# The Magazine of the Institute of Contemporary Arts

CYBERNETIC SERENDIPITY    August 2 - October 20, 1968
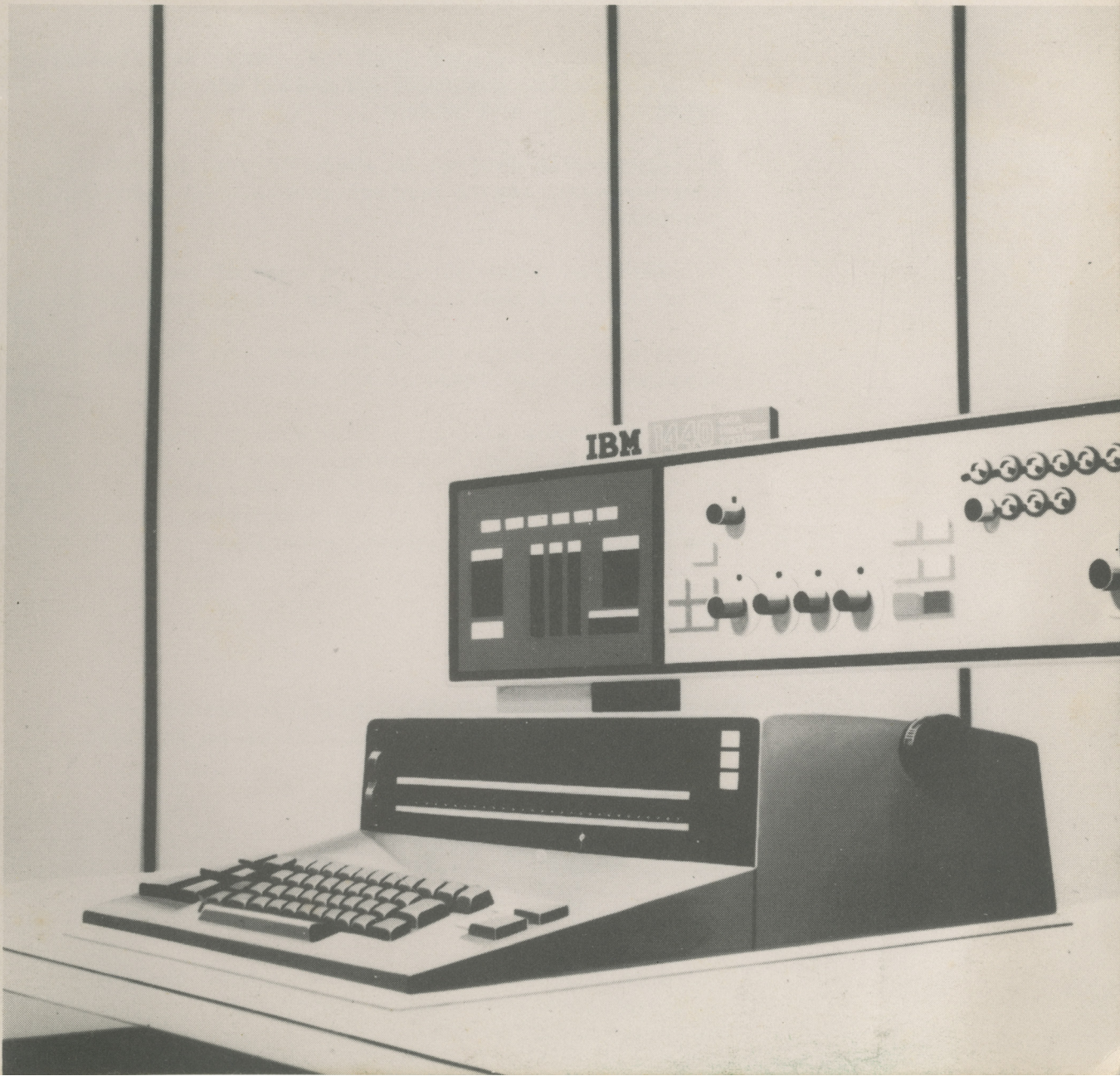
An international exhibition exploring
and demonstrating relationships
between technology and creativity.

The idea behind this venture is to show creative forms
engendered by technology.  To present an area of
activity which manifests artists' involvement with
science, and the scientists' involvement with the arts.
To show the links between the random systems employed
by artists, composers, and poets, and those involved
in the use of cybernetic devices.

The exhibition is divided into three sections:

1.  Computer generated graphics, computer animated
films, computer composed and played music, and
computer verse and texts.

2.  Cybernetic devices as works of art, cybernetic
environments, remote control robots, and painting
machines.

3.  Machines demonstrating the uses of computers and
an environment dealing with the history of cybernetics.

There will be lectures on Tuesdays and Thursdays
dealing with the theme of the exhibition.

Every day there will be a film show in the
auditorium of films either made with the aid
of computers or dealing with the relevance
of computer technology to the humanities,
the arts, and communications generally.




During the course of the Cybernetic Serendipity
exhibition the opening hours will be as follows:

Tuesdays, Thursdays, Saturdays  11-6
Wednesdays, Fridays  11-9
Sundays  2-6
Mondays closed.

Admission 8/-
ICA members 4/-
Children free (special terms for school parties
by arrangement with Leslie Stack)
Admission to films 2/6

# Arts Council Exhibitions
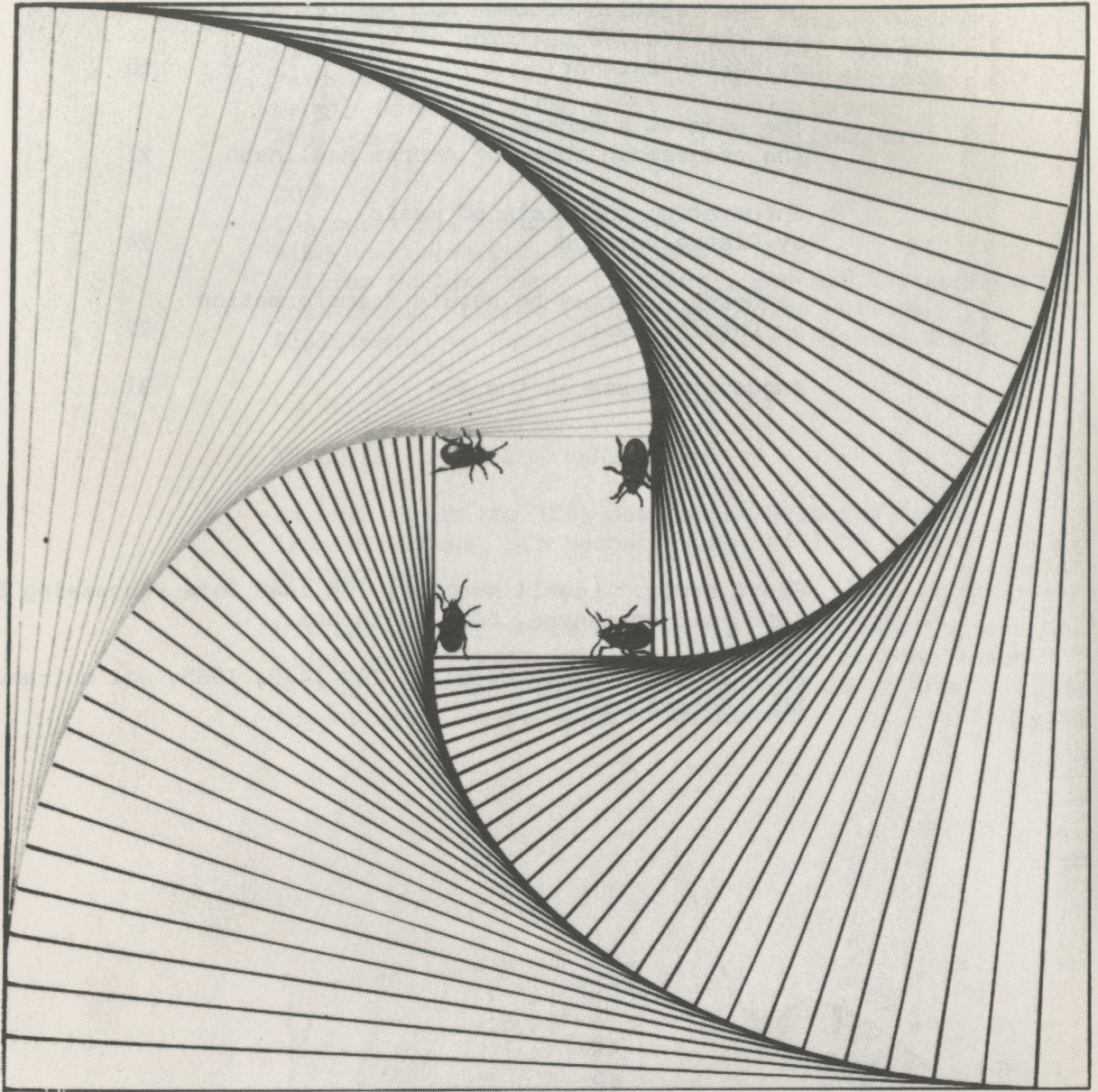
HAYWARD GALLERY
Southbank

Inaugural Exhibition
MATISSE
July 11 - September 8
Weekdays 10.30 - 7  Sundays 10 - 6
Admission 5/-


TATE GALLERY
Millbank
London S W 1

HENRY MOORE
70th Birthday Retrospective Exhibition
July 18 - September 22
Weekdays 10 - 6  (Tuesdays and Thursdays 10 - 8)
Sundays 2 - 6
Admission 5/-

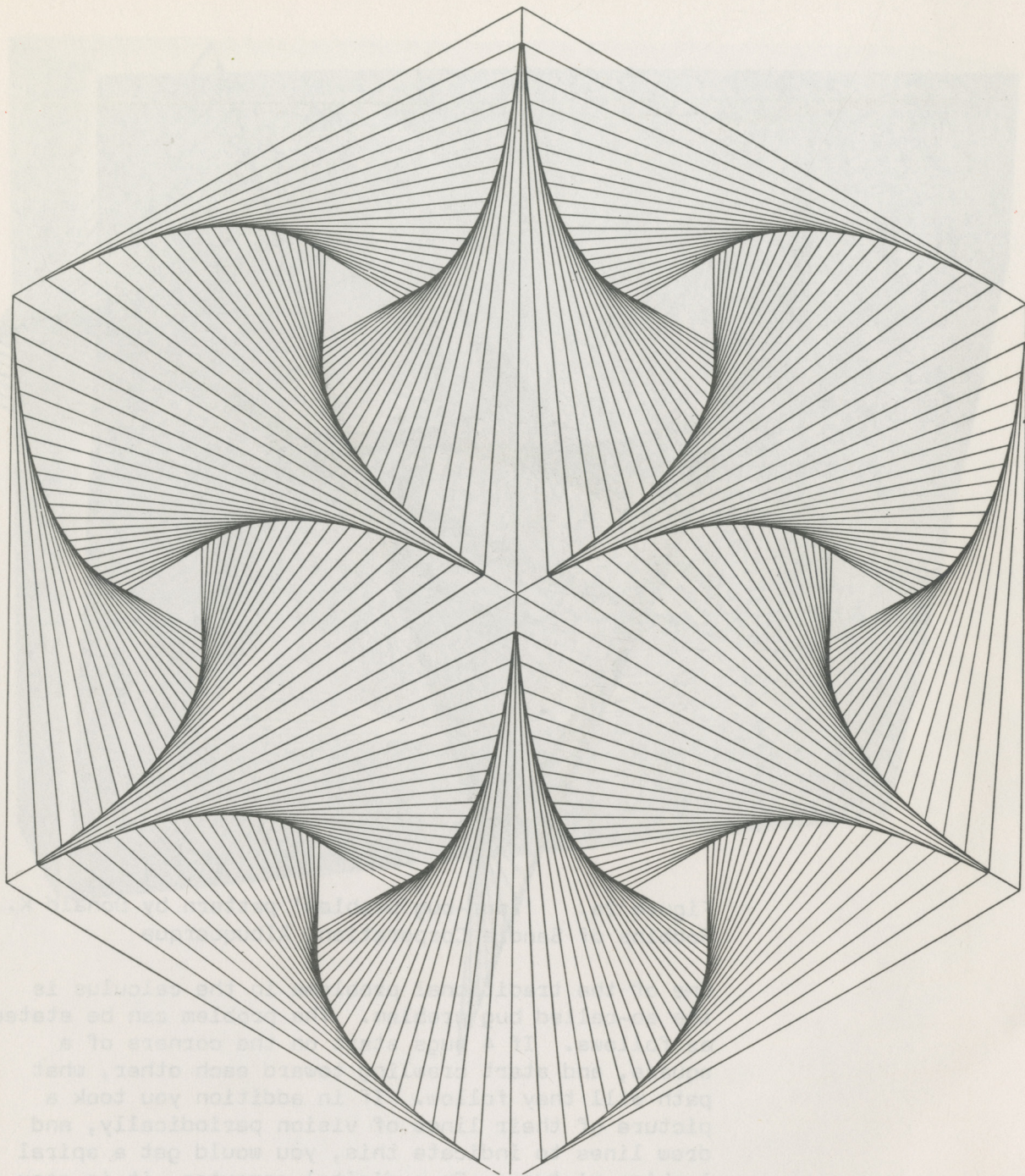Figure 1.   Design based on the 'four-bug problem'.

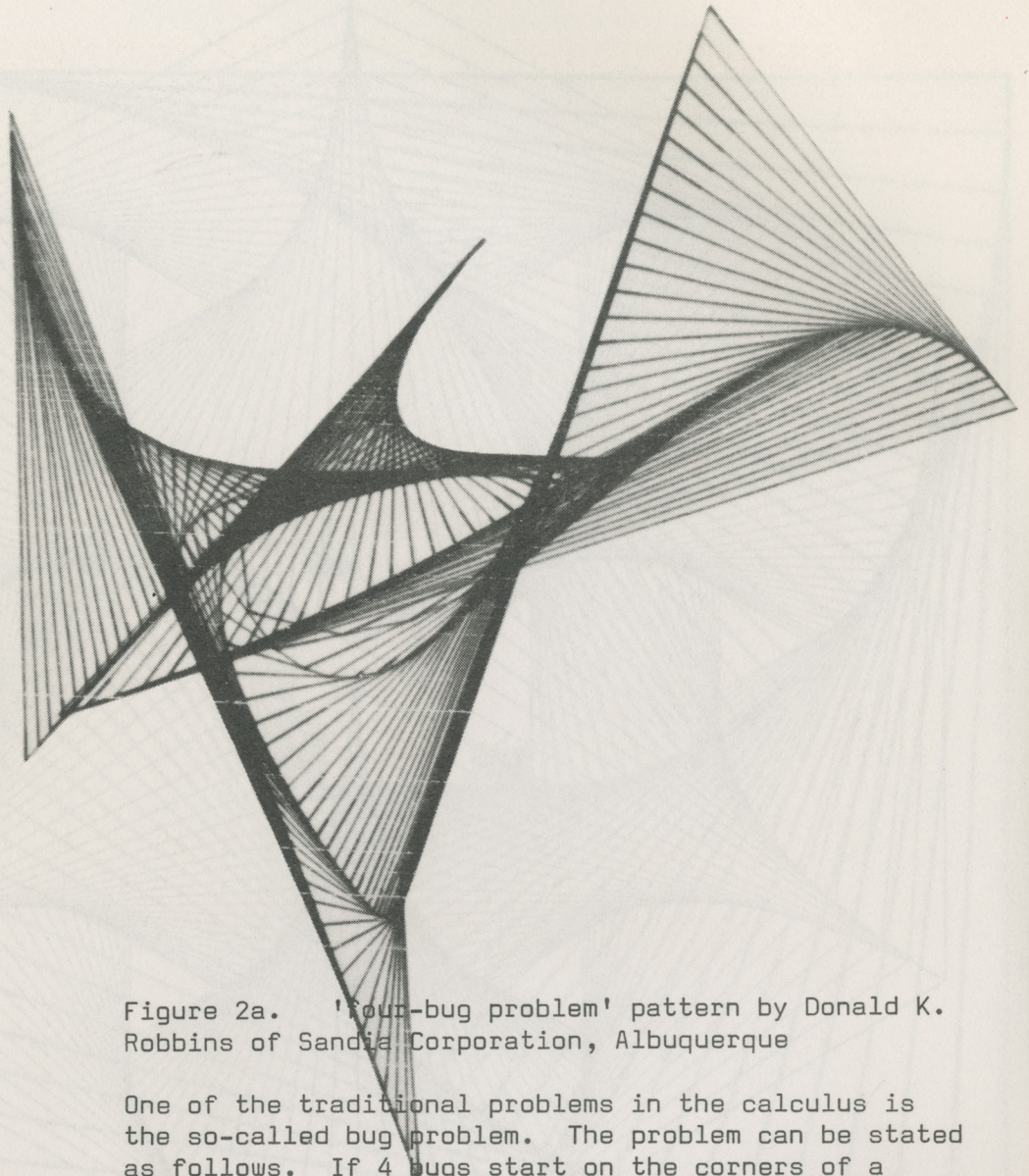Figure 2.    Design based on the 'three-bug problem'.    5

Figure 2a.    'Four-bug problem' pattern by Donald K.
Robbins of Sandia Corporation, Albuquerque

One of the traditional problems in the calculus is
the so-called bug problem.  The problem can be stated
as follows.  If 4 bugs start on the corners of a
square, and start crawling toward each other, what
path will they follow.  If in addition you took a
picture of their lines of vision periodically, and
drew lines to indicate this, you would get a spiral
looking picture.  On a digital computer, it is easy
to put the bug's path into a portion of the programme
called a subroutine.  This subroutine can be manipulated.
The checkerboard pattern shows a replication of the basic
pattern.  A further progression shows the checkerboard
revealed as a three-dimensional entity, with the shape
distorted (or perhaps made more real) by the perspective
transformation.  The computer, under the direction of
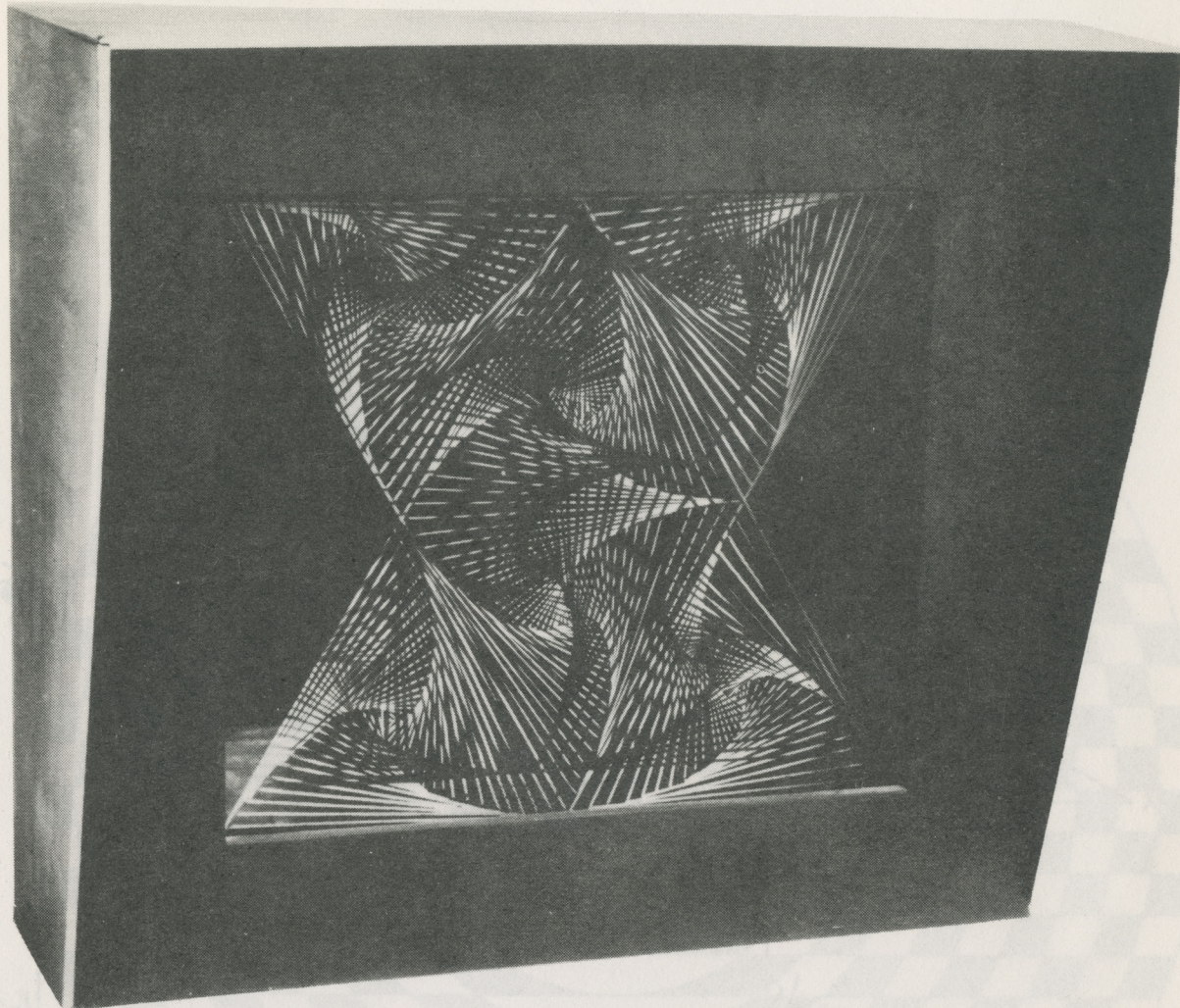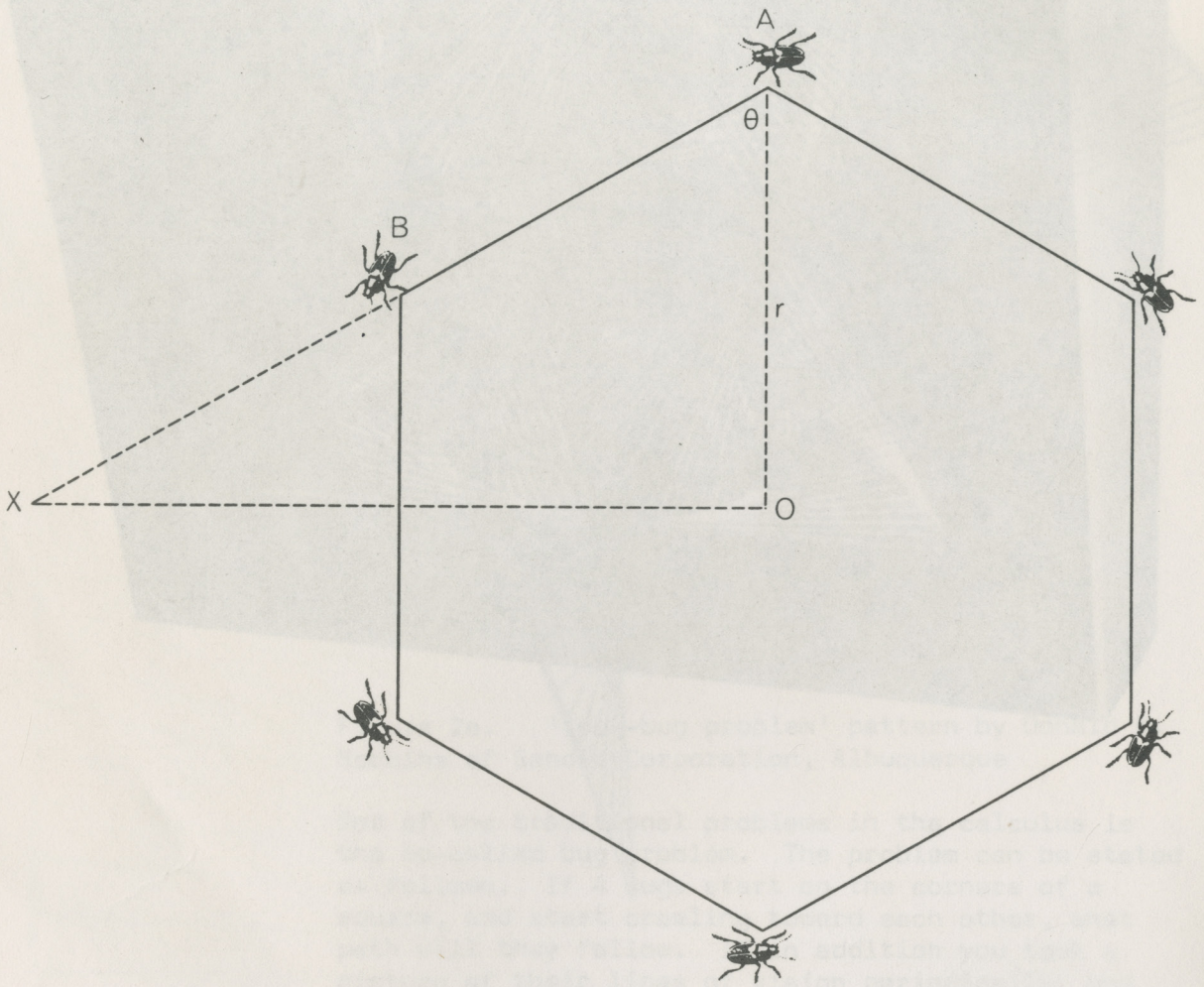the technological artist can readily produce these
picture.

Figure 2b.  Dioximoirekinesis by Irving John Good
and Martine Vite.

This model brings together several separate ideas:
the random combination of pursuit triangles, moire
effects, and kinetic art.  The result is a pulsating
organism in a black box.  The prefix Dioxi is Greek
for Pursuit.

7

Figure 3.    Calculating the length of the bug's path
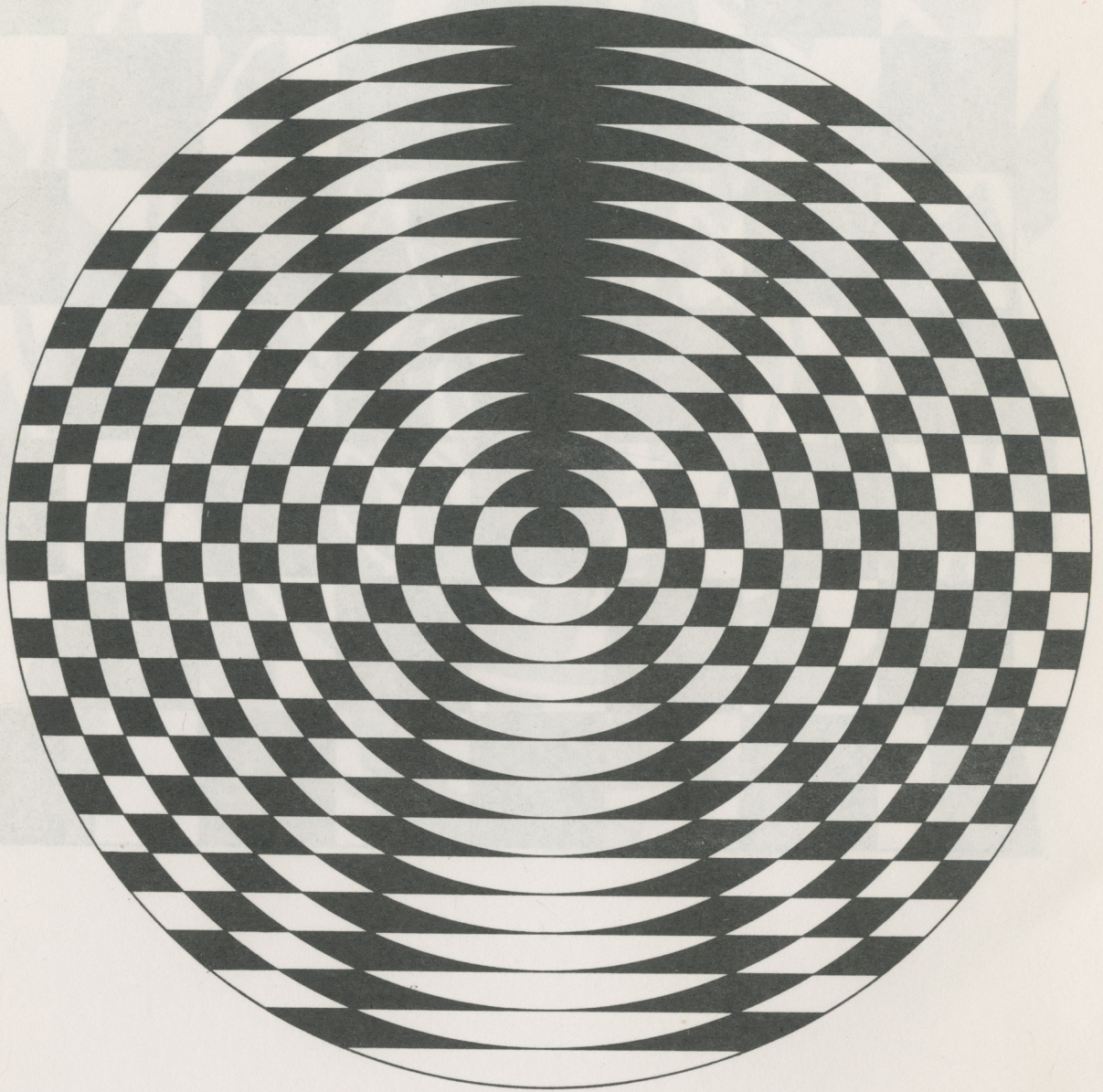
Figure 4.   Baravelle's circular 'checkerboard'

Figure 5. Checkerboard inversion pattern

Figure 6.  'Twisted cord' concentric circles
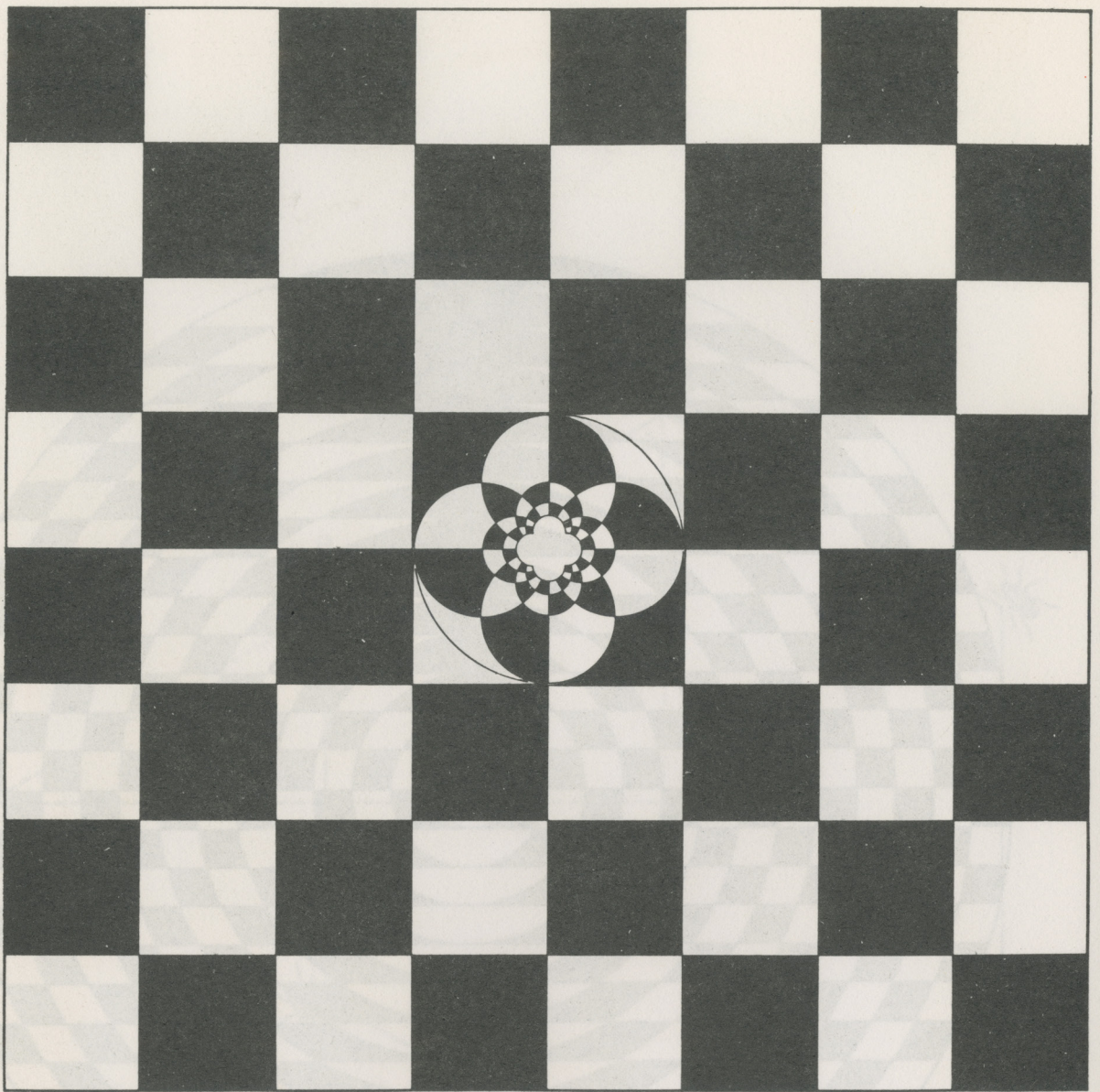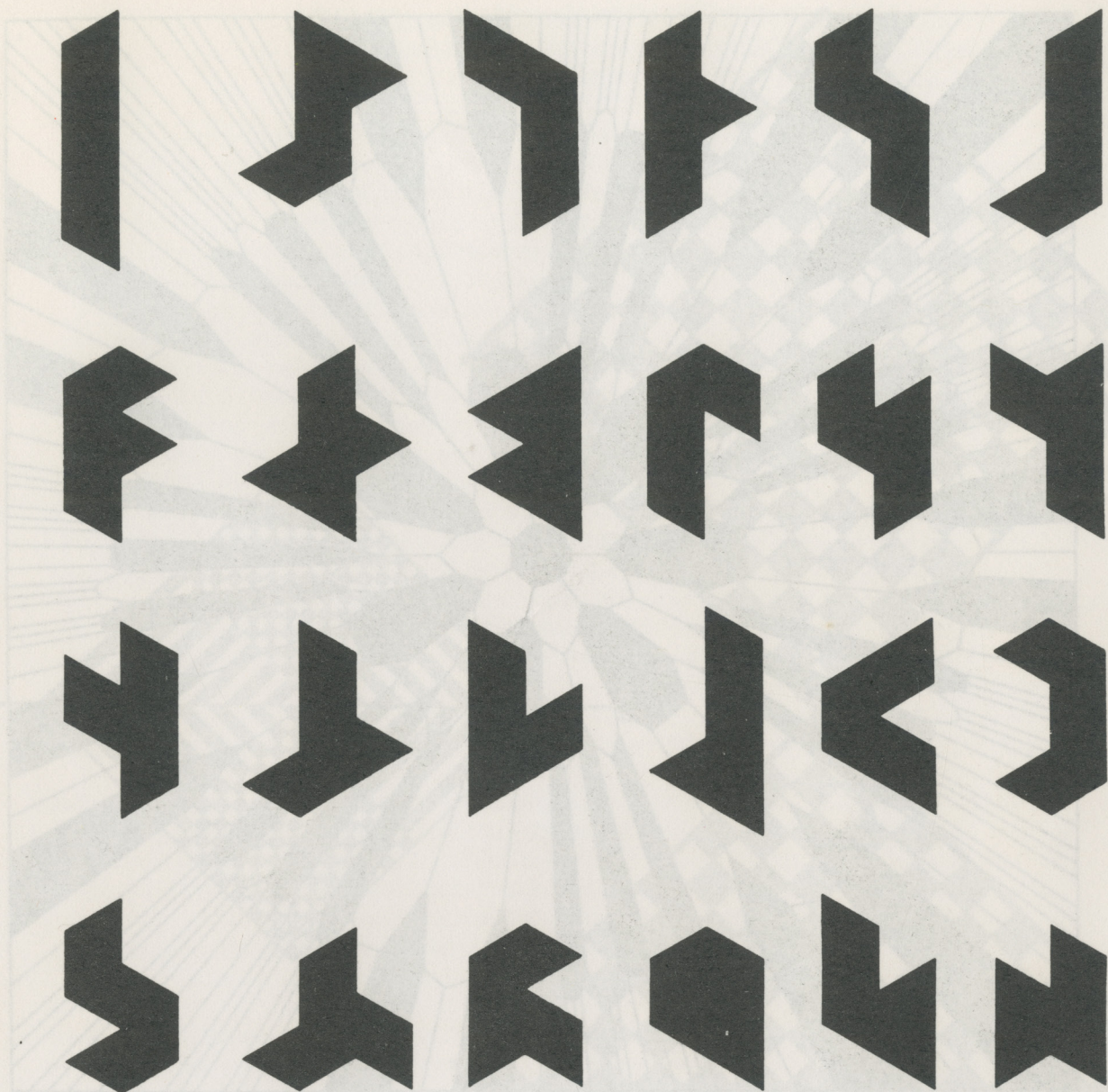
Figure 7.    'Twisted cord' spiral

Figure 8.   The 24 heptiamonds (which cannot tile a plane?)

Tesselation of convex heptagons
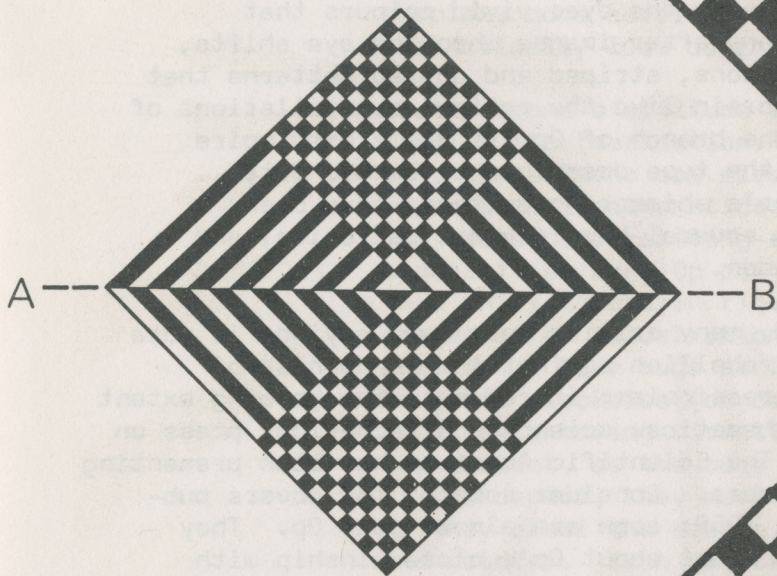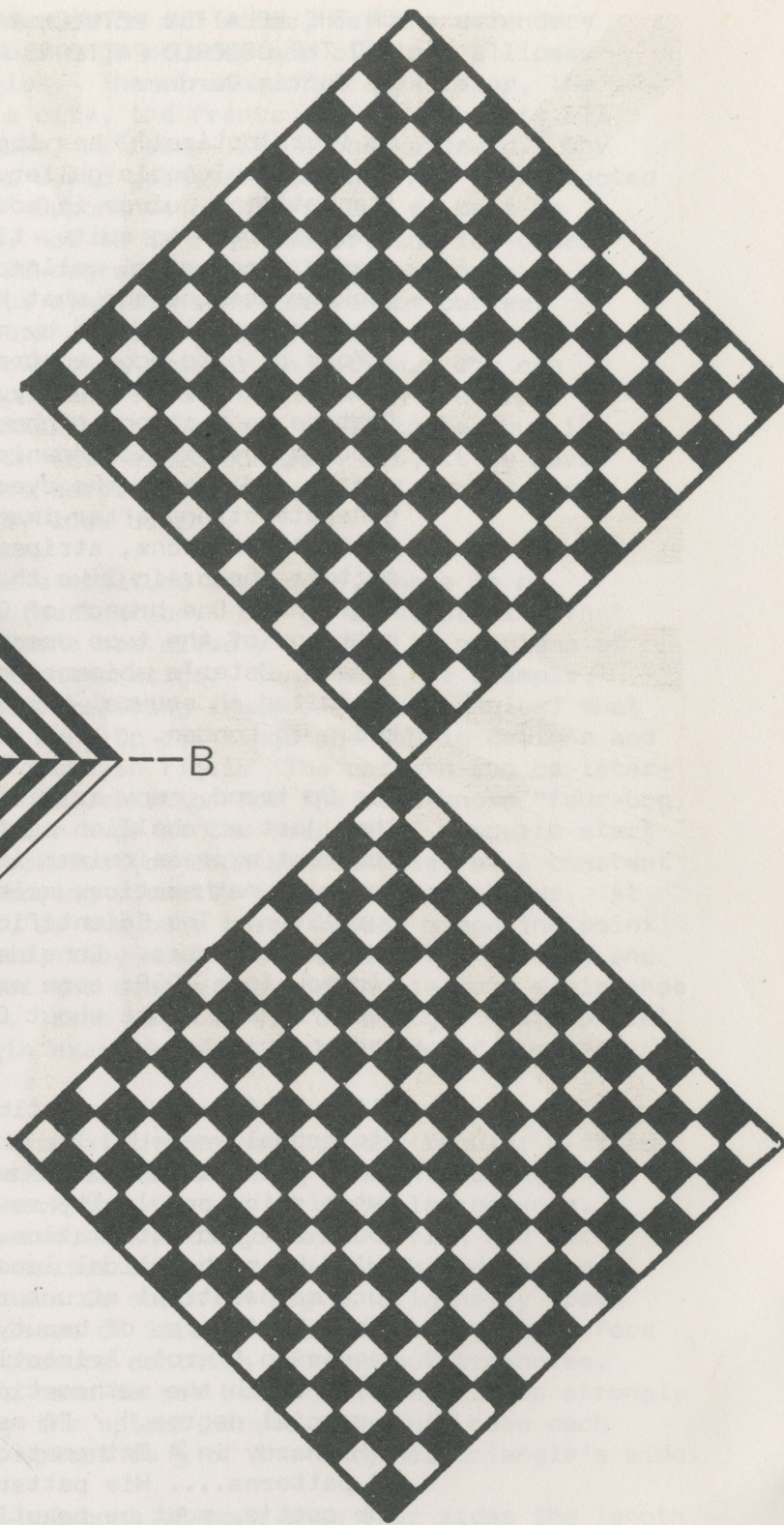
A -- -- B
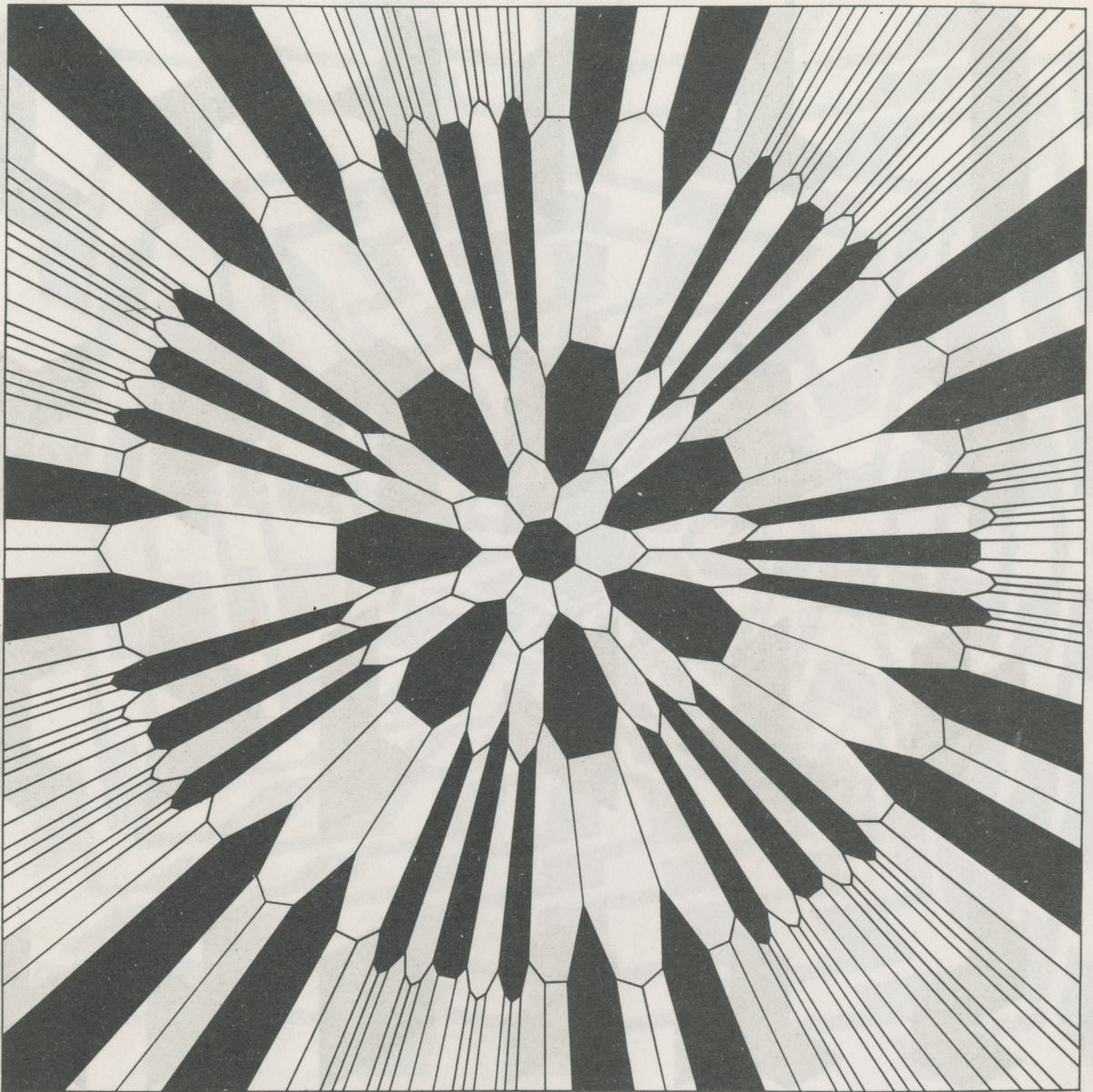
Figure 10.          Figure 11.

ON THE RELATION BETWEEN MATHEMATICS
AND THE ORDERED PATTERNS OF OP ART
by Martin Gardner

Op (for 'optical') has topped Pop (for 'popular')
as the fashionable gallery art of the mid sixties;
its patterns quiver in advertisements and on
dresses, bathing suits, ties, stockings, window
shades, draperies, wallpaper, floor coverings,
package designs and what have you.  Op art, as
everyone surely knows by now, is the new name for
a form of hard-edge abstractionism that has been
around for half a century.  Its distinguishing
feature is a strong emphasis on mathematical order.
Sometimes it is accompanied by effects intended to
dazzle and wrench the eye: vivid colours that
generate strong after-images when the eye shifts,
optical illusions, striped and dotted patterns that
torture the brain like the retinal scintillations of
migraine.  One branch of Op art deals with moire
patterns of the type described by Gerald Oster.
Indeed, Oster's shimmering patterns have been
exhibited in several New York art galleries, and
shown in London.

The Op trend, many critics have been saying, is more
than just a rebellion against the randomness of
abstract expressionism; it reflects the growing extent
to which mathematics, science and technology press on
our lives.  The Scientific American has been presenting
Op art for years.  Consider some of the covers pub-
lished since 1958; some are almost pure Op.  They
leave little doubt about Op's close kinship with
modern science.

Although Op art is sometimes rich and warm with colours,
its appeal seems to lie more in its cold, rigid, pre-
cise, unemotional and impersonal qualities.  Its
astonishing popularity revives ancient questions
about art and mathematics.  To what extent is art
ruled by mathematical laws?  To what extent can
pure mathematical structure arouse aesthetic emotions?
"The chief forms of beauty are order and symmetry and
precision," wrote Aristotle in his Metaphysics (Book
13), "which the mathematical sciences demonstrate in
a special degree."   "A mathematician...," declared
G.H. Hardy in A Mathematician's Apology, "is a maker
of patterns.... His patterns, like the painter's or
the poet's, must be beautiful; the ideas, like the
colours or the words, must fit together in a
harmonious way.  Beauty is the first test: there is
no permanent place in the world for ugly
mathematics."

We are surrounded on all sides, say the defenders of Op, by hard-edge squares and circles, ellipses and rectangles. The windows of a skyscraper, the streets of a city, the fronts of file cabinets all form orthogonal patterns like a checkerboard. Why should these basic geometric designs not be reflected in our art? Opponents counter: But we want to escape from, not to be reminded of, the low-order curves and 90-degree angles of a technological culture. Our eyeballs ache for random curves, impure colours and soft edges; for the patterns of leaves and clouds and water in motion. Who can write an equation for the shape of an oak tree? The mathematical structure is still there, but in nature, as in less rigid abstract art, it is more complex, more careless, and - say Op's detractors - aesthetically less boring.

Whatever one's attitude toward Op, there is no denying its fascination. Nor is it surprising that many Op patterns are closely related to problems of recreational mathematics. Consider, for example, the nested and rotating squares (or rectangles) that appear in so many Op paintings and fabric designs and that whirl inward in fig.1. The pattern can be inter- preted as an illustration for the well-known "four-bug problem". Four bugs at the corners of a square start to crawl clockwise (or counterclockwise) at a constant rate, each moving directly toward its neighbour. At any instant, as the bugs march toward a meeting point at the centre, they mark the corners of a square, and as they crawl the square they delineate both diminishes and rotates. Each bug travels on a logarithmic spiral with a length exactly equal to the side of the original square.

If $\underline{n}$ bugs start at the corners of any regular $\underline{n}$-sided polygon, their positions at any instant during their march will mark the corners of a similar polygon. Like the square, this polygon will shrink and turn as the bugs spiral inward. A design based on the triangular case is shown in fig.2, originally drawn for an old issue of Scripta Mathematica by Rutherford Boyd. The picture contains cothing but triangles, but they are hard to see because the eye is so strongly dominated by the spiral curves. In this case each logarithmic spiral is $\frac{2}{3}$ of the original triangle's side.

For regular polygons of more than four sides the length of each bug's path is greater than a side. As J. Charles Clapham proved in the now defunct Recreational Mathematics Magazine, the length of the path of a bug starting at corner A can be found trigonometrically by

TRIBUTES TO HERBERT READ

An evening at the ICA, devoted to tributes to our
late President, Sir Herbert Read, will be held on
October 24th.

His last public address 'The problem of internation-
alism in art' will be published in the October issue
of the ICA magazine, and is not included in the
August issue as previously announced.

Leonardo transformation  -  see page 27

# CONTENTS

Front cover.  Lowell Nesbitt; IBM 1440 Data Processing System,
1965, oil on canvas, 60 x 60 inches.

Back cover.  Lowell Nesbitt; IBM 1440, 1965, oil on canvas,
60 x 60 inches.

extending a side AB (see fig.3) and locating on it a
point X such that the angle AOX is 90 degrees.  The
distance AX - which is equal to $\underline{r}$ times the secant of
angle θ - is the distance the bug travels.  As the
illustration shows, on a hexagon each bug's path is
twice the length of a side.

Clapham's simple formula also applies to the square
and the triangular cases, and even to the degenerate
"two-sided polygon" - a straight line with a zero
angle θ and bugs at each end that tramp toward each
other until they bump head on.    At the other extreme,
the circle can be considered a degenerate "infinite-
sided polygon" with bugs at an infinite number of
"corners".   These bugs march forever around the circle
like the Pine Processionary caterpillers in a famous
experiement of Jean Henri Fabre's, which trailed each
other for eight days around the rim of a large vase.
When we apply Clapham's right triangle to the circle,
sure enough, angle θ is 90 degrees and the hypotenuse
is infinite.

One suspects that Op painters both in America and
Europe have yet to discover the thousands of eye-
twisting patterns that lie buried in scientific and
mathematical textbooks and back copies of academic
journals.  Early issues of Scripta Mathematica, for
example, vibrate with exciting pre-Op.  The illus-
tration in fig.4 shows a striking pattern the mathe-
matician Hermann Baravalle obtained by ruling parallel
lines across concentric circles and then colouring the
regions in checkerboard fashion.  One might think that
this pattern is topologically the same as a square
checkerboard - in other words, that a square checker-
board on a rubber sheet could be continuously deformed
to produce the pattern.  This in fact is not the case.

In fig.5 Baravalle has inverted every point P that
lies outside the circle on the checkerboard into a
corresponding point P' inside the circle, such that
$OP \times OP' = r^2$, where O is the circle's centre and r
its radius.  Every point on the plane outside the
circle is thus put into one-to-one correspondence
with every point inside.  A line extending outward
from the board to infinity corresponds to a line
inside the central white space, extending inward
toward the centre but never reaching it.

Inversion geometry can, of course, be applied to
three-space as easily as to the plane.  An old
mathematical joke says that to catch a lion you just
build a cage and perform an inversion operation on
the beast.  The cosmos itself can be inverted and

compressed inside a tennis ball.  In America during the 1870's a religious cult was actually founded on the belief that such an inverted three-space reflects the true state of affairs.  Cyrus Reed Teed's "Koreshanity" put the entire universe inside the earth. We imagine ourselves on the outside of the earth looking out at gigantic stars scattered through an infinite space;  the truth, said Teed, is that we are on the inside of a hollow earth looking in at small stellar bodies moving in a space that is the geo-metrical inverse of the space of orthodox astronomy. Teed defended his views in many books and articles; years later his ideas attracted a following in Nazi Germany.

Figs. 6 and 7 are examples of many vertigo-inducing patterns that were studied by psychologists more than 50 years ago.  They are known as "twisted-cord illusions" because they were first discovered by twisting black and white string into a single cord that was then arranged in various ways on differently patterned background. Fig.6 consists of concentric circles (as you can prove with a compass); in fig.7 a spiral is made up of straight horizontal and vertical "cords" (as you can prove with a ruler).

Tesselations of the plane created by fitting together replicas of the same basic shape have long been used in design and are now turning up in many of the latest Op fabrics.  The cross-pentomino appears on an Op dress advertised by Bonwit Teller.  All polyominoes and poly-iamonds (polyiamonds are formed by joining equilateral triangles instead of squares) of order six or less will fit together to cover the plane, but so far I have seen only the cross-pentomino and the L-tromino (the latter on a scarf sold by Gimbels in New York City) on Op fabrics.  The reader can easily create his own new Op patterns by finding ways to tile the plane with each of the 12 pentominoes and the 12 hexiamonds.

Most, but not all, of the 108 heptominoes (for their diagrams see Solomon W. Golomb's recent book Polyominoes, pages 108-109) will tile the plane.  Several British mathematicians are currently working on the difficult question of which of them are not planefillers.  The corresponding problem for the 24 heptiamonds (see fig.8) was proposed by T.H. O'Beirne of Glasgow.  Only one of the 24 shapes is not a plane-filler.

The Op pattern that covers the plane with convex noncongruent heptagons (fig.9) embodies a curious paradox that twiddles the brain even more than the eye.  If this pattern is repeated infinitely, what

19

is the average angle in it? Since the plane contains
nothing but heptagons, and since the interior angles
of any heptagon sum to 900 degrees, it follows that
the average angle is 900/7 or 128 4/7 degrees. Note,
however, that every point on the pattern is a meeting
of three angles. This surely requires that the
average angle be 360/3, or 120 degrees.

The source of this problem and its answer were given
in Scientific American in August 1965, as follows:
"The paradox of the heptagon tessellation was taken
from Hugo Steinhaus' 'One hundred problems in elemen-
tary mathematics' (Basic Books, 1964). The paradox
arises from the fact that a re-arrangement of terms
in an infinite series can lead to a different cal-
culation of the average term. Steinhaus gives as an
example the series 1, 0, 1, 0, 1, 0... for which $\frac{1}{2}$
is the average. But the two infinite sets of ones
and zeroes can also be arranged 1, 0, 1, 0, 0, 0, 0,
1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1... (where successive
sets of zeroes have cardinal numbers that are squares
of 1, 2, 3...), in which case the average is 0. It
is easy to form other arrangements to make the
average any desired integral value between 0 and 1.
In the heptagon pattern two different arrangements
of two infinite sets of angles are considered, and
there is no reason why the calculation of an average
angle should be the same in each."

Readers were asked to make one straight cut across a
circular Op pattern (fig.4) so as to divide the
pattern into two parts, each topologically equivalent
to a square checkerboard. That the pattern itself
cannot be continuously distorted to produce a checker-
board is evident from the fact that the number of its
cells, 392, is not a square. Note also that the two
cells inside the bull's-eye are each three-sided; any
distortion that turns one of these cells into a square
would turn the other into a nonconvex figure. It is
therefore necessary that the cut separate these two
cells. The only straight cut that does this is one
along the horizontal diameter of the large circle.
Fig.10 is topologically the same as fig.4. It is
easy to see that a single cut along AB produces two
halves, each of which is topologically the same as
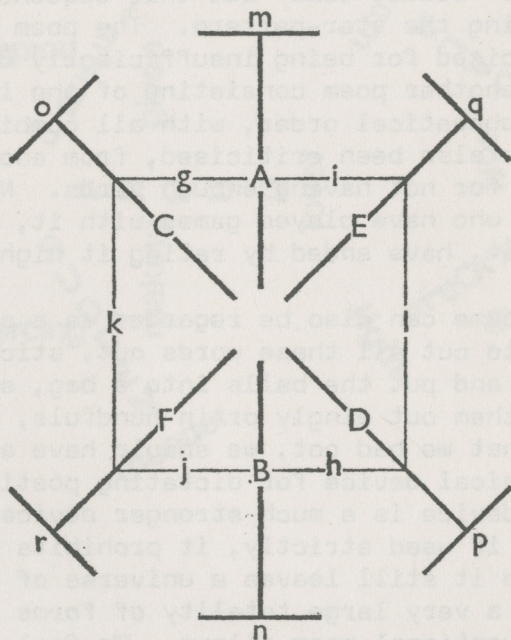a square checkerboard 14 cells on a side (fig.11).

This article has been reproduced by kind permission
of Martin Gardner and Donald H. Miller of the
Scientific American. It first appeared in Scientific
American in July, 1965.

The concrete poems by Andrew Rawlinson, of which the
abstract schema is given below, consist of 18 words
arranged in 19 positions, which, in the schema, are
marked with upper-case or lower-case letters of the
alphabet.  The poet himself took the schema from the
Orthodox three-dimensional cross, and developed it
to make it also into a six-pointed Epiphany start.

It is important to remember that any one of these
poems is not a single assertion, but a schema from
which poetic assertions can be drawn as the reader
wishes.  That is to say, the schema is not a single
poem in itself, (as were, for instance, the comparable
poems of the seventeenth-century emblemists).  It is
a complete poetic, relational totality; a whole
conceptual universe, or world-treasury (or Thesaurus)
from which the reader, by using the schema and being
guided by the star-pattern, may construct for himself
such word-sequences as he thinks fit.

```
                        m

          o                         q

              g       A       i

              C               E


                  k

              F               D

                  j   B   h

          r                         p

                        n
```

The poet himself has supplied no rules as to how the
cross-and-star pattern is to be used, so that the
only thing the reader can do is to play star-games
with the poems until he finds a word-sequence which
satisfies him.  Thus, if he takes the sequence DB,

he will get "Crystal Mountain" whereas is he takes
the sequence CD he will get "Mandala Crystal".  If
he takes the sequence ghij, he will get "secret
prayer flowing growing" whereas if he takes the
sequence mABn, he will get "quiet Quasar Mountain
cell".  If he takes the sequence onq, he will get
"atom cell robot" whereas if he takes the sequence
mrp, he will get "quiet light bones" and so on, and
so on, up to factorial 18 (18!) sequences if no word
in any one sequence is allowed to be repeated twice;
up to $18^{18}$ sequences, if repetitions of words, or of
sequences of words, are allowed but no total sequence
is allowed to consist of more than 18 words, and up to
a denumerably infinite number of sequences if both
word-repetition are allowed and if the sequences are
allowed to be of indefinite length.

Not all sequences which can be drawn from these poems
are equally successful (take, for instance, the sequence
consisting of all the 18 words in alphabetical order).
The poems can therefore be criticised for incomplete
richness.  Likewise, the best sequences are not always
gained by following the star-pattern; for instance,
if you take the sequence mlghn, you get "quiet clear
prayer  secret cell" but this sequence is obtained by
ignoring the star-pattern.  The poem can thus be
criticised for being insufficiently distinguishable
from another poem consisting of the 18 words given
in alphabetical order, with all combinations allowed.
It has also been criticised, from another point of
view, for not having enough verbs.  Nevertheless,
those who have played games with it, by taking sequences
from it, have ended by rating it highly.

The poems can also be regarded as a system.  If we
were to cut all these words out, stick them on plastic
balls and put the balls into a bag, so that we could
fish them out singly or in handfuls, and then look to
see what we had got, we should have a very weak
mechanical device for dictating poetic meaning.  The
star device is a much stronger device than the bag, in
that, if used strictly, it prohibits more sequences,
though it still leaves a universe of "free play" which
gives a very large totality of forms compared with what
a conventional poem allows.  We feel that we should
like to be able to formulate explicitly the principles
which guide us when we react to the star shape, so as
to draw up clear-cut rules for constructing  sequences.
If we could have such detailed rules for poem-construction
from the poem-frame which the star provides, then (in one
of the indefinitely many current senses of "information")
we should have in the poem an information-system of a
simple kind.

22

keep
cross

STAIRWAY praying mortal
flock world mild stern glance logos fuse prove INTERNO arrow
radar CHAMP AMBUSH breath soho crucible river SPECTRUM gold MISSAL fire love
clamant
alert
heart
quiet

anchor self atom prayer robot
maiden found given holding flowing clear
open Dumaur lover soft MOUNTAIN CRYSTAL bones
piercing making RIVER thunder light POOCOE growing secret
song D-I-M-T-R-I SUDDEN ALADAUK WAZDAND DESERT cell

# INFORMATION THEORISTS OF MUSIC
by Pierre Barbaud

## Engineers or musicians?

Suppose we consider, from a bridge, the surge of cars
in one direction along a motorway.  The spectacle
before us depends, on one hand, on definite rules -
the Highway Code - and on the other hand, on how
many cars happen to be passing at that time.  Each
simple event - such as a black Austin passing at
50 m.p.h. on the M1 - has a more or less high proba-
bility of arising, and one could, taking into account
the day, the time, and other factors, give it a precise
numerical value.  This leads on to the probability of
compound events occurring: that of four apple-green
Rolls-Royces passing simultaneously at 7 m.p.h.
would, of course, be very low, but would be an astonish-
ing event of some interest, if once in while it should
arise.

## To compose is to organise

Mutatis mutandis, to compose music is to organise a
spectacle which could be compared to that of our
motorway.  Its virtue stems from a steady balance
between order and disorder, or between homogeneity
and heterogeneity, and should, in this way, keep the
spectator alert.  It sets in action 'things that make
a noise' of which the four dimensions are usually
called pitch (such as a g in the third octave),
duration (quaver, crotchet, minim), intensity
(pianissimo, mezzo forte), and timbre (violin,
clarinet, trombone).  Given, then, a certain number
of combinatory rules - determined by tradition or
arbitrarily applicable to the set of notes and sounds
chosen and a number of musical instruments - we may
organise a sound event.  This event would juxtapose
compound events simultaneously: that is, their harmonic
essence and continuously: that is, their melodic
essence.  We must thus give the traditional expressions
'harmony' and 'melody' a more extensive meaning.

## Specialists in combinatory studies

This process has been performed satisfactorily for
centuries by specialists - the composers, whose
'savoir-faire' is very developed and allows the super-
ficial exploration of a very small part of combinatory
material, defined by the elements which they activate.

For several years, some composers have been moulded
as technicians. These have been the first 'engineers
with a musical sensibility', who have striven to explore
this fabric with the help of electronic computers. Now,
if it is readily admitted that a machine could simulate
traffic flow on a motorway, it can equally well
simulate the notes of a symphony. The language used
by contemporary composers still disconcerts the majority
of the public. This does not make the tasks of the infor-
mation theorists of music any easier. It is in an atmos-
phere of hostility that they continue their experiments.

## Two extra dimensions

In classical music, priority was given to the components
pitch and duration, while timbre and intensity were
added on only as extra ornamentation, rather as if one
coloured a drawing. Now, the four dimensions of sound
are treated on an equal footing, and one thinks of
melodies of intensity, of timbre, or of durations as
one used to conceive melodies only of notes of varying
pitch. It results in an anarchic, apparently random
distribution of sound, which rather puts off a listener
conditioned over the last ten centuries to music with
only two dimensions.

## The musical heritage

It will surely be possible, looking at musicological
research, to simulate in a machine a harmonic or
contrapuntal musical language of the past, and thus
to gain a quick popularity. But such a conception of
the problem still resembles past music (like artificial
antique furniture) more than a creative activity. But
I shall not deal with this narrow aspect of the subject:
you could look it all up in my book, "Initiation a la
composition musicale automatique" published by Dunod,
Paris 1966

A word, now, on the notation used by such a machine.
A note in the chromatic scale is denoted by its
position on the stave within one octave and represented
by a number between 0 and 12, writing 0, 1, 2, 3, ...
as 00, 01, 02, 03, etc. This representation is pre-
fixed by the number of the octave, for instance the
fourth note in the fourth octave is denoted as 404.
The sums are calculated to the base 12 and one uses
the duodecimal system for all the sums containing
elements of the chromatic scale before they are
divided precisely into twelves. Some specific notation
of durations completes this notation of sound.

25

## An effective realization: Algom 7

In the ALGOM 7 programme I proposed to distribute all
twelve notes in each of the seven octaves of the
chromatic scale for four different durations on more
than twenty instruments.  The combinatory constraint,
which is unique, is that the same sound does not arise
at the same time in the same octave.  Anyway, if, at a
given instant I hear sound 307 (E), third octave,
played on a flute, I would reject the simultaneous
sounding of the same note on a different instrument.
I would, however, accept simultaneously 105, 305,
405, and 605.  Given a certain number of instruments
$l_1$, $l_2$, ...$l_n$, (m where n  (is equal to or less than) 20)
whose limits of pitch are respectively $(P_1, P_1,)$ $(P_2, P_2)$...
$(P_n, P_n)$.  These upper and lower limits, arranged in an
increasing order of magnitude, determine over the whole
range of possible sounds, a certain number of adjacent
segments so that the ability to produce one of these
sounds define the instruments which play it at a certain
instant.  When the machine has memorized the limits of
the instruments it controls and defined these segments,
it sorts out all the notes of the chromatic scale, of
which the octaves have previously been determined, taking
into account the constraint shown above, by distributing
them to the different instruments within these limits.
Similar operations take place to deal with durations
and intensities.

The distribution of notes in octaves, of frequencies
in timbres, the determination of durations and
intensities are subject to fixed probabilities given
in the form of stochastic matrices.  The machine can
change the probabilities in the course of its work
at more or less distant intervals.  It also brings
together sequences of varying length with more or
less contrasting characters.

One hopes - and experience shows that this wish is
not merely Utopian - to obtain by this process a
musically feasible work.

LEONARDO
Circle to Square Transformation
by Charles Csuri, Ohio State University

An artist can now make use of complex mathematical
functions. With computer and mathematical technology,
the artist has at his disposal a means to modify or
transform an image. For instance, given a set of
discrete data points it is possible to produce a
drawing (continuous or discrete) by some mechanical
device or procedure. Now if the original data is
transformed by means of a mathematical function and
a new drawing produced, we say that this function
establishes a relationship between the first and the
second drawing. In this context the function maps one
set or drawing into another or it is the rule of
correspondence between two sets such that to each
element in one set there can be assigned a unique
element in the other. We may now write a computer
programme which implements this function or trans-
formation so that the computer makes the necessary
computations for a new set of coordinate points.
Mathematical analysis may be used to determine the
way in which coordinate points can be transformed to
a new position and relationship in space.

The drawings presented here were obtained using a
transformation in which a pre-image point, P, becomes
an image point, P', in a transformation which stretches
the interior of a circle into the interior of a square.
If P is a pre-image point and O is the centre of the
circle, the ray OP cuts the circle at S and the square
at T. Then P' is the point for which $\dfrac{OP'}{OT} = \dfrac{OP}{OS}$.

If the original image were on a circular rubber sheet
which was then stretched into a square, the image would
be similar to the ones displayed. The images were pro-
duced using the same transformation but by rotating the
pre-image in the circle through increments of 45 degrees.

A stretching technique can be used to transform any
arc of a circle into a new boundary. In the diagram
showing a circle, a square, a heart, and a rhombus, 8
numbered regions are shown. Five transformations can
be associated with each region: the point T can be on
the circle (no change in drawing), on the square, on
the heart, on the rhombus, or at point O (a portion of
the drawing will be eliminated). The number of such
transformations is $5^8 = 390,625$. If each transformation
is used with 16 rotations the number of images is
6,250,000. Additional images can be found by adding
more boundary curves or by introducing other types of
transformations.

27
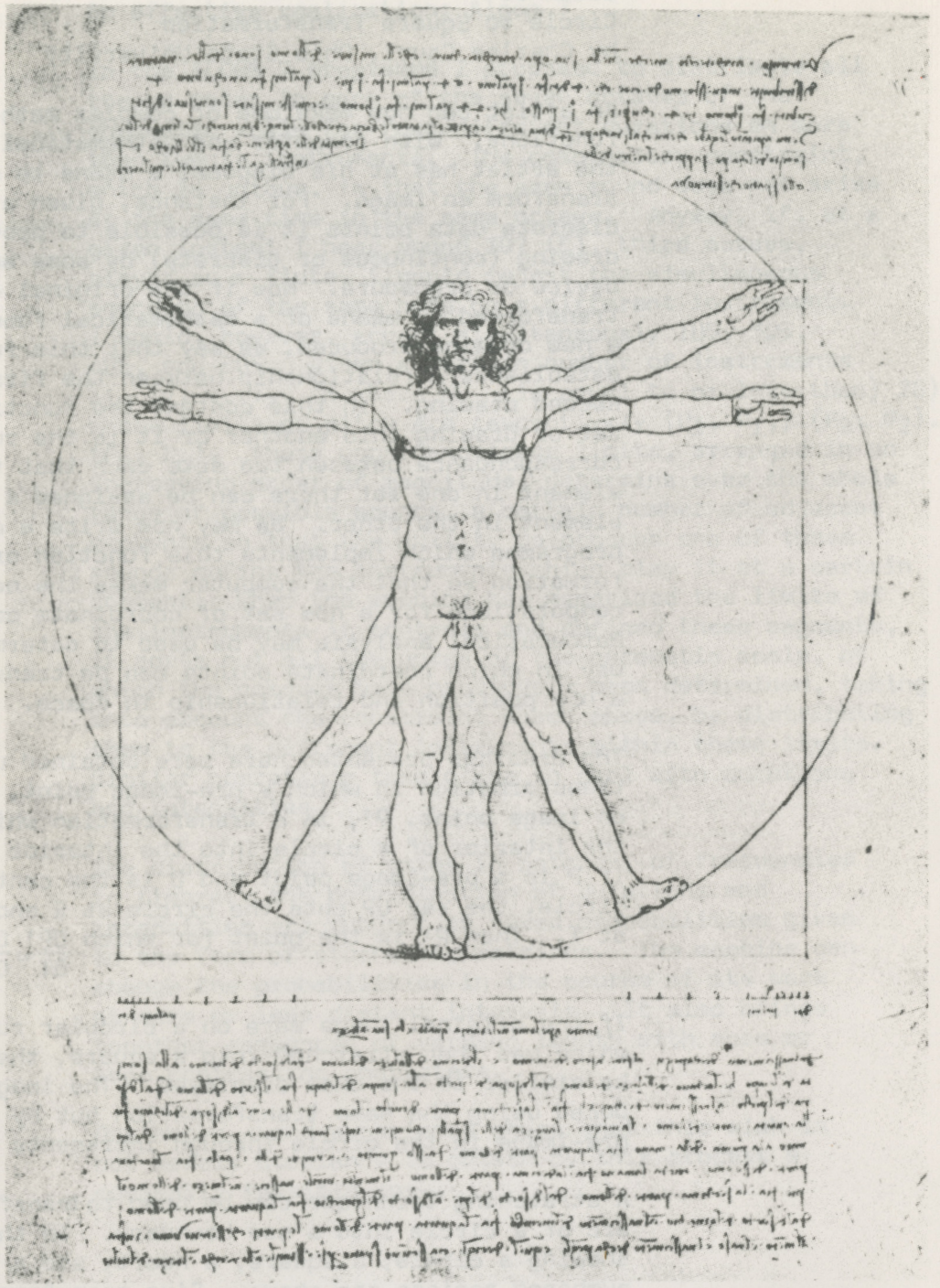
INTERPRETATION OF VITRUVIUS' THEORY OF PROPORTIONS
ca. 1500, by Leonardo da Vinci

This drawing represents the orientation of man in
the universe.  It gives an impression of a kinetic
concept through the figure touching simultaneously
both the circumference of the circle and the out-
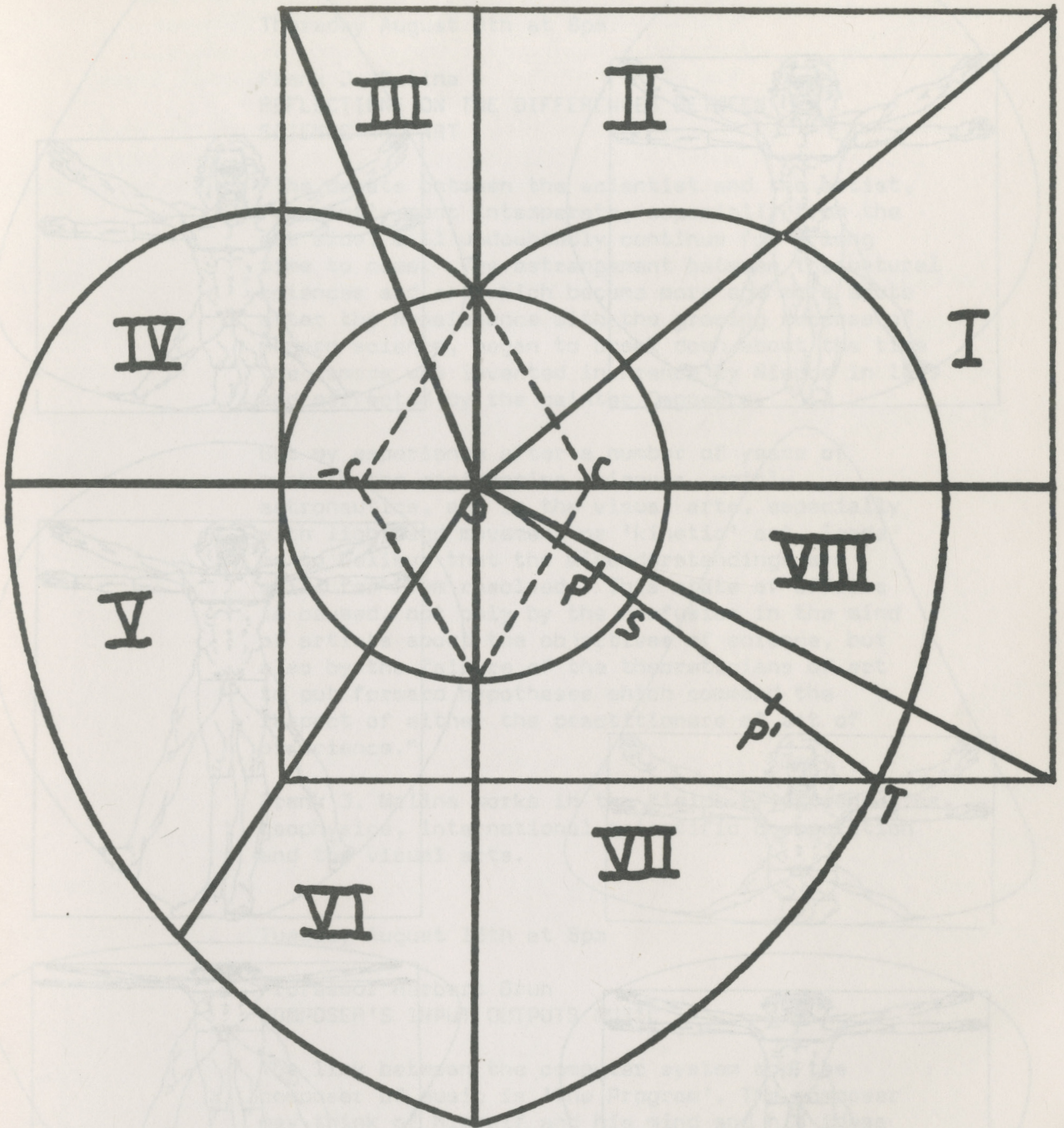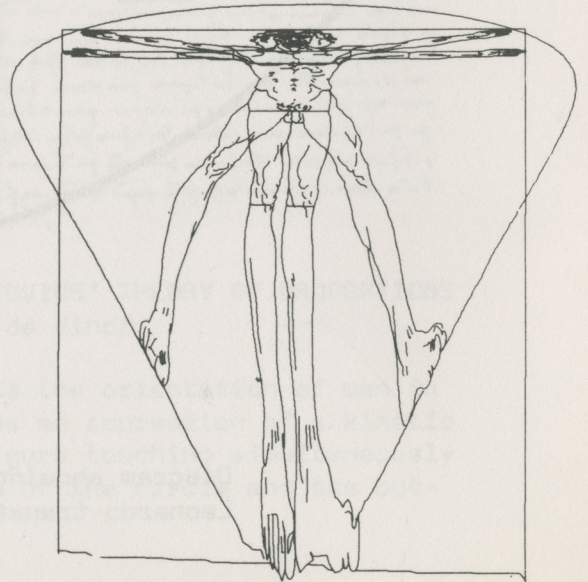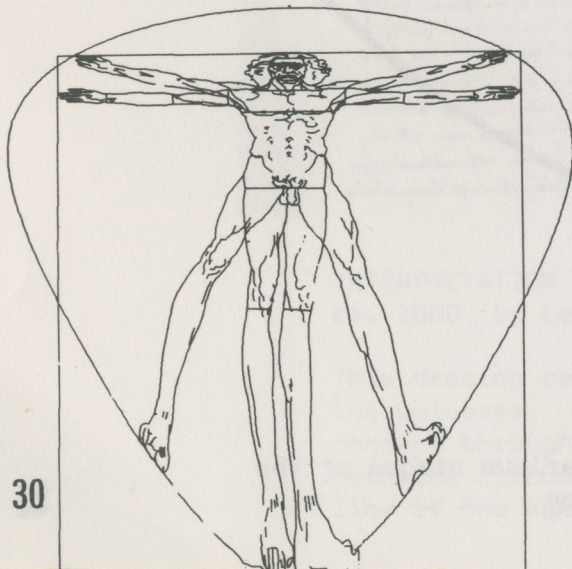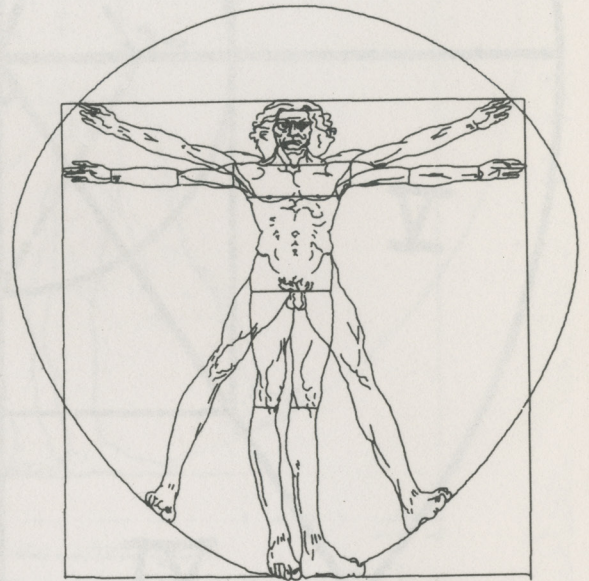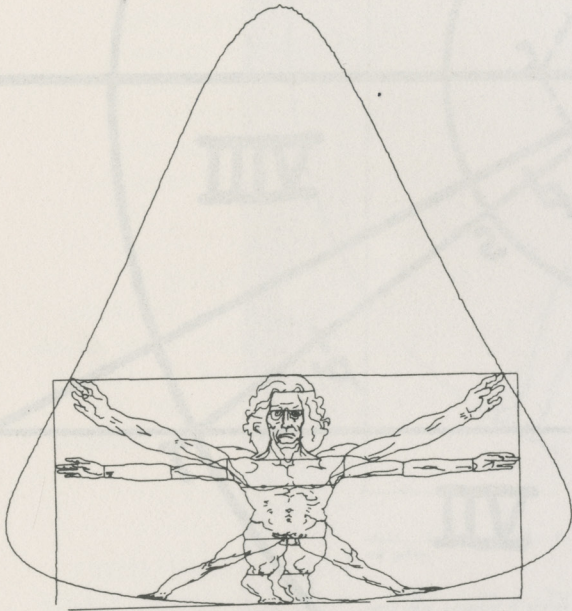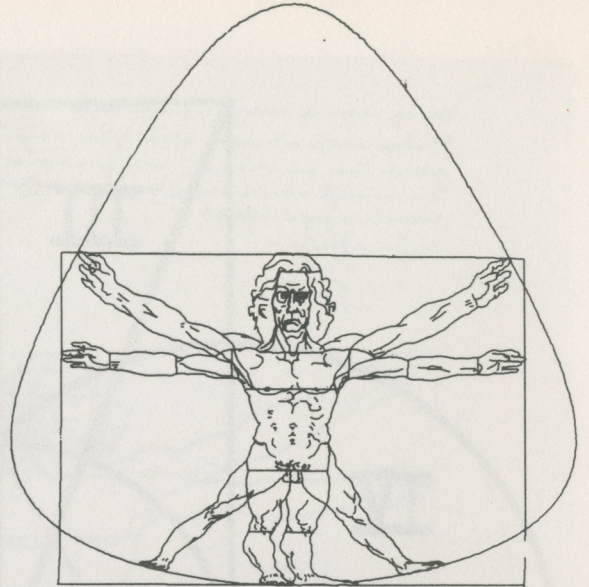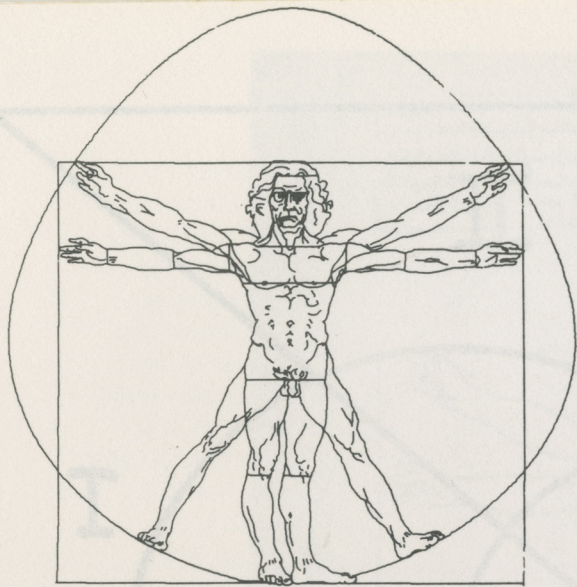line of the square.

Diagram showing the various stages of the
Leonardo transformation

# AUGUST LECTURES AT THE ICA

Thursday August 8th at 8pm

Frank J. Malina
REFLECTIONS ON THE DIFFERENCES BETWEEN
SCIENCE AND ART

"The debate between the scientist and the artist,
frequently most intemperate, especially from the
art side, will undoubtedly continue for a long
time to come.  The estrangement between the natural
sciences and art which became more and more acute
after the Renaissance with the growing success of
modern science, began to break down about the time
the camera was invented in France by Niepce in 1829
and perfected by the painter Daguerre.

But my experience after a number of years of
work in the engineering sciences, mainly
astronautics, and in the visual arts, especially
with light and movement or 'kinetic' art, leads
me to believe that the misunderstandings are
still far from resolved.  This state of affairs
is caused, not only by the confusion in the mind
of artists about the objectives of science, but
also by the failure of the theoreticians of art
to put forward hypotheses which command the
respect of either the practitioners of art of
of science."

Frank J. Malina works in the fields of astronautics,
geophysics, international scientific co-operation
and the visual arts.


Tuesday August 13th at 8pm

Professor Herbert Brun
COMPOSER'S INPUT OUTPUTS MUSIC

The link between the computer system and the
composer of music is 'The Program'. The composer
may think of himself and his mind and his ideas
in any way he pleases, until he decides to use the
computer as an assistant.  From that moment on
the composer must envisage himself, his mind, and
his ideas as systems, since only systems can
be translated into that language, the program,
which can generate their analog appearances in
the computer.  Under control of a program, the
computer system will simulate all the
processes in and of the particular system which

the program represents.  The main problem thus
appears at the beginning and again at the end
of the entire proposition:  Can the composer
program musical ideas for a computer, and will
the output of the computer contain musical ideas?

Another problem, especially for the more philoso-
phically inclined composer, tends to become more
acute as his work progresses:  If it should be
proven that everything is possible, that every
sound, every constellation, every logical or
random process is available - in short, if
everything thinkable <u>can</u> be done, why then go
ahead and still do it?

In the lecture Professor Brun will attempt to
deal with some less obvious aspects of such
problems to propose some methods for analysing
or even solving them. He will also present a
number of the computer's audible and visual
outputs.

Herbert Brun, composer and lecturer, is concerned
with the function of music in society, and has
been teaching at the School of Music of the
University of Illinois since 1963.  He is
primarily involved with research on the
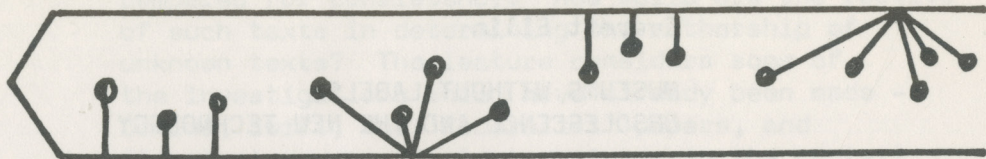significance of computer systems for the
composition of music
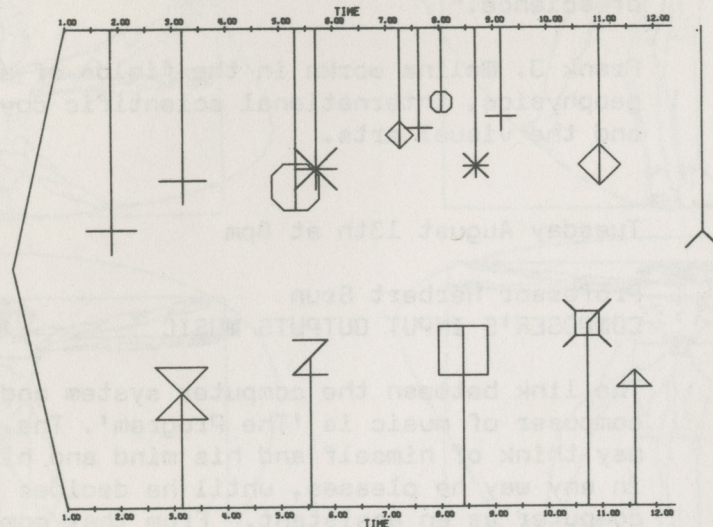


Instructions to the performer and a part
of the score from Herbert Brun's 'Stalks
and Trees and Drops and Clouds' 1967.
The complete score consists of 31 pages,
and would last about 7½ minutes in
performance.  It was composed on an IBM
7094 computer.

To the performer of STALKS AND TREES AND DROPS AND CLOUDS:



You need **two sets of instruments.**

Set A, for STALKS AND TREES:   Seven non-reverberating instruments,
dry, dead, explosive, whipping, rattling, wooden, etc. Preferably,
but not necessarily, just <u>one</u> of each of seven <u>very</u> different kinds.
The seven symbols for Set A, and the number of times each appears in
the score:



48       31       17       16       14       9       8
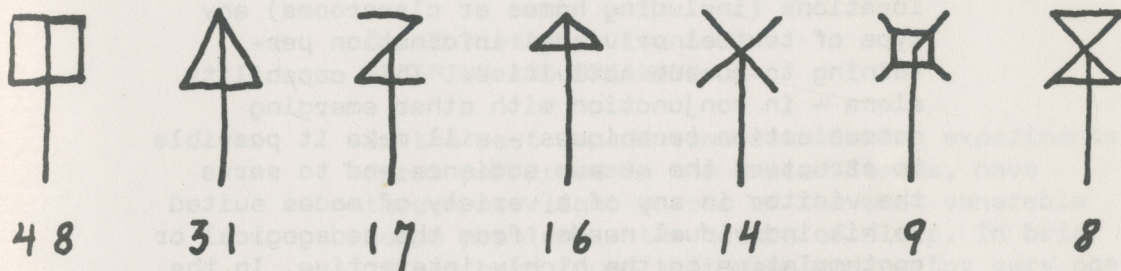
Set B, for DROPS AND CLOUDS:  Six reverberating instruments, resounding,
ringing, vibrating, sizzling, noisy, whispering, etc.  Preferably, but
not necessarily, several of each of six <u>very</u> different kinds.  The six
symbols for Set B, and the number of times each appears in the score:



65        43        37        18        18        15
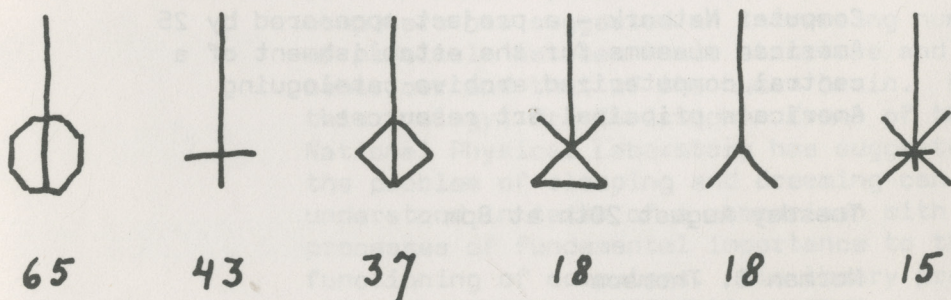
During the first preparatory stage (see General Preface) you have to
determine the particular kind of instrument, which each symbol will
represent throughout the piece.

Thursday August 15th at 8pm

Everett Ellin

MUSEUMS WITHOUT LABELS:
OBSOLESCENCE AND THE NEW TECHNOLOGY

As the ascending population curve, the implosion
of leisure time and the public's runaway appetite
for recreational/educative input close on a
collision course, the classical museum experience
is facing accelerated obsolescence.  If museums
are to continue to serve a growing audience
already attuned to multi-sensory levels of
reception, they must reconcile themselves to
a sweeping redesign of their traditional
services and facilities.  Dramatic advances
in computer technology will, for example,
soon permit the assembly of electronic archives
which can store, and deliver to even remote
locations (including homes or classrooms) any
type of textual or visual information per-
taining to museum activities.  This capability
alone - in conjunction with other emerging
communication techniques - will make it possible
to structure the museum audience and to serve
the visitor in any of a variety of modes suited
to his individual needs, from the pedagogical or
contemplative to the highly interactive. In the
not-too-distant future, new technology promises
to reshape and expand the museum environment
in ways which can be scarcely imagined today,
and to insulate it form the cultural overload
that may presage its demise.

Everett Ellin has practised law, worked as an
art dealer, curator and teacher. Recently, he
has become Executive Director of the Museum
Computer Network - a project sponsored by 25
American museums for the establishment of a
central computerized archive cataloguing
America's principal art resources.


Tuesday August 20th at 8pm

Norman D. Thomson
WHO WAS MARTIN MARPRELATE?

Computers have made possible feats of enumeration
previously beyond the bounds of human patience.
In the field of literature, statistics about words,
sentences, parts of speech etc can be obtained

rapidly and accurately, and different texts
compared for consistency.  How valid are the results
of such texts in determining the authorship of
unknown texts?  The lecture considers some of
the investigations which have already been made -
Junius, Swift, the 'Federalist' papers, and
illustrates some simple techniques in the context
of Victorian and Elizabethan authors, and describes
the problem of the authorship of the Marprelate
pamphlets, and the work currently in progress on it.

Norman D. Thomson is a schoolmaster at
Gordonstoun School in Morayshire.  The application
of computers to literary problems has been his hobby
for some years, and his first completed work in this
field was an analysis of the chronology and style
of the Greek writers Xenophon and Thucydides.


Tuesday August 27th at 8pm

Dr. Christopher Evans
SLEEPING AND DREAMING


In the past decade some astonishing experiments,
first performed in the United States, have
thrown new light on one of the most venerable
human problems - the nature of sleep. In brief
it has been found that people dream for very con-
siderable periods of the night (instead of merely
in momentary bursts as had been previously thought);
it has also been found that people deprived of the
opportunity to dream soon became psychologically
disturbed.  The difficulty has been to make sense
of this exciting material - what can possibly
be so important about sleeping and dreaming
that we spend as much as a third of our lives at
it?  In recent years the development of advanced
computers has suggested an increasing number
of parallels between their structure and
behaviour and that of the human brain.  Persuing
this analogy, Dr. Christopher Evans of the
National Physical Laboratory has suggested that
the problem of sleeping and dreaming can be
understood in terms of a comparison with certain
processes of fundamental importance to the correct
functioning of computers.  His theory proposes
some interesting modifications in our current
conception of the nature of sleep and he will
discuss it in relationship to such topics as
psychoanalysis, the use of sedative and
hallucinogenic drugs, and the changing of sleep
requirements of the aged.

35

Dr. Christopher Evans is Principal Research Fellow
in the Division of Computer Science at the National
Physical Laboratory.  His main research interests
lie in the field of human visual and auditory
perception.  His new theory of dreaming, first
published in 1964 as a speculative work, has
since received interesting experimental
confirmation.  Dr. Evans is Psychological
Consultant to the ICA.


MUSIC COMPOSED WITH AND PLAYED BY COMPUTER
Thursday 29th August 8 pm

admission 7/6  ICA members 5/-
or by exhibition season ticket

a concert of taped computer music during the
Cybernetic Serendipity exhibition, from
The Experimental Music Studio
of the University of Illinois
Works by Lejaren A Hiller, Herbert Brun, Gary
Grossman, James Cuomo, and others
with commentary by Herbert Brun
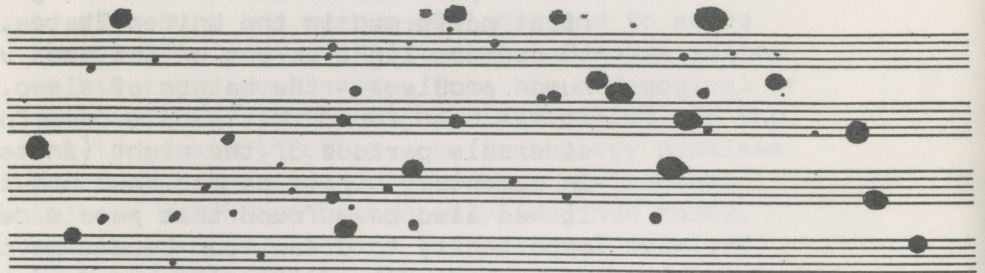


Page from a score by Lejaren A. Hiller
Random music can be composed by spattering ink
from a brush onto blank music paper (top).  When
the spots are transcribed (bottom), the horizontal
distance between them defines their time value.
Meters are obtained by drawing cards from a deck.

AXIOM GALLERY
79 Duke Street, W.1.
493-6646
CURRENT PROJECTS
Including Lijn, Walker,
Milow
Until September 7

GREENWICH THEATRE
ART GALLERY
Crooms Hill, Greenwich S.E.10
858-7755
August 13 - September 24
McLean/MacLeod/Tebby
Paintings and Constructions
1.00 - 6 pm daily (Sat & Sun)
Closed Mondays

DRIAN GALLERIES
5 - 7 Porchester Place
Marble Arch, W.2.
SANDRA KINGSLEY
Sculpture - Paintings
GIDEON KOLB
Paintings
August 6 - 23
SUSANNE LEVY
Paintings
From August 27

GROSVENOR GALLERY
30 Davies Street, W.1.
629-0891
FRIENDS & FAMOUS PEOPLE
Portraits - from caricature
to formal likeness
July 30 - August 24

GIMPEL FILS
50 South Molton Street, W.1.
493-2488
NOGUCHI
Until August 24

HANOVER GALLERY
32a St. George Street, W.1.
629-0296
THE 8 SCULPTURES
OF MAGRITTE
Until August 31

GRABOWSKI GALLERY
84 Sloane Avenue, S.W. 3.
536-1868
100th EXHIBITION
OF THE GALLERY
Until September 28

ANNELY JUDA Fine Art
IMPORTANT PAINTINGS
11 - 12 Tottenham Mews
off Charlotte Street, W.1.
580-7593
Mon-Fri  11 - 6 pm
Sats     10 - 6 pm

KASMIN GALLERY
118 New Bond Street, W.1.
629-2821
GROUP SHOW
Through August

MARLBOROUGH FINE ART
(London) Limited
39 Old Bond Street, W.1.
629-5161
SUMMER EXHIBITION
including new works
by Bacon, Kitaj, Moore
Sutherland

LEICESTER GALLERIES
22a Cork Street, W.1.
629-1159
SUMMER EXHIBITION
Paintings and Drawings
Sculpture

EWAN PHILLIPS
22a Maddox Street, W.1.
629-4204
19th and 20th Century
Paintings and Sculpture
Permenant collection
of modern jewellery

LONDON GRAPHIC ARTS
84 Grosvenor Street, W.1.
2nd Floor   493-4238
FINE ORIGINAL PRINTS
15th to 20th Century
Publishers of Contemporary
Printmakers

PICCADILLY GALLERY
16a Cork Street, W.1.
629-2875
SOME MODERN SYMBOLISTS
30 July - August 24

MARLBOROUGH NEW LONDON
17-18 Old Bond Street, W.1.
629-5161
ARNALDO POMODORO
Sculpture
Until Mid August

ROWAN GALLERY
31a Bruton Place, W.1.
493-3727
GALLERY ARTISTS
August

Membership Rates
Full Membership: £5.5.0. per year
Free admission to all ICA exhibitions.
Invitations to preview performances
and private views.
Priority booking and reduced rates for
cinema, theatre, music, poetry, lectures
and other events.
Regular diary of activities & the ICA Magazine

Standard Membership: £1.0.0. per year
Admission to all ICA exhibitions
at half-price or less.
Admission to ICA films and theatre performances.
Priority booking and reduced rates for music, dance,
poetry, lectures and other events.
Regular monthly diary of activities.

Cut off the lower section of this page and send it
to the Membership Secretary, ICA, Nash House, The
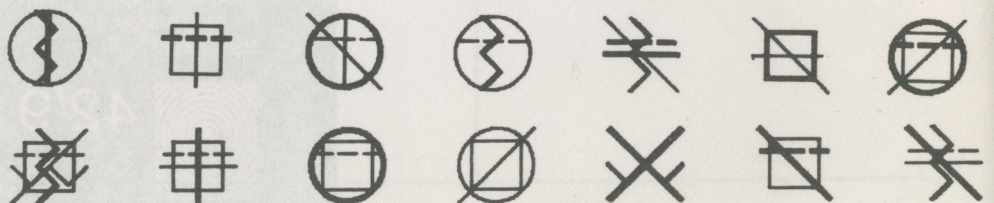Mall, London S.W.1.  For further.details enclose
S.A.E.

I would like to join the ICA for one year as a
Full/Standard member, I enclose £5.5.0./£1.0.0.
for my membership card & printed information.

Name
Address

Telephone
Date

# Arts Council Exhibitions

```
HAYWARD GALLERY
Southbank

Inaugural Exhibition
MATISSE
July 11 - September 8
Weekdays 10.30 - 7  Sundays 10 - 6
Admission 5/-




TATE GALLERY
Millbank
London S W 1

HENRY MOORE
70th Birthday Retrospective Exhibition
July 18 - September 22
Weekdays 10 - 6  (Tuesdays and Thursdays 10 - 8)
Sundays 2 - 6
Admission 5/-
```