select number of artists and scientists from Europe, the USA, and Japan next to "characteristic works" by New Tendencies representatives.[17]

THE SYMPOSIUM AND THE EXHIBITION, 1969

The 1968 colloquium provided the foundation for the May 1969 conference "Computers and Visual Research," which again united artistic and scientific researchers in Zagreb, this time at the Workers' University Moša Pijade. Among

the speakers were a number of artists and architects (Kurd Alsleben, Thomas Michael Stephens, Nancy Stephens, and John Brees Thogmartin from the Art Research Center, Kansas, Waldemar Cordeiro, Karl Gerstner, Leonardo Mosso, and Vjenceslav Richter), several engineers and natural scientists (Vladimir Bonačić, Herbert W. Franke, Alfred Grassl,[18] Zdenko Šternberg, Josef Hermann Stiegler, and Božo Težak), art critics, historians, and other humanities scholars (Jonathan Benthall, Umberto Eco, Vera Horvat-Pintarić, Grgo Gamulin, Josef Hlaváček, Želimir Koščević, Renzo Beltrame, and Silvio Ceccato), and, of course, Bek and Kelemen. The presented papers dealt with a broad scope of topics, such as a possible philosophy of visual research, social aspects of computer art, and the interrelation between today's research and the future of society.

The proceedings of both conferences were published in the multilingual journal *Bit International,* which was launched together with the new program and whose title was a combination of the terms *binary* and *digit,* signifying the smallest unit of information. *Bit International* became the key medium for international exchange on theoretical issues and practical projects concerning the new technology. In the spirit of the reformation of artistic practice, the editors emphasized the necessity of adopting the coordinated structure of scientific research and industrial production for the arts. The journal was conceived of as "an instrument of international cooperation in a field that is becoming daily less divisible into strict compartments. Individual and isolated activity is also becoming less efficient, and the results of efforts based on an organized division of work on all levels are becoming more important."[19] Until 1972, nine numbers of *Bit International* appeared in seven issues—*Bit* 5–6 and 8–9 were double issues—and covered diverse topics ranging from visual research by means of computers to design, concrete poetry, and television and culture.

The opening day of the conference was shared by the vernissage of the *Computers and Visual Research* exhibition at the Gallery of Contemporary Art Zagreb. In the exhibition, visitors wandered through a presentation of computer-generated drawings, paintings based on computer-generated paintings, and one object. Another exhibition, with works from the first three New Tendencies exhibitions and "examples of current research," opened the same evening at the Museum for Arts and Crafts: *Nove tendencije 4.* The two exhibitions were announced and promoted together, and both presented examples of "visual research." Shared promotion aside, a fifteen-minute walk between the two venues separated the works of constructive and kinetic art from those artifacts produced by the means of computers.

The manifestations and publications associated with these shows at the Gallery of Contemporary Art and the Museum for Arts and Crafts offer the researcher important traces of the endeavor to include computer technology in an existing artistic movement, even if it was more or less an effort of reanimation. It is important to emphasize that the continuity between the New Tendencies of concrete art, op art, and kinetics on the one hand and the new program on the other hand was maintained mainly by a small group of art historians, critics, and curators—Bek, Kelemen, Meštrović, Putar, and Moles—and by two artists, Ivan Picelj and Vjenceslav Richter, both former members of the group EXAT 51. Of all the artists who had taken part in the former exhibitions, only Marc Adrian, Zdeněk Sýkora, and Waldemar Cordeiro actually started to use computers for their artistic experiments and presented the results in Zagreb. However, it ought not to be overlooked that according to their own retrospective statements, Gerhard von Graevenitz and Alberto Biasi (Gruppo N) attempted—though unsuccessfully—to gain access to computing technology, that in one of his essays François Morellet recommended the use of "electronic brains,"[20] and that Karl Gerstner actually presented the model of a computer-controlled tower, the *Farb Zeit Turm* (Color Time Tower), in the 1969 *New Tendencies 4* exhibition.

New protagonists, primarily mathematicians, physicists, and computer scientists unfamiliar with the historical and aesthetic discourses of the artists, stepped onto the stage. The Italian Alberto Biasi criticized this radical change of cast. Frieder Nake, the trained mathematician and artist, countered his criticism laconically: "This seems to me to be a problem of the Tendencies. On the one hand artists do not really know anymore how to go on, on the other hand there are scientists who seek to enter the arts."[21]

ART AS RESEARCH, PROGRAMMING AS METHOD

The choice of the phrase "computers and visual research," as opposed to "computer art," signaled the retrospective acceptance of research as a defining principle within New Tendencies. In 1963, a number of members even had coined an additional name for the movement, undeniably under the strong influence of the Paris-based Groupe de Recherche d'Art Visuel (GRAV): Nouvelle Tendance—recherche continuelle (NTrc).[22] "We are," noted GRAV member François Morellet already in 1961, "at the eve of a revolution in the arts as great as the revolution in science. Therefore reason and the spirit of systematic research has to replace intuition and the individualist expression."[23]

Objectivity, transparency, and traceability of the scientific method promised a new ground for the development of artistic criteria. Some New Tendencies artists sought to explore the "objective psychophysical bases of the plastic phenomenon and visual perception"[24] and even considered developing a scientific "terminology" for the arts that would prevent "any error of interpretation."[25] Art was intended to become radically intersubjective, communicable, comprehensible, and reproducible, characteristics that are commonly attributed to the scientific experiment.

By strategically invoking scientific research, artists and theorists explicitly distanced their approach from the romantic notion of the artistic genius: collectives such as GRAV, the Milanese Gruppo T and Gruppo N, and the group MID, for instance, echoed collaborative practices of the laboratory. They thereby tested forms of knowledge production that conflicted deliberately with the demands of the art market for marketable stars. On the other hand, their commitment to scientific methods also promised an additional social legitimacy for the arts that borrowed from the authority and necessity of the natural and engineering sciences. Even so, the difficulties of the ideal of "artistic research" were already visible at the meeting in Brezovica in 1965. The Italian artist Enzo Mari critically noted that "eighty percent does not represent research at all, but rather only a mimicry of research or even its commercialization." And Davide Boriani from Gruppo T urged more humility: at that moment, artists were, as "far as pure scientific experimentation is concerned [...] not equal to the level attained by specialists."[26] Nevertheless, New Tendencies decided to pursue transnational, group-based work on computers and visual research. The "incentive for the formation of an international movement of researchers in the field of computers and visual research"[27] was founded at the colloquium of 1968.

For the New Tendencies artists, the computer was perceived as a tool intrinsically associated with the specifically methodic procedure of image production as linked to the rational construction of art: In the *Programme-Information PI-7*, the organizers underlined: "The works of artists belonging to the 'NT' in the sense of declaring the principles, have the character of programmed experiments."[28] Putar evoked the works of the Swiss artist and graphic designer Karl Gerstner, who had "spoke[n] about the programming of procedures" and "routine procedures of encoding of picture elements" already in the 1950s.[29] Gerstner not only produced manipulable objects, but inquired into the relation among design, programming, and artifact on a theoretical level in *Programme entwerfen* (*Designing Programs* [1963] 1964), which became a cult book in the European design scene.[30]

At the beginning of the 1960s, *programming* was a term that conveyed a generalized sense of modernity and future orientation. In the industrial context, programming promised the possibility of planning and controlling events and optimizing procedures. In the arts, the term referred to the planning of "projects," and to automata in general and not exclusively to computers. Artists and theorists applied the term to a number of overlapping circumstances: (1) the artist programs his work by restricting himself to the definition of certain rules and refrains from interfering in the following quasi-mechanical process of design and the physical production; (2) he or she would conceive serial works, which would confront the observer with an imaginary system, a program, that could never be totally realized physically; and (3) he or she would program an artifact supposed to be manipulated by accidental forces such as the wind in the gallery

space or the actions of the observer. The meaning of programming mentioned above first was formulated by Morellet in the 1962 essay "Pour une peinture expérimentale programmée" (In favor of an experimental programmed painting): "A real experiment," he wrote, should "be carried out based on controllable elements, whereby systematic progress would be made by following a program. The development of an experiment should happen all by itself almost over and above the programmer."[31] By this account, the artist-programmer mechanistically follows a rule once it has been established as the basis for a work. This was probably the intended sense of Putar's statement that many artists "have tried to give their work the habit of the machine."[32] The computer was perceived as a tool in service of a rigorously rational approach.

Some of this logic inhered in the mechanism of computing technology itself. The punch card– or punched tape–driven digital machine forced the programmer to laboriously formalize even the simplest procedures. The artist had to account for every move and, as a result of this procedural discipline, was subjected to a discipline that corresponded to the scientific aspirations of New Tendencies. As remarked upon by architect Vjenceslav Richter during the 1968 colloquy, this requirement would lead to the exclusion or selection of certain artists: those "unable even on completion to say a single word about their work, for saying it would almost amount to sacrilege. Those authors are left standing before the entrance to the computer era as a reminder of the past."[33] New Tendencies' analytical interest in the creative process was mirrored in the request to all authors to hand in flowcharts and programs, "quoting the random elements, the principle of work, the model applied, explanation of the model, the presence of intuition."[34] All works in the catalogue were accompanied by information about the program, the computer, the peripheral equipment, and the place of production. These documents were of central significance in the perception of these new kinds of artifacts since, as Karl Gerstner has remarked, they were consumed by taking "a detour via the intellect."[35] What actually could be seen on the walls was outshined by New Tendencies' interest in the method of creation, by the aura of the still expensive and exclusive auratic machines, and by the potential of an art to come.

Walking through the exhibition, the "visual," the inquiry into optical effects that was formally one of the central research fields of the New Tendencies, lost importance: with the arrival of the new tool and its then rather limited visual possibilities, New Tendencies focused its attention on its impact on the process of creation.

By the time the computer arrived, a number of New Tendencies members were already familiar with the "programming" of artworks by hand as well as through the use of mathematics. Would automatic processing of calculations and output via printers and plotters originate a new aesthetic quality? While the

artist Waldemar Cordeiro underlined the continuity—the use of computers simply represented "a technological difference, not a difference of method"[36] theorists such as Kelemen, Moles, and Jiří Valoch pointed out that, indeed, a new quality could be attained by the speed and exactitude of the computer. "Above all," noted Kelemen, "a computer can solve otherwise completely inaccessible complexities, and then enable the manipulation of those complexities in all possible ways. This fact is important for the expansion of the problem of visual research, and also for discovering dimensions as yet almost unknown."[37]

By emphasizing the notions of planning and programming, New Tendencies introduced concepts that shifted the emphasis from the traditional artwork to ideas and procedures, but without abandoning the object completely. Yet the value of the physical artwork was radically queried by the new protagonists of New Tendencies, many of whom were not trained in art studios and art history courses, but by hands-on experience with calculating machines: "[Leslie] Mezei and also Petar Milojević could not understand," wrote Frieder Nake in March 1969 to curator Boris Kelemen, "why the competition of t4 [Tendencije 4] is for 'objects' and not for 'programs,' and why nevertheless flow diagrams are requested. For this reason they decline to participate."[38] The opinion that "the artwork of computer art [is] the program" was also expressed by Herbert W. Franke.[39] And though the competition was announced in November 1968 with the statement that it referred "to works, and not to programs," Kelemen tried to appease the participants with his answer to Nake that the jury would take into account "the program to a higher degree than the work."[40] In the end, Mezei and Milojević took part in the competition and exhibition.

At this juncture, it ought to be mentioned that one aspect of the term programming was overlooked when organizers of New Tendencies created their genealogy, which was designed to link the artistic practices of the early years to the procedures of computer-generated arts: the creation of dynamic works that could be altered by the observer, or by other environmental forces. One exhibition closely related to New Tendencies addressed this approach paradigmatically, namely arte programmata, an exhibition organized in 1962 by Giorgio Soavi and Bruno Munari in the Olivetti showroom in Milan. The traveling exhibition comprised a range of "kinetic art, multiples and open works" and included many artists who had already been presented in the first New Tendencies exhibition or who would participate in the following shows: members of GRAV, Gruppo T and Gruppo N, Getulio Alviani, Enzo Mari, and Bruno Munari.[41] In his essay, Umberto Eco classified arte programmata as a special case of the "open work," as outlined in his book on form and the indeterminacy of contemporary poetics, Opera aperta (Open work, 1962).[42] Artists, wrote Eco, create "'fields of events' in which random processes can happen": "kinetic sculptures" or "mobile objects." Its quality "did not consist in its being an expression of a law whose basis remained immutable and intangible, but in a kind of 'propositional function' according to which it continually attempted the adventure of mutability, following determined lines of orientation."[43] Objects as described by Eco had been part of New Tendencies exhibitions since 1961. The "programmed" kinetic and manipulable works left their final form up to chance—to the environment or the observer. A visitor to the Nove tendencije 4 exhibition at the Museum for Arts and Crafts—a retrospective of New Tendencies and a survey of current research without computers—could manipulate the artworks or experience with his whole body spaces filled with light or the movement of lumino-kinetic installations. In these works, the artist's program was embedded in the artifact or the environment in such a manner as to necessitate an active role for the observer. Existing hierarchies composed of artist and observer were meant to be dismantled, and the observer liberated from the meek position of silently admiring the pseudo-sacral artwork: by playing with the artwork, he was supposed to discover the exterior world as something he could change.

In contrast, the same visitor walking through the parallel exhibition, Computers and Visual Research at the Gallery of Contemporary Arts, would look at drawings and paintings on the wall. In Computers and Visual Research, it wasn't the observer's influence on the procedure that finalized the outcome. Rather, pseudo-random generators within the machine made all "decisions" leading to the result: for example, the distribution of squares on a picture surface. This capacity, of course, qualified the computer as a medium for visual research: the pseudo-random generators unburdened the artist from making hundreds of little decisions and allowed liberated artists—now encumbered only by the slow speed of plotters and printers—to explore systematically and in depth different classes of forms. The observer, however, was excluded from physically taking part in this game of chance or witnessing the transformation of the artwork in time. This relation between observer and computer-related artwork actually mirrored the general state of technology. Computers allowing for real-time interaction were still not available. Yet a few participants in the Zagreb program Computers and Visual Research did transgress this technical horizon: Vladimir Bonačić's computer-controlled light panel DIN. GF100 permitted one, in principle, to start two programs and to stop the movement arbitrarily. Gustav Metzger presented the project proposal Five Screens with Computer, a public computer-controlled installation consisting of five walls consisting of 1,200 steel elements that would destroy themselves gracefully over the course of several years. "The program," explained Metzger, "can allow for variations due to spectator participation via the photo-electric effect. There can also be sections of the program where there are a series of random ejections determined by atmospheric conditions."[44] Herbert W. Franke envisioned a synthesis of computers and performance, a "visual, computer controlled improvisation" that included the public. It would have

been a performance in the spirit of the New Tendencies, as Franke underscored, in contrast to the artistic form of the "Happening," which contained mainly "destructive elements," the computer would provide "highly complex structures of order."[45]

Although these artists actually addressed the possibilities of creating computer-based artworks that allowed for viewer participation, the historical genealogy created by the organizers of *Tendencije 4* to legitimate the inclusion of the computer excluded this aspect of programming. The theorists did not see a direct relation between kinetic art and reactive computer-based works.

INFORMATION AESTHETICS

The integration of the computer into New Tendencies' visual research was accompanied by the proclamation of a new theoretical basis, information aesthetics, as represented by the French engineer and philosopher Abraham A. Moles and the German physicist and philosopher Max Bense.[46] Information aesthetics synthesized different approaches, all formulated by U.S. scientists—Claude Shannon's theory of information, George David Birkhoff's "Aesthetic Measure," Charles Sanders Pierce's semiotics, and Norbert Wiener's cybernetics. Information aesthetics was an all-embracing theory applicable to fine arts as well as to literature and music, to high and low art, and to fine and applied arts, providing the intellectual tools for a scientific aesthetic analysis of "objective," not "subjective," problems.[47] But this theory did not restrict itself to analysis. It also encouraged new forms of creative production: Moles published the *Erste Manifest der permutationellen Kunst* (First manifesto of permutational art) in 1962; Bense formulated his "generative aesthetics" in 1965.[48] Information aesthetics considered the computer to be a helpful tool first of analysis, and then of production.

The first number of *Bit International* was dedicated to "the theory of information and the new aesthetics" and presented texts by Moles and Bense. It was launched to set the tone of the discourse. In his introduction to Abraham A. Moles in this number, Matko Meštrović praised the curative impact of his specific mode of expression: "The language is technical and scientific: the words are terms, not expressions, the thoughts are formulas, not locutions. The scholar uncovers the artistic phenomenon and the myth of art ad nauseam, like a surgeon who knows how the human heart is made. Two articles in the same spirit produce a therapeutic effect."[49]

The New Tendencies sought to reform both the terminology and the models for the analysis of art in order to demystify it. Information aesthetics seemed to provide a scientific language adequate to these tasks.

THE COMPETITION, BONAČIĆ, AND THE EVOLUTION OF A FIGUREHEAD

The open call for the 1969 *Tendencije 4: Computers and Visual Research* exhibition asked for "works visualising plastic themes which derive from the elaboration of programs by means of analogue or digital computers or other such instrument."[50] Whether a work's final realization was done by mechanical means or by hand was of minor importance. The exhibition included several artists who calculated the parameters of the form, but painted, glued, or drew the final picture manually; these included Marc Adrian, Hiroshi Kawano, Zdeněk Sýkora, and Evan Harris Walker. "If there are [...] no automatic machines at our disposal at the moment, why should we be so purist and condemn that little part of handicraft at the end of the whole process?" asked Frieder Nake, who also thought about experimenting with different materials.[51]

The competition welcomed images from diverse contexts: drafts for industrial design as well as results of "any other exact researches in the field of mathematics, geometry, physics or other disciplines, having plastic character."[52] The resulting exhibition was meant to be a survey of contemporary developments. The chosen results should be paradigmatic for the future path, "the discovery of new methods of work and yet unknown aesthetic situations."[53] The jury consisted of Eco, Gerstner, Horvat-Pintarić, Kelemen, and Martin Krampen—a philosopher and semiotician, an artist and designer, a historian of art, an art critic and curator, and a psychologist and design theoretician.[54]

With regard to evaluating the artists' achievements in the realm of computer-aided visual research, the jury considered it necessary to emphasize the experimental nature of the task at hand: "In our opinion, in view of the experimental nature and completely open domain represented by the materials exhibited, criteria for judging the entries, e.g., aesthetic quality, complexity of programming, or mathematical ingenuity, cannot be established for the time being."[55] As computer-aided aesthetic research should suggest "new aesthetic parameters in the future," the jury refused "to submit such research to judgment in terms of traditional parameters." Its members pleaded for a plural perspective, which allowed them to consider the specific qualities of each single work, be it technical, scientific, economic, social, or aesthetic.

Two research laboratories that had a great impact on early computer graphics were lauded for the "best developed techniques and programming of visual phenomena."[56] These included scientists from Bell Research Laboratories in Murray Hill, New Jersey—Leon Harmon, Kenneth C. Knowlton, A. Michael Noll, and Manfred R. Schroeder—and the graphic designer William A. Fetter and his collaborators from Boeing Computer Graphics in Bellevue, Washington. Bell

FIGURE 5.1. *New Tendencies 4* installation: view of the meeting of the jury evaluating all works submitted to the exhibition, 1969. From left: Božo Bek, Biljana Tomic, Dalija Grün, Martin Krampen, Umberto Eco, Matko Meštrović, and Vladimir Bonačić. Photograph by Muzej Suvremene Umjetnosti Zagreb, Zagreb.

Research Laboratories had handed in visualizations of mathematical functions and computer-processed photographs; Boeing contributed wire-frame models of humans, airplanes, and landscapes. With these pictures (as well as works by Charles Csuri, Leslie Mezei, Jane Moon, and Kerry Strand), figurative imagery entered the *New Tendencies* exhibitions.

Three awards of equal ranking were announced. One was given to the theater piece *SYSPOT* by the Austrians Marc Adrian, Gottfried Schlemmer, and Horst Wegscheider. This story of a love triangle consisted of a computer-aided montage of text elements from popular journals. Although for financial reasons the piece was not staged in Zagreb, the jury saw in it the potential to reveal "new possibilities of visual happenings."[57] Another award went to the group Compos 68—Jan B. Bedaux, Jeroen Clausman, and Arthur Veen—from Utrecht, Netherlands. They designed the *Compos Hobby Box,* a multiple consisting of a computer-designed pattern, colored cardboards, and a needle that served as a tool to transfer the pattern onto the cardboards, which were then cut and mounted on a plane as

indicated. The project was praised by the jury for the "possibility of creating multiples as well as of the possibility of larger social application." The jury referred to a goal that had been central for the New Tendencies, especially for *Nova tendencija 3:*[58] the "serial, industrial production of art effects."[59] In each case, single unique works were rejected as cult objects and as functions of a fetishized commodity in the capitalist art market. It was believed that multiple, industrially produced objects could guarantee the "rapid socialization of material and spiritual values."[60] In this context, the *Compos Hobby Box* was perceived as a prototype for computer-generated multiples, each different from the other.

Arguably, the most profound impression on the competition jury was made by the young electrical engineer Vladimir Bonačić. Having received his Ph.D. for a dissertation on pattern recognition ("Pseudorandom Data Transformation in Associative Analysis by Computer") in 1968, Bonačić became the head of the Laboratory for Cybernetics at the Zagreb Institute Ruđer Bošković in November 1969. The institute was a center for advanced research in nuclear physics, electronics, chemistry, and biology. When the organizers of *Tendencije 4* visited the institute to build collaborations for their new program on computers and visual research, Bonačić involved himself with great enthusiasm. In 1969, he realized together with the artist Ivan Picelj the light object *t4:* it was a dynamic, spatial version of Picelj's poster for *Tendencije 4* in form of a programmed light panel. In the following years, the young engineer built his own artworks using the results of his scientific explorations.

As a researcher at the Institute Ruđer Bošković, working in the field of nuclear research, Bonačić inquired into the properties of pseudo-random transformers and generators that were based on Galois fields. Using digital computers as well as electronics he crafted himself, he focused on the Galois fields $GF(2^n)$ and used them to generate pseudo-random sequences of patterns of deliberate length. These patterns were represented as sound or as luminous spots on a screen. This procedure allowed him to determine whether any algebraic calculation resulted in patterns that could be clearly distinguished by the human observer, or in irrelevant, random distributions. For *Tendencije 4,* Bonačić submitted photographs of his oscilloscope that showed samples of these patterns, some directly stemming from his research, others produced specially for the exhibition.[61]

Perhaps the most impressive work presented by Bonačić in the *Tendencije 4* exhibition, however, was the "Dynamic Object" *DIN. GF100,* which consisted of a homemade screen made of 256 single, individually addressable light fields. The static distribution of colors to the different light fields was based on a particular Galois field pattern. The observer could watch the flashing lights representing the "behavior" of another Galois field function. A simple remote-control device allowed him to select and study patterns of personal relevance. Bonačić had simulated these specific processes first on the SDS-930 computer and then implemented

them in the electronic circuits of a control unit that emulated the sequences.[62] In 1969, Bonačić also realized his pattern generation methods on a permanent computer-controlled installation in public space, one of the first of its kind: on the façade of the department store Nama, on Kvaternik Square in Zagreb, he installed *DIN. PR18*, eighteen elements, each one composed of a five-by-three matrix of light cubes, controlled by a special-purpose hardwired program based on Galois fields computation.

The jury gave prominence to Bonačić's work, as they were fascinated by the harmony between mathematics and visualization and the important role that the visual played in the epistemological process of his scientific research.[63] His works were paradigmatic examples of the link between New Tendencies' lumino-kinetic tradition and *Computers and Visual Research*: time-based artifacts with "programmed event fields"[64] emitted light signals to the gallery space and into the night above Kvaternik Square.

THE ETHICAL DEBATE

The colloquium took place in August 1968, three months after the political upheavals in France. In June, student protests also erupted in Yugoslavia. But discussions during the *Tendencije 4* events in 1968–69 bear few traces of these developments, with the notable exception of a discussion of the role of technology in working conditions and the accumulation of power in highly industrialized capitalist societies. The technophilic dimensions of the New Tendencies in general, and *Computers and Visual Research* in particular, met with a certain criticism. Alberto Biasi, for instance, reproached the organizers for not having considered the circumstances of the capitalist economy. He believed that the New Tendencies had blindly grasped a new technology that was, first of all, a means of automation and worker exploitation: "Any innovation is thus used by a well-defined class to continue exploiting the working class. Everyone has seen that the consequence of the innovation in mechanization is a greater exploitation of man by man. Innovation and automation have not diminished man's exertions or given him greater freedom at work. It is used to rationalize exploitation. Artists cannot continue to be unconcerned by these conditions."[65] With these words, Biasi appealed to the artists and organizers to give up the naive belief that "technological evolutions and economic transformations alone would be enough to gradually and spontaneously introduce socialism." He reflected two arguments characteristically associated with the student revolt as well: within student circles, debate centered around the question of whether automation would accelerate changes within the social system or if it was, to the contrary, a tool of power that fueled the disorganization of the working class, the manipulation of social behavior, and the production of the *One-Dimensional Man*, as Herbert Marcuse described him in 1964.

Nake reacted to Biasi's contribution by encouraging participants in the colloquy not to demonize the computer. As many "leftists" as possible should work with this technology. The individual should be "schizophrenic"—working during the day at the computer to make a living and discussing in the evenings "in a group of 'progressive intelligence' actions against his own place of employment." Nake appealed to participants to perceive the computer as a means in the pursuit to use "rationality in service of mankind."[66]

A critique of technology could also be seen in the texts and project descriptions handed in by London-based artist Gustav Metzger, a German-born artist of Polish-Jewish extraction who escaped National Socialism and immigrated to England in 1939: he pointed to the central role of the computer in military purposes, in research on the hydrogen bomb, and in nuclear warfare. Thanks to computers, the western world would face "the most totalitarian system of all time."[67] He emphasized that specifically visual research with computers was initiated by the military. "There is little doubt that in computer art, the true *avantgarde* is the military."[68] Like Nake, Metzger did not see a solution in abandoning technology. While he identified with the aims of the student movement, he criticized it for being overly simplistic. The only path to survival for modern man was to master existing knowledge in order to produce a "more refined, penetrative understanding of science and technology."[69]

Despite these nuanced critical appraisals, fascination with technology prevailed in publications associated with *Computers and Visual Research*. The articles and objects bear witness to a combative optimism that had characterized New Tendencies from the beginning. And, as before, its organizers laid bare to the public their internal struggles, continuing a remarkable style of discourse.

CONCLUSION

In June 1971, artists and scientists once again convened for a conference, this time entitled "Art and Computers 71," and later, in 1973, for the last New Tendencies exhibition, *Tendencije 5*, which took place in Zagreb. *Tendencije 5* included "constructive visual research" and "computer visual research," both categories of work associated with the history of the movement, and introduced as its third theme "conceptual art," with works by On Kawara, Sol LeWitt, and many others. The organizers tried to establish a dialogue between the artists participating in this exhibition through an international conference called "The Rational and Irrational in Visual Research Today." But the representatives of the various research fields found few affinities. After a symposium in 1978, "t-6 = Art and Society," the New Tendencies vanished quietly after seventeen years.

During the five years between the benchmark work on computers initiated in 1968 and the conceptual art program of 1973, artists and scientists from around

the world and both sides of the Iron Curtain had engaged in a critical and cooperative project on visual research with computers, exploring the artistic and social horizon of an emerging technology. The organizers, artists, and theoreticians of the New Tendencies, a movement that started with an exhibition of the young Western European avant-garde in Zagreb in 1961, had created the aesthetic and organizational premises. But the whole process of integration of a new technology implied a revision of New Tendencies' history by the organizers: it was a version of the movement's history focused primarily on aspects of the "programming" of artworks and inquiry into the creative process. Inquiry into optical effects and the "democratization" of art through observer participation were abandoned.

It should be noted that the initiative taken by organizers of *Computers and Visual Research,* notably Bek and Kelemen and the circle of Croatian theorists and artists around them and the Gallery of Contemporary Art, contrasted with the state of computerization in Yugoslavia. In 1968, only ninety-five computers were installed in the country. Yugoslavia had 5 computers per million habitants, as compared to Germany with 51 per million and the United States with 261 per million.[70] The initiative did not originate from a particularly favorable technical setting, but emerged from an aesthetic discourse and artistic practice developed by a circle of artists and theorists chiefly from France, Italy, Germany, Switzerland, and Austria during the early 1960s.

New Tendencies' idea of art as research, the endeavor to enforce a constructive, rational, demystified art and to overcome the gap between current art practices and processes in science and technology, as well as the wish to stop the art market from defining artistic aims and methods, made it possible to open this art movement to the world of computing technology and its own band of practitioners. The Croatian organizers managed to create the circumstances favorable to a new medium and, equally important, to create a complex discourse on the aesthetic and social practice contingent on that medium, the computer, a piece of technology that was about to cause a revolution that was, as Abraham Moles predicted in Zagreb in 1968, "more important than the mechanized revolution that inspired Marx."[71]

NOTES

Unless otherwise noted, all translations are by the author. Epigraph: Radoslav Putar, "New Tendencies 4," in *Tendencije 4,* exh. cat. (Zagreb: Galerija suvremene Umjetnosti, 1970), n.p.

1. The artists' movement and exhibition series changed its title several times and used different versions simultaneously: while the first exhibition used the plural *Nove tendencije* (New Tendencies), the French members already in 1962 used the singular Nouvelle Tendance (New Tendency). From 1968 on, the adjective "New" was given up and "Tendencies" was used to announce the manifestations.

2. Jerko Denegri, "Inside or Outside 'Socialist Modernism'? Radical Views on the Yugoslav Art Scene, 1950–1970," in *Impossible Histories: Historical Avant-Gardes, Neo-Avant-Gardes, and Post-Avant-Gardes in Yugoslavia, 1918–1991,* eds. by Dubravka Djurić and Miško Šuvaković (Cambridge, MA: MIT Press, 2003), 170–208, quotation 172.

3. The City Gallery of Contemporary Art (Gradska galerija suvremene umjetnosti) and the Gallery of Contemporary Art (Galerija suvremene umjetnosti) are former names of the institution that is today known as the Museum of Contemporary Art (Muzej suvremene umjetnosti).

4. Participating artists were Marc Adrian, Alberto Biasi, Enrico Castellani, Ennio Chiggio, Andreas Christen, Toni Costa, Piero Dorazio, Karl Gerstner, Gerard von Graevenitz, Rudolf Kämmer, Julije Knifer, Edoardo Landi, Julio Le Parc, Heinz Mack, Piero Manzoni, Manfredo Massironi, Almir Mavignier, François Morellet, Gotthart Müller, Herbert Oehm, Ivan Picelj, Otto Piene, Uli Pohl, Dieter Roth, Joël Stein, Paul Talman, Günther Uecker, Marcel Wyss, and Walter Zehringer.

5. The Anonima Group included Ernst Benkert, Francis Hewitt, and Edwin Meisz Koviskij (Mieczkowski).

6. Dviženije (Movement) was a group founded by Lev V. Nusberg in Moscow in 1962. The first members were Mikhail Dorokhov, Francisco Infante-Arana, Viacheslav Koleichuk, Anatolij Krivčikov, Viacheslav Sčerbakov, Viktor Stepanov, and Rimma Zanevskaya; others were to join the group later. The group dissolved in 1972.

7. The newsletter *Nouvelle Tendance—recherche continuelle, Bulletin No. 1,* which was written after a meeting in Zagreb, listed those artists who were meant to be excluded from the movement. See *Nouvelle Tendance—recherche continuelle, Bulletin No. 1* (August 1968), 6 pages, Archives of the Museum of Contemporary Art Zagreb.

8. Ibid. *Bit International* 3: *Kompjuteri i vizuelna istraživanja / Computers and Visual Research* (1968): 11–23, quotation 19.

9. Adrian, "Notizen zu t-4," 13.

10. See Matko Meštrović and Radoslav Putar, "18.8.1965 u Brezovici radni sastanak učesnika NT3," in *Nova tendencija 3,* exh. cat. (Zagreb: Galerija suvremene umjetnosti, 1965), 161–65;.

11. Abraham A. Moles, "Cybernétique et œuvre d'art," in *Nova tendencija 3,* 91–102, quotation 91.

12. The theorists and artists participating this discussion were Božo Bek, Radoslav Putar, Dimitrije Bašičević, Boris Kelemen, Ivan Picelj, and Vjenceslav Richter. See untitled protocol of a meeting at the Gallery of Contemporary Art Zagreb, December 18, 1967, Archives of the Museum of Contemporary Art, Zagreb.
The artist Ivan Picelj exhibited in October 1965 at Howard Wise Gallery in New York, the venue at which the exhibition *Computer Generated Pictures* had been held in April 1965. Whether or not Picelj knew about that exhibition prior to December 1967 or had been instrumental in considerations about including "Computer Art" in New Tendencies could not be confirmed by available documents and interviews by the author.

13. Boris Kelemen, "Computers and Visual Research," in *Tendencije 4,* exh. cat., (Zagreb: Galerija suvremene umjetnosti, 1970), n.p.

14. Max Bense, *Aesthetica. Einführung in die neue Ästhetik* (Baden-Baden: Agis, 1965).

15. Matko Meštrović, untitled, in *Nove tendencije 2,* exh. cat. (Zagreb: Galerija suvremene umjetnosti, 1965), n.p., trans. Andy Jelčić.

16. Putar, "New Tendencies 4," n.p.

17. *Programme-Information PI-8,* August 1968, Archives of the Museum of Contemporary Art Zagreb.

18. Alfred Grassl spoke for the artist Otto Beckmann, with whom he collaborated in the group "ars intermedia."

19. N.N., "Why bit appears," *Bit International* 1: *Teorija informacija i nova estetika / The Theory of Informations* [*sic*] *and the New Aesthetics* (1968): 3–6, quotation 5.

20. François Morellet, "The Choice in Present-Day Art" (1965), in *Data: Directions in Art, Theory and Aesthetics*, ed. Anthony Hill (New York: New York Graphic Society, 1968), 236–38.

21. Frieder Nake, "Replik an Biasi," *Bit International* 3 (1968): 35–40, quotation 36.

22. It has to be noted here that the authors of the bulletin that launched the new title rejected being "classified as an artistic movement." See *Nouvelle Tendance—recherche continuelle, Bulletin No. 1.*

23. François Morellet untitled, in *Nove tendencije,* exh. cat., international version (Zagreb: Galerija suvremene umjetnosti, 1961), n.p.

24. Matko Meštrović, untitled (1963), n.p.

25. Jean-Pierre Vasarely (Yvaral) quoted in *Nove tendencije 2,* n.p.

26. Mari and Boriani quoted in Meštrović and Putar, "18.8.1965 u Brezovici radni sastanak učesnika NT3," 164.

27. *Programme-Information PI-6,* June 1968, Archives of the Museum of Contemporary Art Zagreb, quotation 2.

28. *Programme-Information PI-7,* August 1968, Archives of the Museum of Contemporary Art Zagreb, quotation 1.

29. Putar, "New Tendencies 4," n.p.

30. Karl Gerstner, *Programme entwerfen* (Teufen: Niggli [1963], 1964).

31. François Morellet, "Pour une peinture expérimentale programmée," *Groupe de recherche d'art visuel. Paris 1962,* eds. Galerie Denise René and GRAV, exh. broch. for exhibition *L'Instabilité* (Paris: Musée des Beaux-Arts, 1962), n.p., here quoted after English translation in *GRAV. Groupe de recherche d'art visuel, 1960–1968: Stratégies de participation,* exh. cat. (Grenoble: Le Magasin, 1998), 85.

32. Putar, "New Tendencies 4," n.p.

33. Vjenceslav Richter, "Dilemma," *Bit International* 3 (1968): 25–28, quotation 27.

34. *Programme-Information PI-4,* April 1968, Archives of the Museum of Contemporary Art Zagreb.

35. Karl Gerstner, "Mit dem Computer Kunst produzieren" (1969), *Bit International 7: Dijalog sa strojem / Dialogue with the machine* (1971): 149–54, quotation 150.

36. Waldemar Cordeiro, letter to Božo Bek, August 5, 1968, Archives of the Museum of Contemporary Art Zagreb.

37. Boris Kelemen, "Computers and Visual Research," in *Tendencije 4* (1970), n.p.

38. Frieder Nake, letter to Boris Kelemen, March 12, 1969, Archives of the Museum of Contemporary Art Zagreb.

39. Herbert W. Franke, "Gesellschaftliche Aspekte der Computerkunst," *Bit International 7* (1971): 19–26, quotation 24.

40. Boris Kelemen, letter to Frieder Nake, Zagreb, March 31, 1969, Archives of the Museum of Contemporary Art Zagreb.

41. Umberto Eco, *Opera aperta. Forma e indeterminazione nelle poetiche contemporanee* (Milan: Bompiani, 1962).

42. Umberto Eco, untitled, in *Arte programmata. Arte cinetica, opere moltiplicate, opera aperta,* exh. broch. (Milan: Archivio Gianni Colombo, 1962), n.p.

43. At the first venue, the Olivetti showroom in Milan, GRAV and Getulio Alviani didn't participate. The exhibition was then shown from July to August at the Olivetti stores in Venice, and in October in Rome; from June to July 1963, it was shown at Olivetti in Düsseldorf (from this point onward, it did not include GRAV's works). Finally, from July 1964 to July 1966, the exhibition went on a tour through the United States organized by the Smithsonian.

44. Gustav Metzger, *References to Cybernetics and Computers in the Published Writings of Gustav Metzger,* typescript, Archives of the Museum of Contemporary Art Zagreb, 1 page.

45. Franke, "Gesellschaftliche Aspekte der Computerkunst," 25.

46. For a detailed description of information aesthetics and the differences between Max Bense and Abraham A. Moles, see the essay in this volume by Christoph Klütsch (chapter 4).

47. Max Bense, "Ästhetik als Programmierung," *Bit International 1* (1968): 79–88, quotation 83.

48. Abraham A. Moles, *Erste Manifest der permutationellen Kunst. rot Nr. 8* (Stuttgart: Elisabeth Walther, 1962); Max Bense "Projekte generativer Ästhetik," in *Computer-Graphik. Georg Nees. buch rot nr. 19,* eds. Max Bense and Elisabeth Walther (Stuttgart: Elisabeth Walther, 1965), 11–13.

49. Matko Meštrović, "L'observateur observée," *Bit International 1* (1968): 9–16, quotation 9.

50. *Programme-Information PI-10,* November 1968, Archives of the Museum of Contemporary Art Zagreb, 1.

51. Frieder Nake, letter to Boris Kelemen, September 1, 1969, Archives of the Museum of Contemporary Art Zagreb.

52. *Programme-Information PI-10,* 1.

53. Ibid., 2.

54. In 1961, as an editor of nonfiction for the publishing house Bompiani, Eco had edited the book *Almanacco Letterario Bompiani 1962. Le applicazioni dei calcolatori elettronici alle scienze morali e alla letteratura* (Milan: Bompiani, 1961). Krampen had organized the symposium "Computers in Design and Communication" in Canada in 1966, and two exhibitions of computer graphics in Germany in 1967.

55. *Programme-Information PI-13,* May 1969, Archives of the Museum of Contemporary Art Zagreb, quotation 1.

56. Ibid., 2.

57. Ibid.

58. For *Nova tendencija 3* (1965), the organizers announced the theme "Divulgence of Research Examples," formulated by Enzo Mari.

59. *Programme-Information PI-7,* 1.

60. Meštrović, untitled (1963), n.p.

61. Four of the images presented at the *Tendencies 4* informative exhibition were published in December 1968 in Branko Souček, Vladimir Bonačić, and K. Čuljat, "Million Channel Pulse Height Analyser through Pseudo-Random Digital Transformation," *Nuclear Instruments and Methods* 66 (1968): 202–12, pictures 205.

62. Interview by the author with Bonačić's collaborator Miro A. Cimerman, February 6–7, 2007, Berlin.

63. *Programme-Information PI-13,* 2.

64. Eco, untitled, n.p.

65. Alberto Biasi, "Situazione 1967," *Bit International* 3 (1968): 29–33, quotation 33.

66. Frieder Nake, "Replik an A. Biasi," *Bit International* 3 (1968): 35–40, quotation 38.

67. Gustav Metzger, untitled (1969), *Bit International 7* (1971): 27–34, quotation 28.

68. Ibid.

69. Ibid., 30.

70. Milan Mesarić, *Suvremena znanstveno tehnička revolucija* (Zagreb: Ekonomski institut, 1971), quotation 58.

71. Abraham A. Moles, "Introduction à colloque," *Bit International 7* (1971): 3–10, quotation 6.