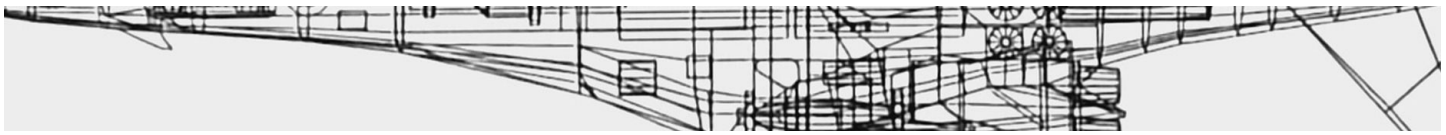
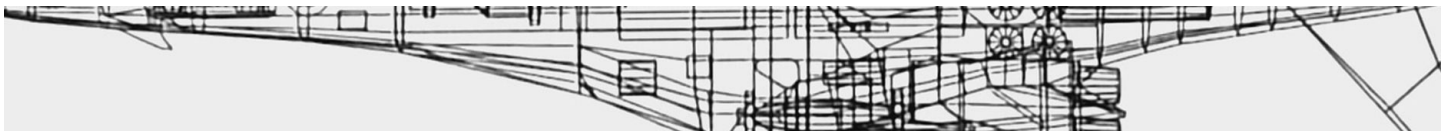


Wireframe Computer Graphics
Gareth Edwards
1980 to 1984

Contents



Introduction

My intention when compiling this document was to assemble various documents, and a portfolio of artwork, all dating from the early 1980's, into a self-explanatory visual narrative about my early years in the Computer Graphics industries. This was wishful thinking, and quite a lot of writing was also required to "tell the story".

This document tells the story of how an Art Student from Aberdeen, mastered drawing with a Pen Plotter, and then mastered Wireframe 3D Computer Graphics.

It is comprised of two parts:

Part 1: Mastering The Pen Plotter

A personal creative/technical history and an introduction to the Pen Plotter, the drawing device used for making all the line pictures in this document.

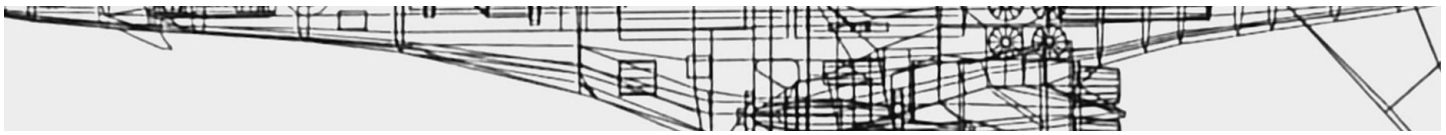
Part 2: Mastering Wireframe 3D Computer Graphics

The story starts with me being awarded a scholarship to study in Italy, and how this led to an interest in sacred geometry, which led to my developing a passion for using a Personal Computer and Architectural CAD, as a one and three-point perspective aids in my paintings:

This then leads too my being awarded the Royal Scottish Academy's Gillies Award in 1982 and gaining a place at the Royal College of Art (RCA), London, also in 1982 with the aim of exploring and better understanding use to what ends my newfound interest and skills could be focused:

The RCA introduced me to several leading world authorities in related areas, such as Digital Art, Artificial Intelligence and mathematical thinking and drawing. This led to me working as an assistant for Harold Cohen in his 1983 Tate, exhibition, and later becoming a Graphics Analyst working with Prof. John Vince in 1983:

Finally:



The Tale of Three Pen Plotters

From 1980 to 1984, I mastered with computer graphics how to create 3D imaginary objects in 3D imaginary worlds with numbers, and how to turn these numbers into 3D scenes made up of 3D lines, and how to draw these in 2D onto paper.

This process of drawing 2D lines onto paper is called pen plotting and was – and still is – done using a **Pen Plotter**.

What is a Pen Plotter?

There are three different types of plotter: a flatbed plotter, with a pen that moves in X and Y to draw lines; a flatbed plotter, where the paper moves in the Y axis and the pen plots in the X axis; and a drum plotter where a roll of paper is scrolled backwards and forwards in the Y axis as and the pen plots in the X axis. Most small flatbed plotters (e.g., A3 paper size) lie flat (on a desk). Large format (e.g., A0 paper size) plotters are often mounted vertically.

How did I master the Pen Plotter?

I was awarded a scholarship in 1978 to study in Tuscany and was introduced to the Quattrocento by a former member of the WW2 British “Monuments Men”. I studied in Florence, Arezzo and San Gimignano, and worked in the Duomo in Sienna. During that time, I was introduced to many Renaissance Artists, including Fra Angelico, Paolo Uccelo, Massacio, and especially Piero Del la Francesca. From this I became obsessed with Sacred Geometry, and it’s use in my art.

“Sacred Geometry explores the belief that certain geometric shapes and proportions hold spiritual significance and are present throughout nature and art. It's seen as a universal language connecting the physical and spiritual realms, often used in sacred spaces and architecture to symbolize order and harmony. Key concepts include the Golden Ratio, Platonic solids, and specific geometric patterns like the Flower of Life. Considered a perspectival manifesto, Masaccio’s ‘Trinity’ fresco, has been shown to bend the rules of one-point mathematical perspective, probably because it looked better that way.” Amanda Lillie, NG.

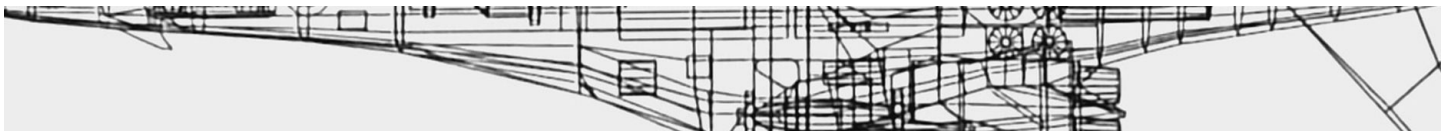
In 1980, my 4th year at Gray’s, one of my friends used his wife’s Academic credentials to gain access to the University of Aberdeen University’s Personal Computers. This was a small room with lab benches down both sides and in the centre, on which were crowded several dozen Personal PCs. These included the Zilog Z-80 Microcomputer System, Commodore PET 2001-32N, TRS-80 Microcomputer System and the Sharp MZ-80K.

It was however the Apple II+ which caught my eye, with its simple vector graphics games including one in which the player as a WW1 pilot “flew” over enemy trenches and dropped bombs. All depicted with only a very few vector lines on a very low-resolution (280x192, 6 colour) screen. And it was with this PC that I started programming graphics. I realised that – if I could master the programming and maths required – I could use this graphical machine as a tool to explore Sacred Geometry.

“The Apple II, developed by Steve Jobs and Steve Wozniak in the late 1970s, is recognized as the first successful preassembled personal computer, marking a significant milestone in the evolution of computing. It emerged from a period when computers were primarily viewed as tools for scientific and business applications, with little consideration for personal use. ” Ehrhardt, George R.

By dint of hard labour, I painted and sold (much harder!) a stack of paintings and bought my first PC: an Acorn Atom (which I bought in kit form for £120, and self-assembled, with some soldering required). The now very famous BBC Micro Model B began life as an upgrade to the Atom, and this I bought in late 1981, for (I think) £399. Multiply these £ #’s by 4 or 5 to get 2025 prices. To learn programming, I enrolled in evening classes at Robert Gordons College (now University) of Technology.

Pen Plotter #1: In my 4th year and post-graduate year at Gray’s School of Art in Aberdeen, I taught myself to create 3D scenes using professional architecture CAD software at the Scott Sutherland School of Architecture, **which could be plotted in 2D onto overhead projector acetate sheets, then projected onto a canvas or paper, and used as the perspective underdrawings for whatever I was working on**. This was considered revolutionary by my tutors at Gray’s School of Art. When I needed financial help to continue my computer aided pen-plotting drawing studies at the Royal College of Art in London, they brought my work to the attention of the Royal Scottish Academy. They decided to award me the Gillies Award, which was £1,000, and a welcome contribution to my first year in London. I knew that I would need to raise a lot more funds but estimated that I could make enough money to live by selling my own computer games, and by part time lecturing and teaching.



Plotter #2: In my first year at the Royal College of Art, Painting School, **I learnt how to design and build my own professional 3D CAD software, and how to use this software to make drawings with a Radio Shack TRS-80 pen plotter.** The RCA then used this to showcase their support for me by bringing what I was doing to the attention of some of the most world's most famous technology artists. One of these, Harold Cohen, asked me to be an assistant curator for his 1983 Tate Gallery exhibition. By then I was an expert in pen plotters, and pen plotter software. This exhibition featured Aaron 2, an AI image generating program, which needed an expert in pen plotters to manage plotting these images and consequently he considered that I was a very useful person to have as an assistant.

Plotter #3: In the weeks preceding the Harold Cohen Exhibition, I was awarded the post of Graphics Analyst at Middlesex University (then Polytechnic) to work for Prof. (then Dr.) John Vince. In the early 1980's he was one of the most highly regarded European experts in Computer Graphics and author of the PICASO (PIcture Computer Algorithms Subroutine Orientated). PICASO was a FORTRAN (FORmula TRANslation) based computer graphics system designed to ease the interface between various creative and technical graphical problem areas. I had introduced myself to him early in 1983, and he took a shine to this ambitious young artist. After I had finished working for Harold Cohen, I immediately started work for John at the Middlesex University Bounds Green site in north London.

My role as a Graphics Analyst involved supporting and developing PICASO, providing maintenance support for PICASO and its graphical output onto vertical large format pen plotters, and assisting John as an animator doing private work for animated graphics for slits-can TV idents and logos. **This involved creating and animating 2D & 3D data sets (e.g., Channel 4 logo), and plotting each frame of this animation onto animation Cel's mounted on the plotter**. For this my knowledge and experience of plotters was very useful.

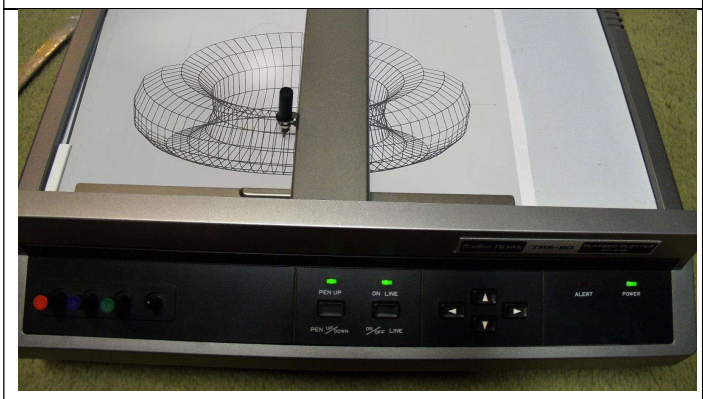
In September 1984, after working for a year with Prof. John Vince, I left to work for CAL Videographics, the very first digital video company – ever! CAL made pictures made up lines of pixels (**PIC**ture **EL**ement**S**, typically at the time 720 pixels x 576 lines, and yes, "pixels" works better than "picels") and so my days working with pen plotters was finally over. By then I had spent three years of creative and technical experience working with many of the top Artists, TV Graphic Designers and Commercials Agencies. My expertise shifted from making pictures from lines on a screen or plotted onto paper, to making animation from pictures comprised of pixels.

And that was that for plotters, except recently, when I started working on projects that require 3D printing, and a 3D Printer looks and works a lot like a Pen Plotter!

The Three Pen Plotters

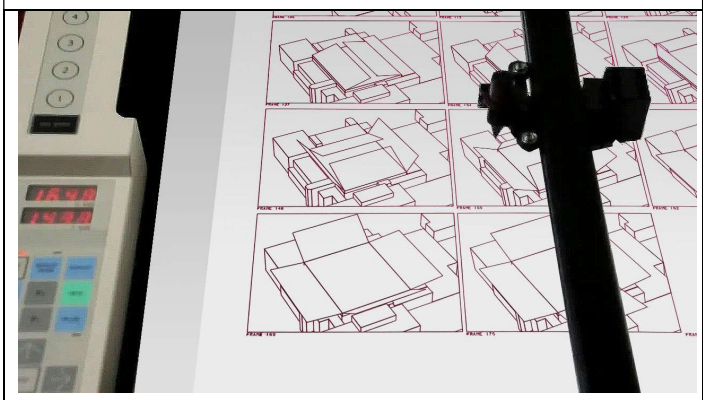
Plotter #1: Painting by Numbers, Gray's School of Art, 1980 to 1982

In my last two years at Gray's, I used the Scott Sutherland School of Architecture computer CAD system and pen plotter to draw one-point and three-point perspective for my paintings. For transposing the drawings to canvas or paper I plotted onto overhead acetate projector transparencies.



Plotter #2: Art & Digital Imaging, Royal College of Art, 1982 to 1984

In my first year at the RCA, I didn't have access to a pen plotter. The RCA kindly helped part finance the purchase of a Radio Shack TRS-80 FP-215 Flat Bed Plotter.

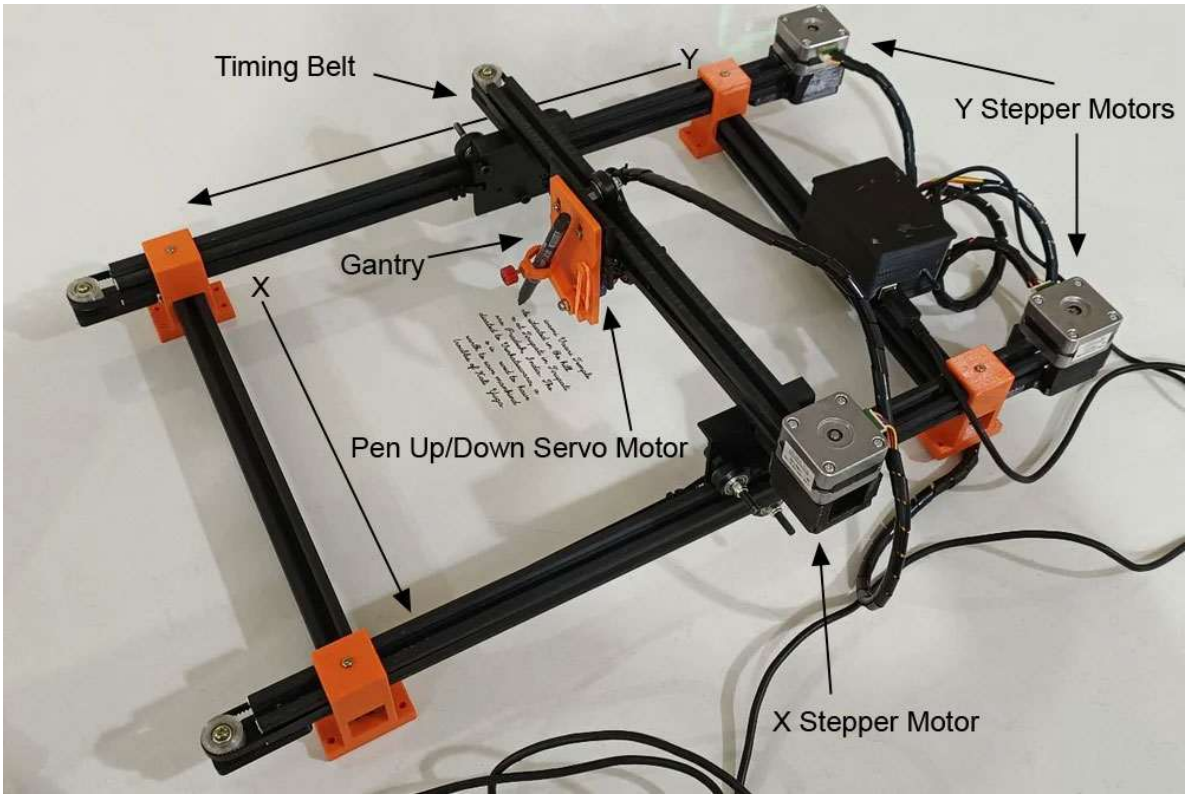


Plotter #3: PICASO/ICARUS, Middlesex University, 1982 to 1984

Finally, unlimited access to multiple very fast, industrial quality, pen plotters.

Typically, an animation test would be output on A2 paper, and when I was satisfied that the frame-to-frame difference would provide the quality or type of animation required, it was plotted frame by frame onto A3 or A4 animation CEL's.

Anatomy of a Pen Plotter



40+ years ago pen plotters were very expensive, difficult and costly to maintain.

Today hobbyist pen plotters can be purchased as plug & chug bits of highly affordable kit. But beware! Most are of very inferior quality. On close inspection even the most expensive (over £1,000) are often very poorly made.

Today they are often referred to as CNC (Computer Numerical Control) plotters, and are comprised of a 2D printing mechanism, and a microcontroller. For hobbyists this is typically an Arduino UNO (or similar). This accepts transmitted G-code (graphics-code) and tell the 2D printing mechanism what to do.

You can also assemble a pen plotter from parts sourced online, and there is a plethora of “how to build a pen plotter” web pages and YouTube videos.

However, the adage “you get what you pay for”, is apt. For extended usage, long plots, or high accuracy (suitable for handwriting), then companies such as IDrawHome XY manufactured by Robot House and based on AxiDraw by Evil Mad Scintist (really!), and range in price from £400 to £900. These are most others require assembly. There are a few pen plotter companies that manufacture high-end, complete pen plotters. These are typically very accurate and are often sold as “handwriting” machines for letters, envelopes, cards, and (ominously) signatures.

Painting by Numbers, Gray's School of Art, 1980 to 1982

Item printed in the Aberdeen Press & Journal in early 1982 (see next page)

Painting by computer

Aberdeen art student wins scholarship

AN ABERDEEN art student, who has just been awarded a £1000 scholarship, is setting out to prove that creativity and computers can go hand and hand. Gareth Edwards (24), 120 Walker Road, Torry, will use his award to study the application of computers to painting at London's Royal College of Art next [academic] year.

Gareth, a post-diploma student at Gray's School of Art, was nominated for the Royal Scottish Academy's Gillies Award by his college. The money will give him a chance to develop his skills in the fast-growing field of high-technology art.

"I will be working in a fairly unique area," he said. "But it is really beginning to take off now, and withing the next few years it should become quite well established.

" The work involves feeding information about an object into a computer, making it possible to create a three-dimensional image. "Later, the image can be used to help produce a painting, so the computer is really being used as a tool to help the artist."

To help develop his skill Gareth has been using computers at his college and the Scott Sutherland School of Architecture, Aberdeen. But he is so eager to tame the microchip and aid progress in conventional art that he bought his own home computer. "The only trouble with buying computers is that they are like cars," he said. "You get one and, after a while, you see something better and want to buy it."

Gareth, whose parents have since left the North-east was educated at Aberdeen Grammar School

Gray's School of Art

In my 2nd year my parents moved to Amsterdam, and after 5 years at Gray's it was my home. Several of my lecturers had to put up with me for many, years. Two of my lecturers, William (Bill) Littlejohn and Joyce Cairns, were especially helpful and kind. At the time I didn't fully appreciate the time and effort that these two truly outstanding people and great artists, put into me.

Bill (who seemed always to have a lit cigarette on the go) in particular, invested much time in formal personal tuition. Joyce (who also almost always had a lit cigarette on the go) dropped by to interject pithy observations about what I could do better. Both realised that by my post-graduate year I needed to go on to a place where my adventure could be better supported. I didn't understand at that time what the impact of my computer graphics research might be, but later – from many remembered conversations - I came to understand that they both had!

Painting by Computer, Gray's School of Art 1982

McKAY — ANDREW McKAY

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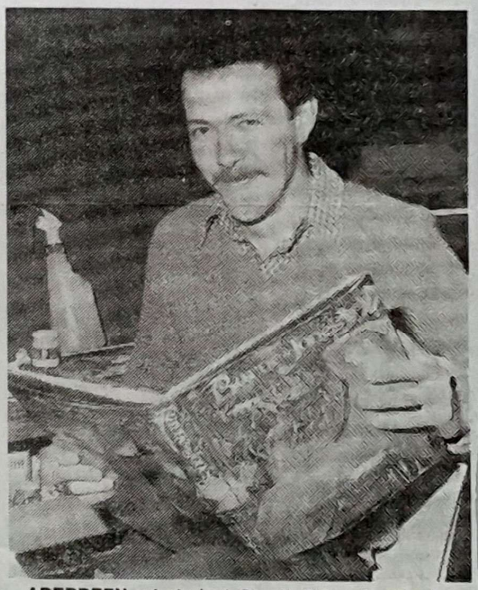


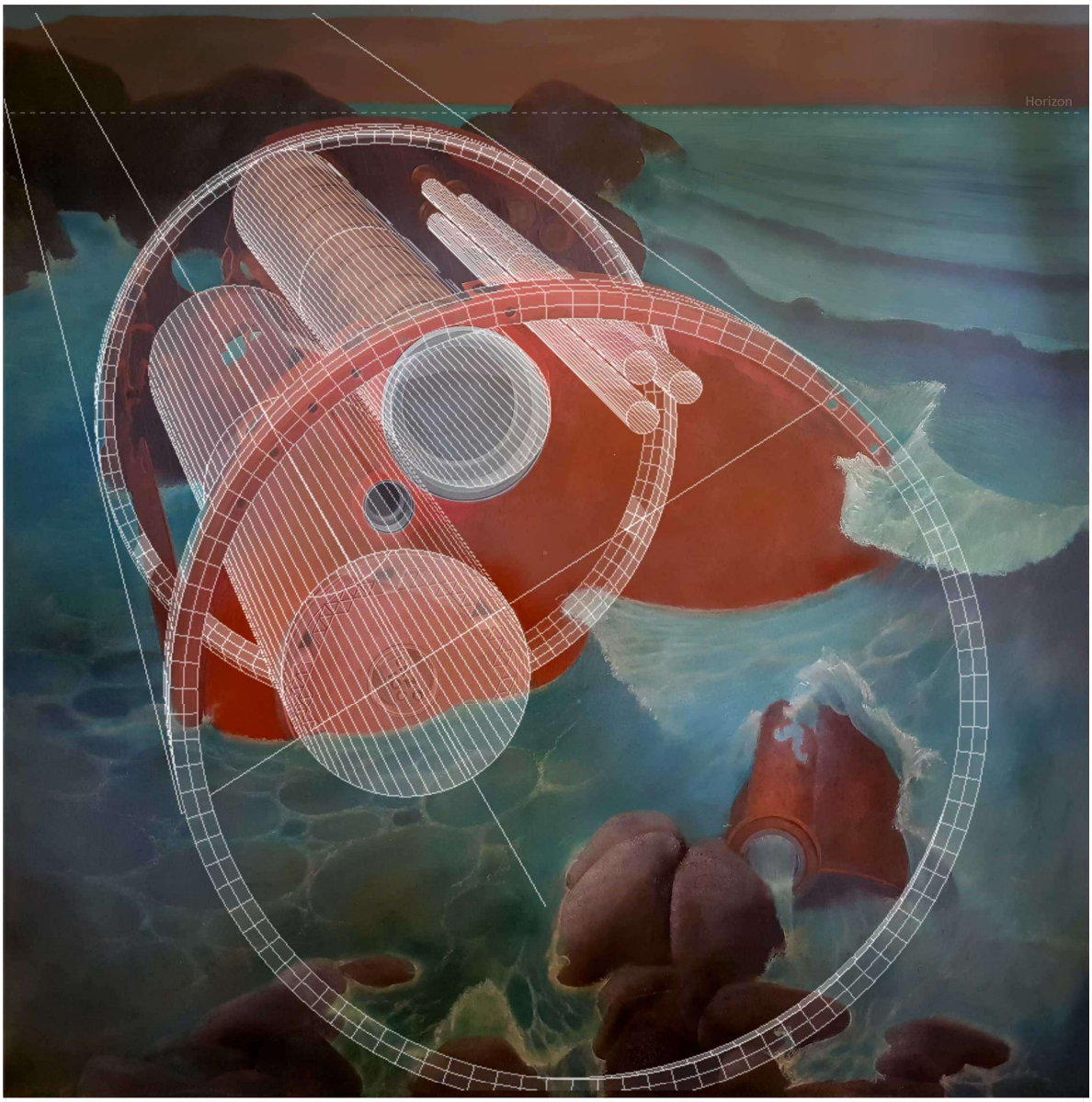
ABERDEEN art student Gareth Edwards who has won the £1000 Royal Scottish Academy's Gillies scholarship, which he hopes to use to study the application of computers to painting.

I used the Scot Sutherland School of Architecture CAD systems to help plan the multi-point perspective for my paintings and create graphical output using a small format flatbed pen plotter.

My process was simple. I created draft 3D compositions on my home PC, then copied the data into the CAD system. I then output CAD drawings onto overhead projector acetate sheets which I then projected onto a canvas or watercolour paper. From this I would then create an under drawing for a painting. If I was disciplined about the projector/target surface projection alignment and registration setup, I could re-project to check perspective, add perspective features or enhance a painting.

Ben Screel Boiler, Gray's School of Art 1981

Oil painting (60" x 60") with SSSR 3D CG wireframe overlay showing perspective composition.



In this painting I wanted to achieve a synthesis between Japanese sea prints (e.g., Hokusai, The Great Wave) and European one-point perspective Renaissance paintings (e.g., Carlo Crivelli, The Annunciation, with Saint Emidius).

First, I photographed and sketched in situ the Ben Screel boiler (all that remained of a wrecked Aberdeen fishing vessel). Next, in my preparatory composition drawings, I "sandwiched" a flattened one-point perspective 3D pseudo-cylinder, with the back face "slipped" to almost touch the real-world visual vanishing point cue of the sea/land horizon and the front face just underlapping the bottom edge of the canvas.

These cues forced a viewer to accept that the boiler was within a real space, one which could not be "realistically" depicted, but could visually exist!

Ben Screel Boiler, Gray's School of Art, 1981

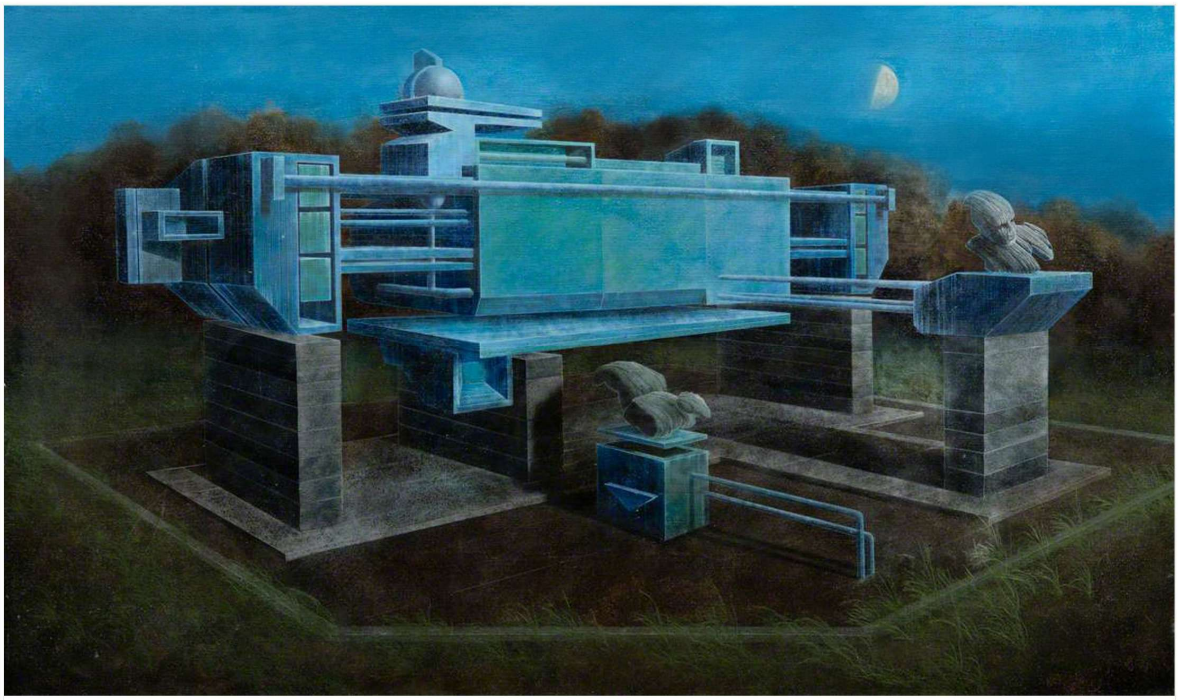
Oil painting (60" x 60").

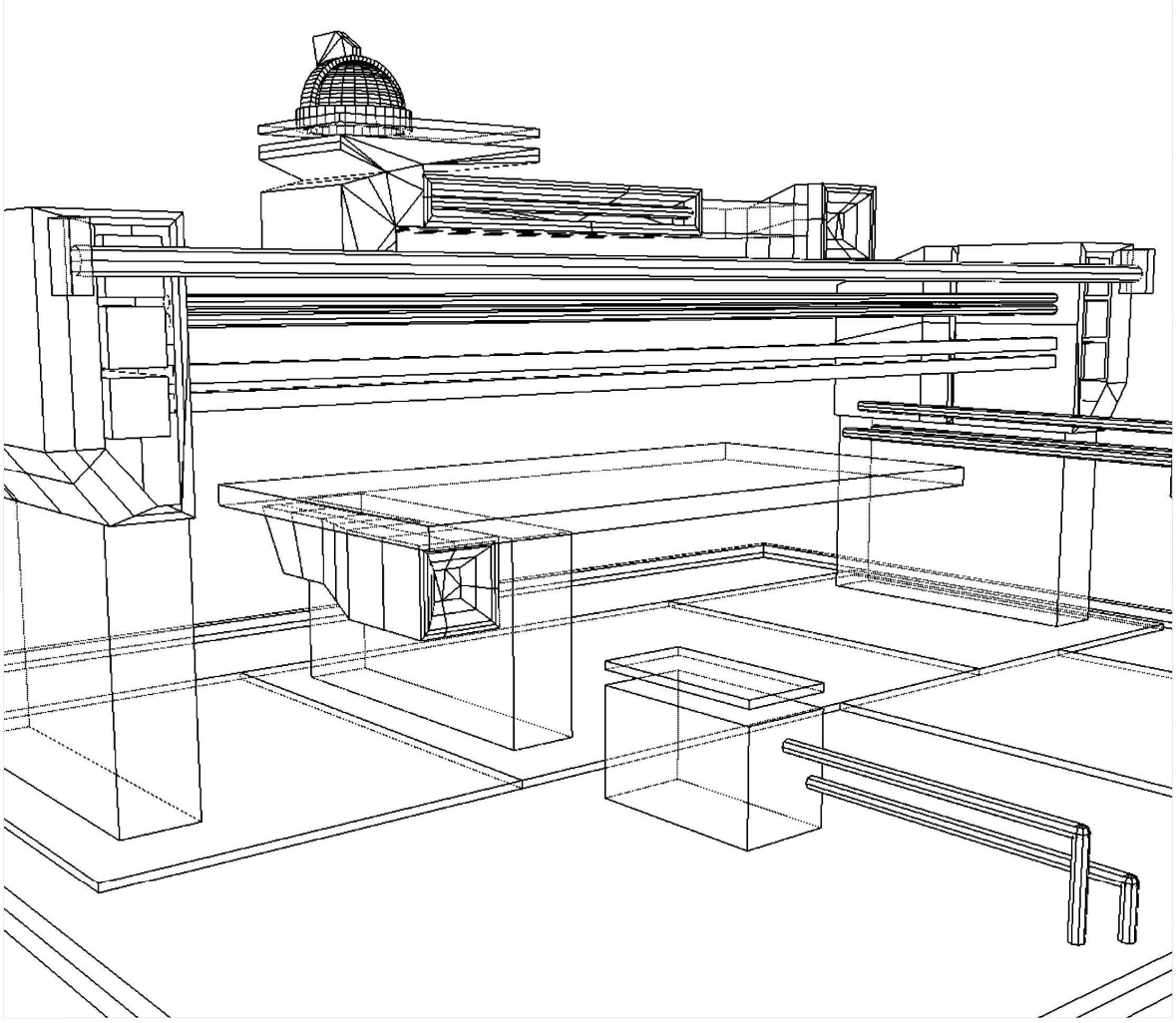
I wanted to create the illusion that the boiler and the sea are dangerously tipped up and threaten to crash down onto and over the viewer. However, the sea is frozen. There is no motion. There is no threat. I wanted to walk in the footprints of Renaissance one-point perspective Artists and find out why - though many showed that they were masters of three-point perspective – they chose one-point.

I concluded that by subtracting the other perspective dimensions that spatial one-point compositions provided for a viewer to "be" completely within a painting and its narrative. To my eye, one-point perspective also provided for a viewer to dwell more comfortably - with a "stillness of sacred geometrical experience" not found in three-point – within the composition. The one-point perspective 3D model is very complex and can be seen in in my Drawing & Painting web document.

Nyet, Gray's School of Art, 1981

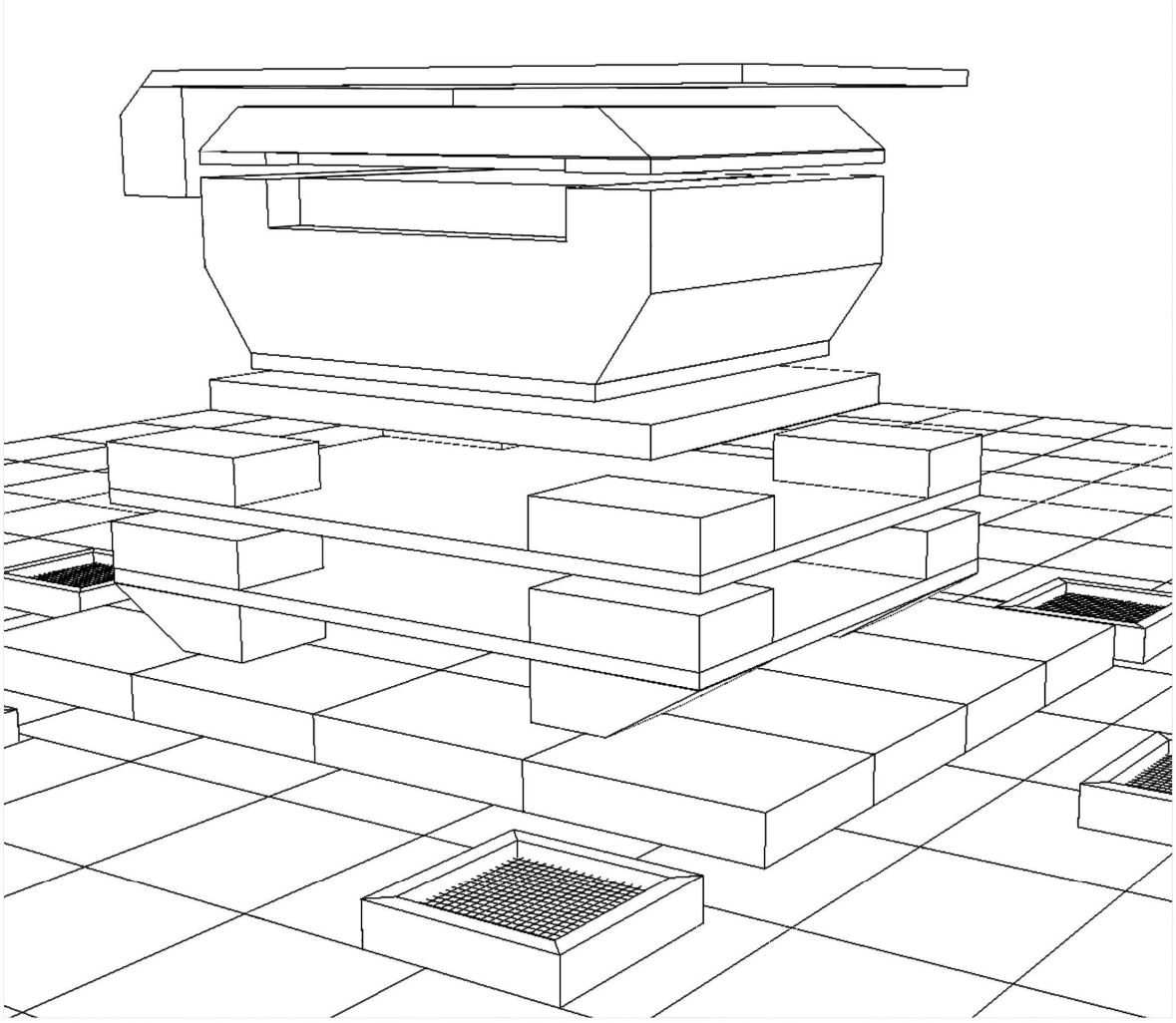
Oil painting (72"x42") with SSSR 3D CG wireframe perspective composition shown below.





Tomb, Gray’s School of Art, 1981

Oil painting (72”x42”) with SSSR 3D CG wireframe perspective composition shown below.



Art & Digital Imaging, Royal College of Art (RCA), 1982 to 1984

The Painting School treated me with great kindness and did their very best to try and understand what my strange new digital computer imaging technology (Computer Graphics) was, and how it could become a tool for the artist.

The Head of the painting School was Peter Laurent de Francia (25 January 1921 – 19 January 2012), an Italian British artist, who was Professor of Painting at the RCA. He often engaged me in long argumentative discussions about the nature of randomness (which I think he believed to be a core evil lurking at the heart of the new Computer Graphics technologies). When not doing this, he was charming and often offered constructive and practical help (such as buying me a desktop plotter). During an end of year viva, it was Prof. Peter who asked me if I would prefer to make pictures with my computer, or pin the code to the wall? I replied, “code”.

My Tutor Stephen Farthing (later Master at the Ruskin School of Fine Art and Fellow of St Edmund Hall, Oxford in 1990, and then Executive Director of The New York Academy of Art) was also very supportive. In 1984 when I was given the opportunity to stay on at the RCA and do a PhD. or take up a job in UK Film & TV Industry, he - without hesitation - told me to grab the job.

Both Prof. Peter and Stephen worked hard to introduce me to the leading Digital Artists & mathematical creative thinkers, including Harold Cohen, Edward Ihnatowicz, Annabel Jankel, Keith Critchlow, Keith Critchlow and Jasia Reichard. Several of my fellow students also became great friends and were very supportive. These included Jeremy (Jed) Gardiner and William Latham.

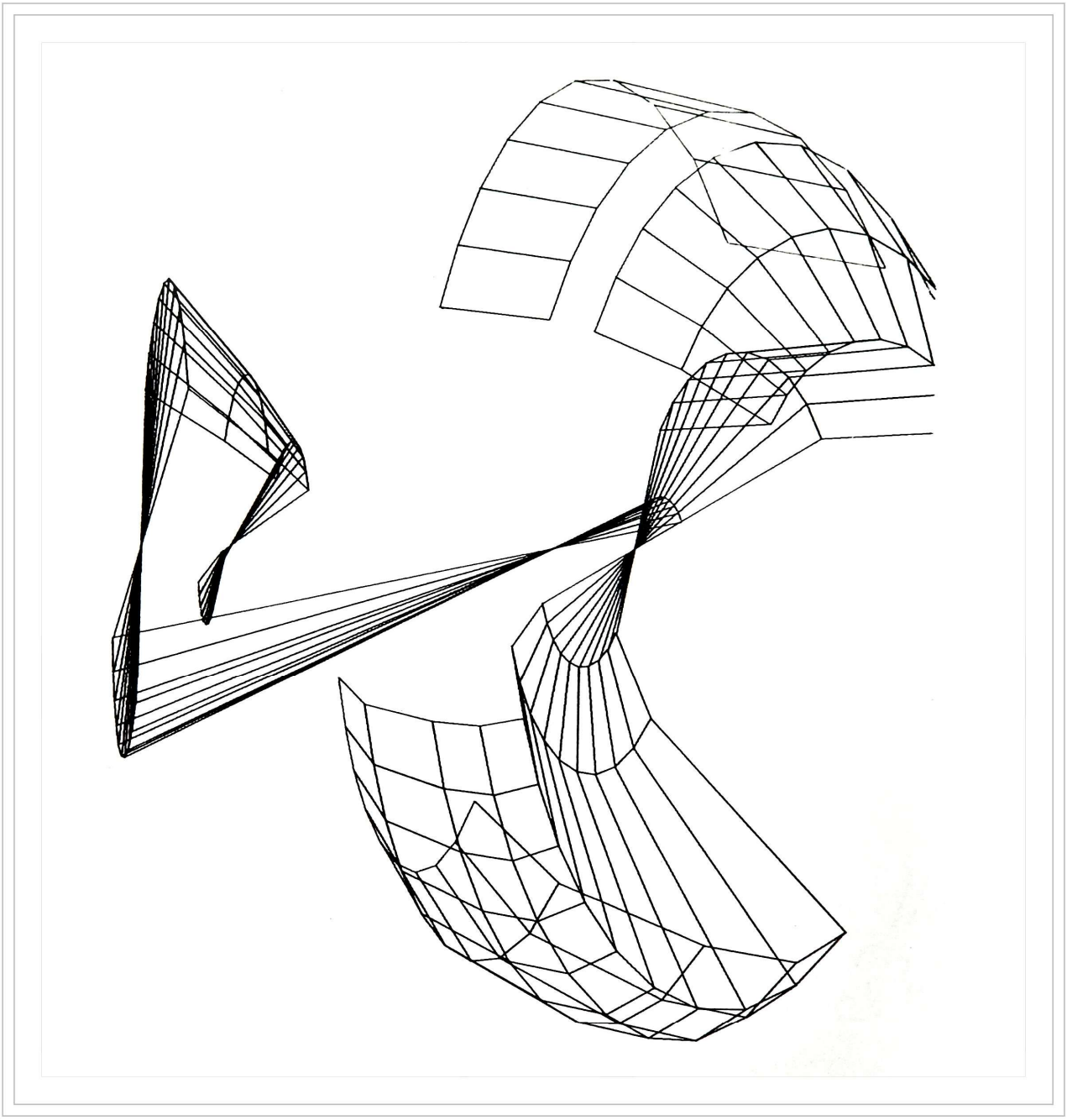
Prof. Peter also encouraged Harold Cohen and Keith Critchlow to work with me, which led to them giving much needed paid work in their commercial projects, examples of which can be found later in this document. I also received a lot of support from Edward Ihnatowicz, who later became a good friend, and whom I “adopted” and supported with my team at CAL Videographics in the mid 1980’s, not long before his death.

William Latham (now Prof. at Goldsmiths) has stayed in touch and brought me into many of his commercial projects. In 2008, to cover for him during a two-year sabbatical, he asked me to teach his undergraduate course at Goldsmiths. This led to him and his colleague Prof. Frederic Fol Leymarie, asking me to design, write, and then teach, a post-graduate MSc course in real-time Applied (e.g., architectural, industrial, scientific, computer gaming) Mathematics for Computer Graphics

My “Art” at the RCA was dominated by the complexity of the technologies I had to master to make great pictures with computer graphics. Despite this struggle, Prof. Peter worked hard to get me taken on as a full-time Ph.D. and even managed to find much of the required funds (something I did not know until many years later!). However, I left the RCA, and embarked on a 40 year+ career, at the cutting-edge of Computer Graphics. Initially this was in TV graphics (e.g., logos, idents, commercials) then in digital effects for Film, and now in multiple different industrial sectors, specialising in industrial inspection.

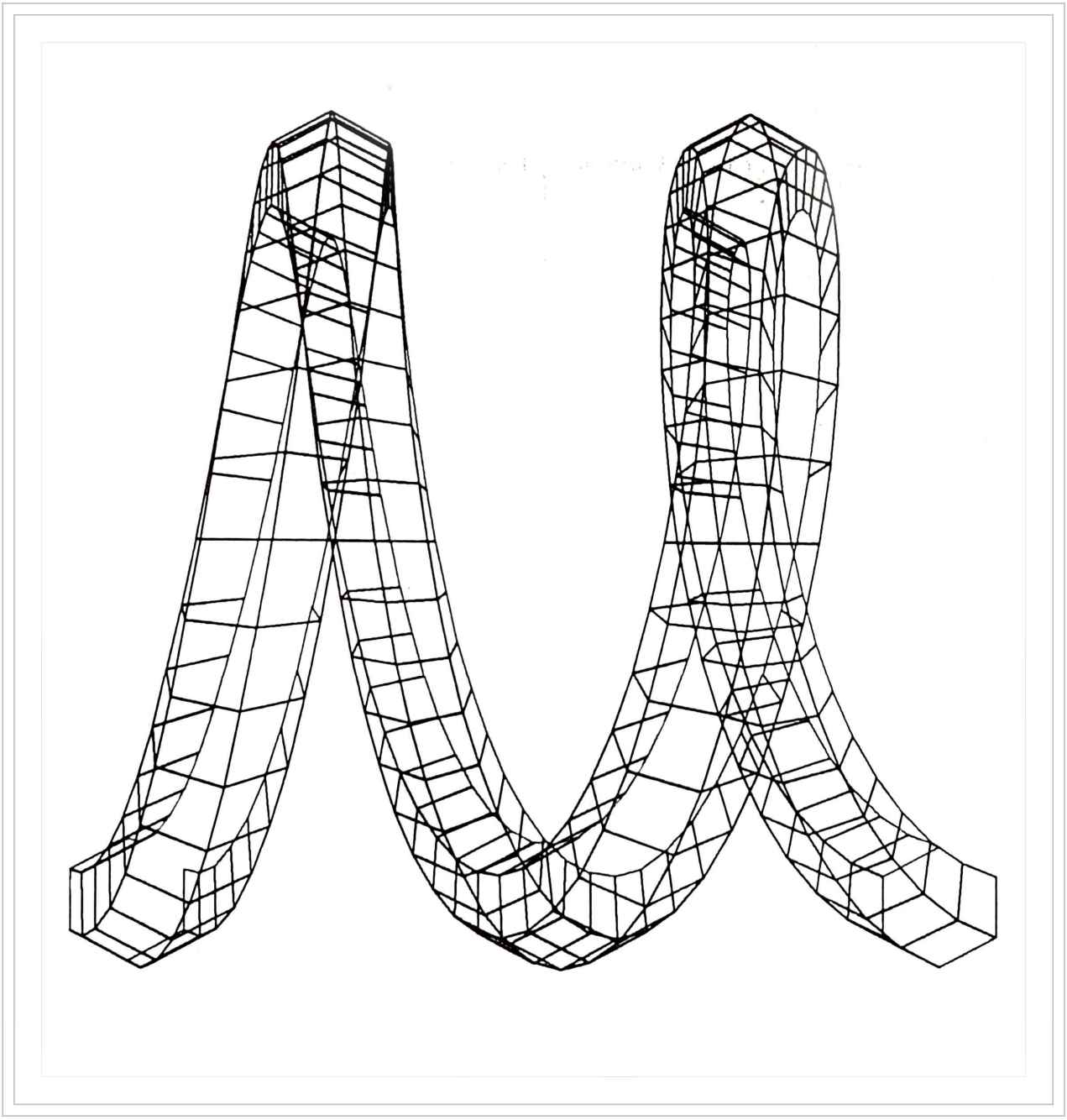
Rotational Spatial Construction, RCA,1982

3D CG A4 ink drawing (low quality desktop plotter).



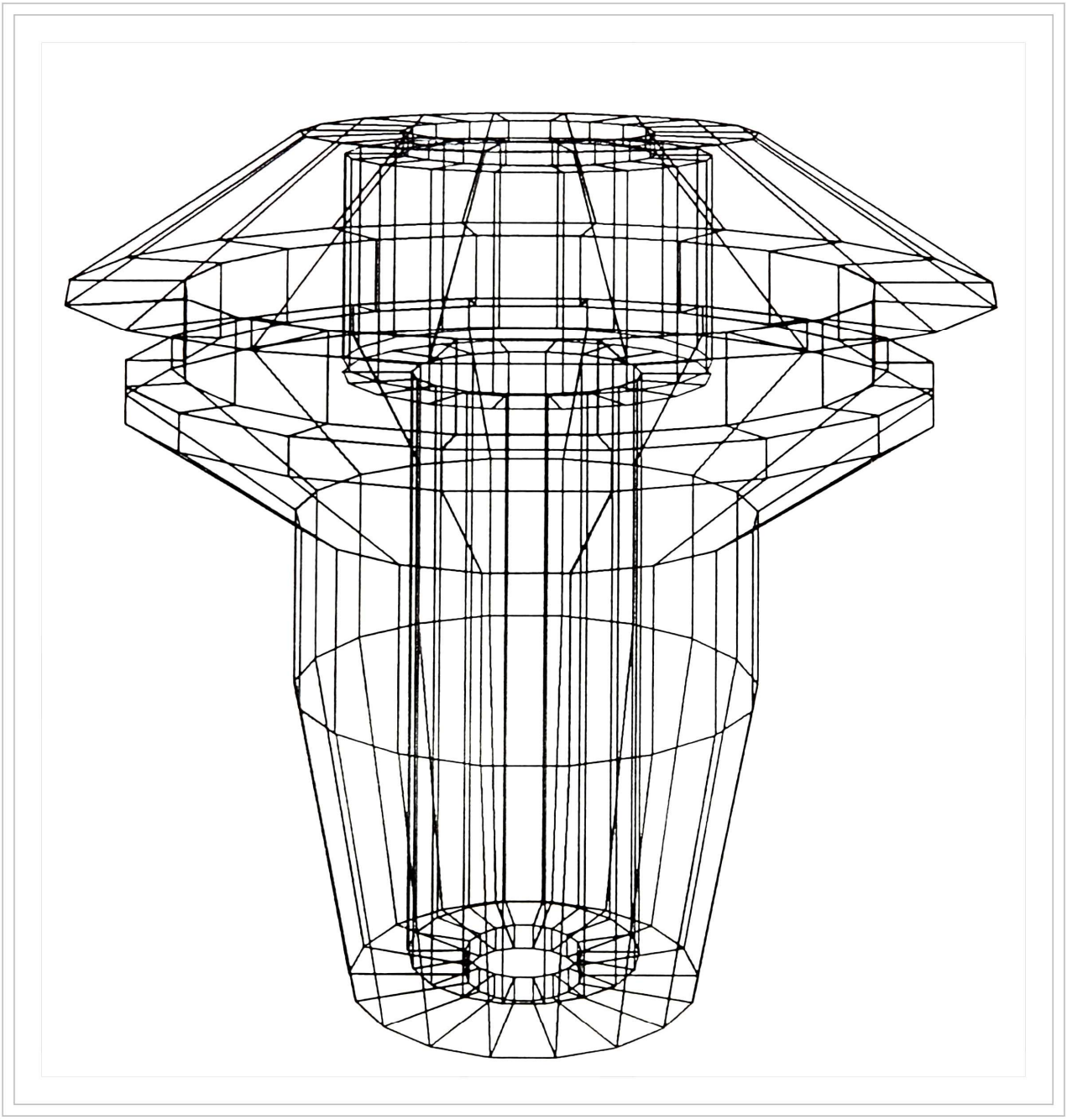
Spiral Spring, RCA, 1982

3D CG A4 ink drawing (low quality desktop plotter).



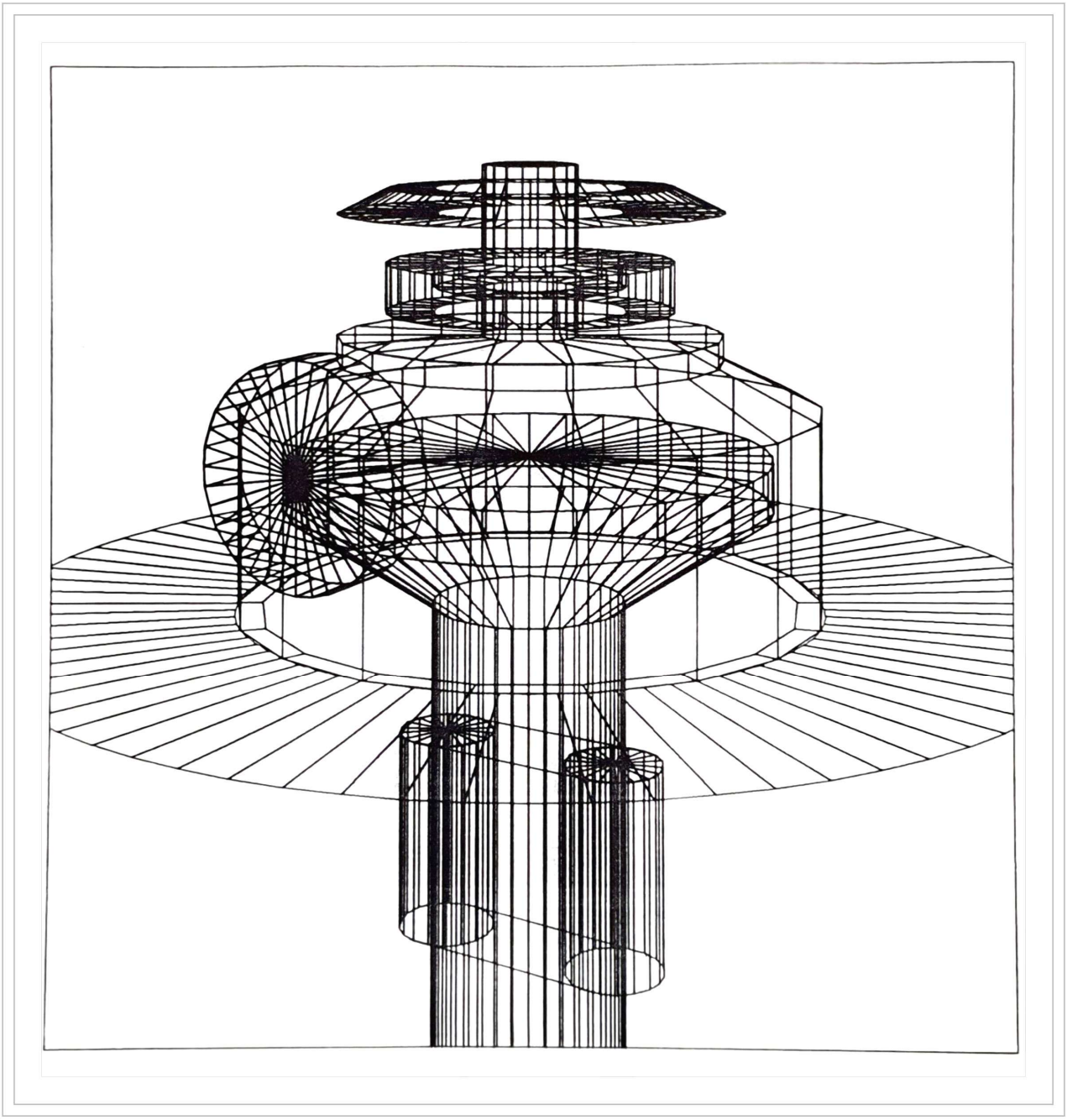
Rotational Object Construction 1, RCA, 1982

3D CG A4 ink drawing (low quality desktop plotter).



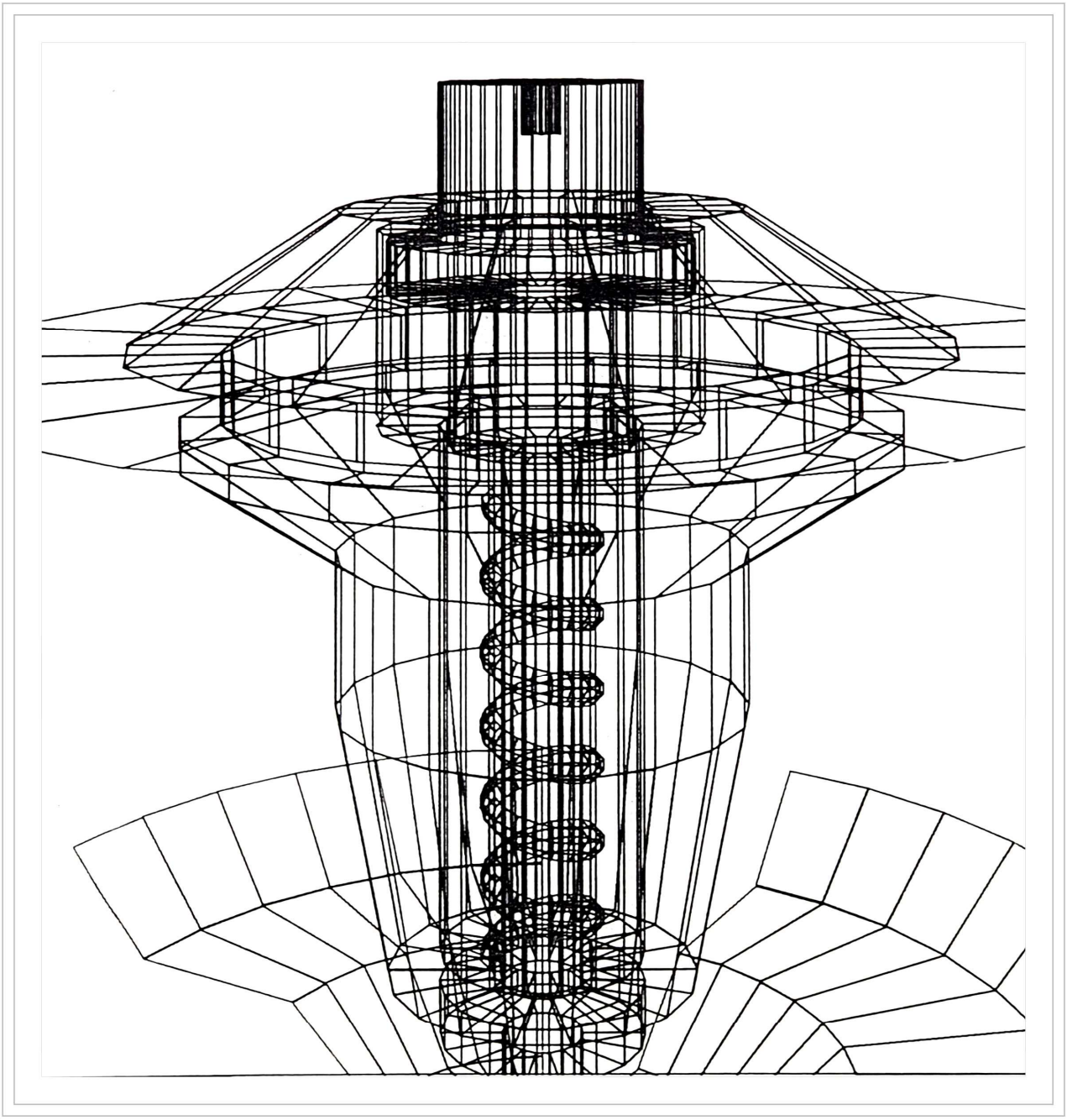
Rotational Object Construction 2, RCA, 1982

3D CG A4 ink drawing (low quality desktop plotter).



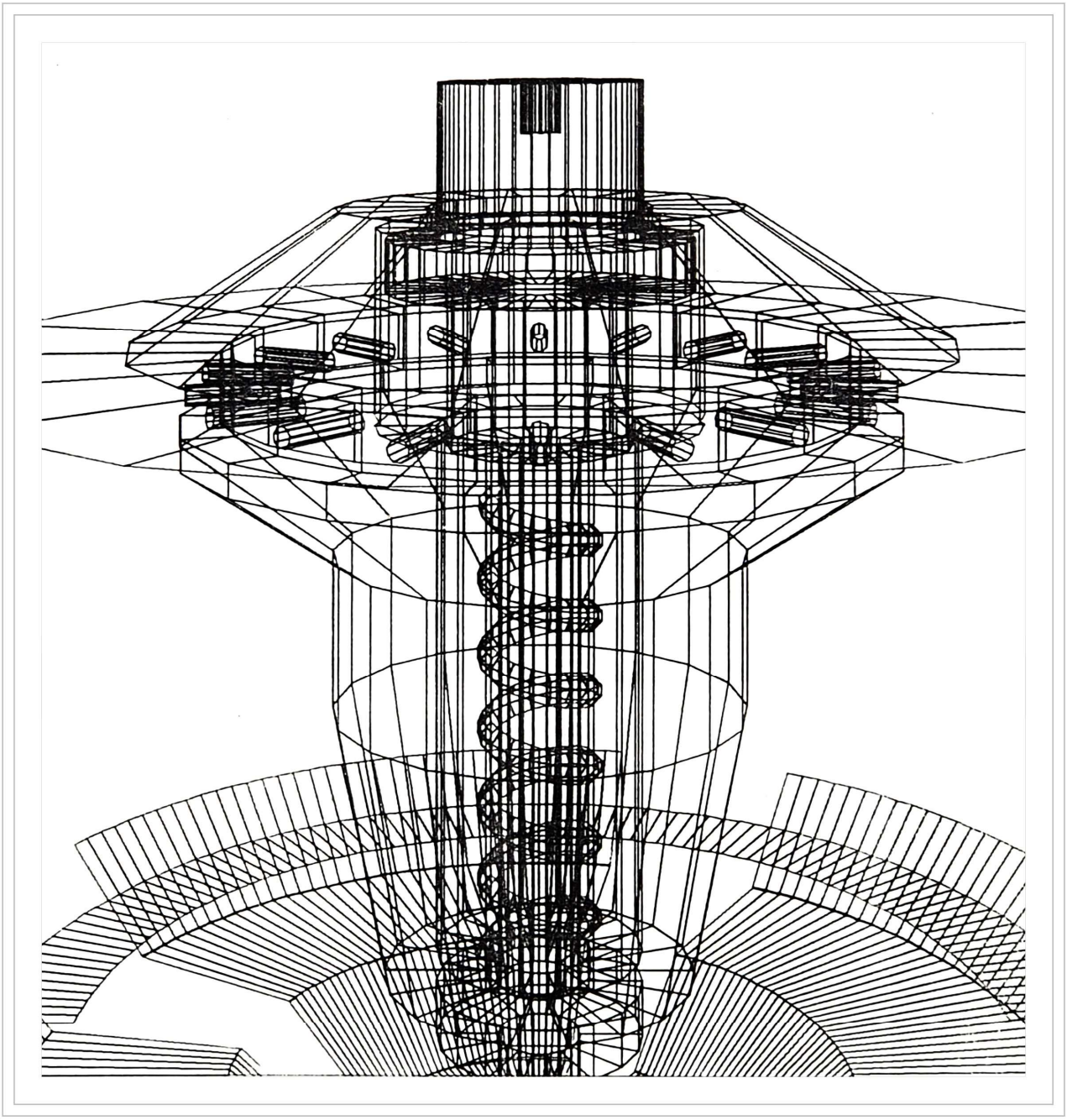
Rotational Object Construction 3, RCA, 1982

3D CG A4 ink drawing (low quality desktop plotter).



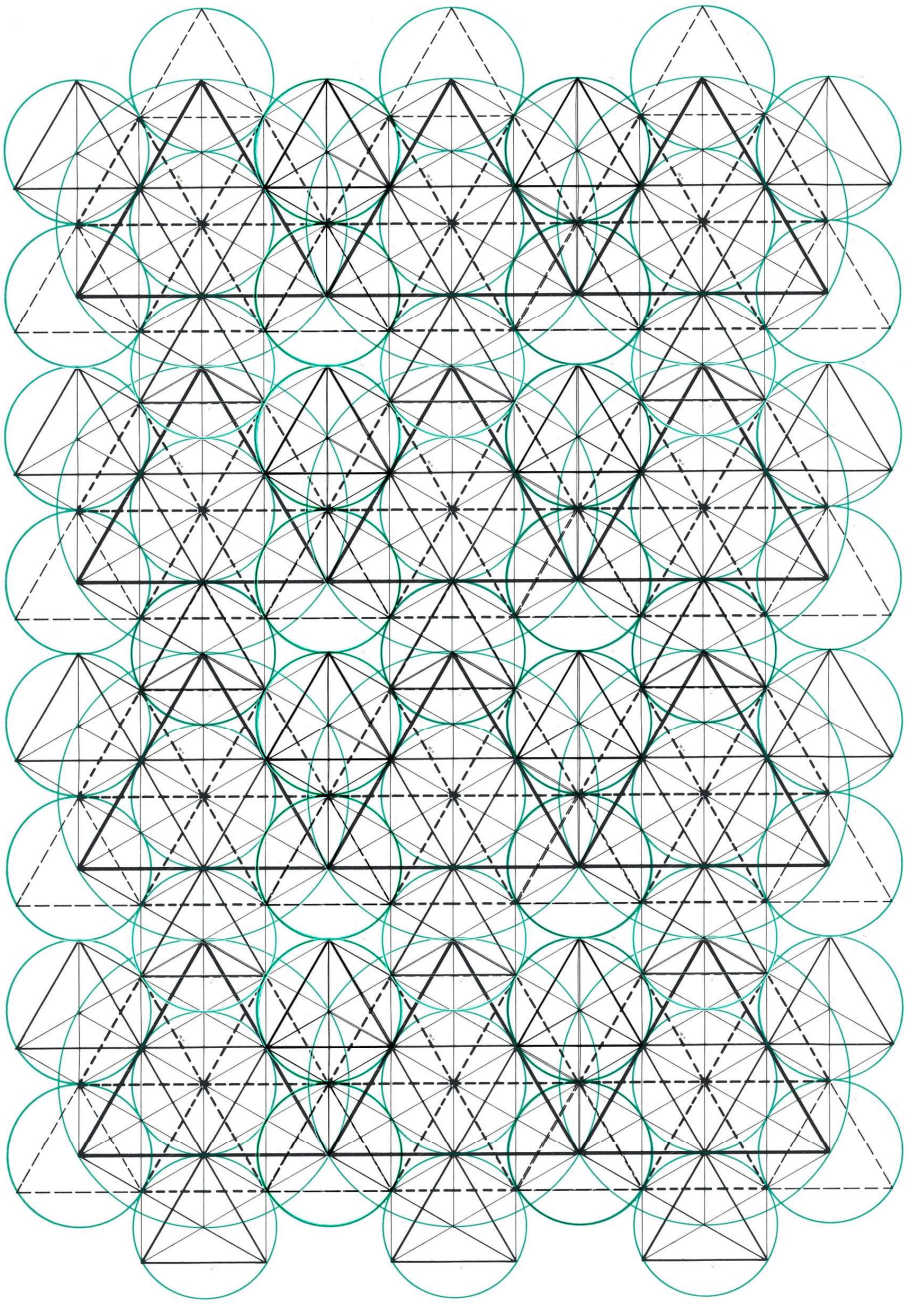
Rotational Object Construction 4, RCA, 1982

3D CG A4 ink drawing (low quality desktop plotter).



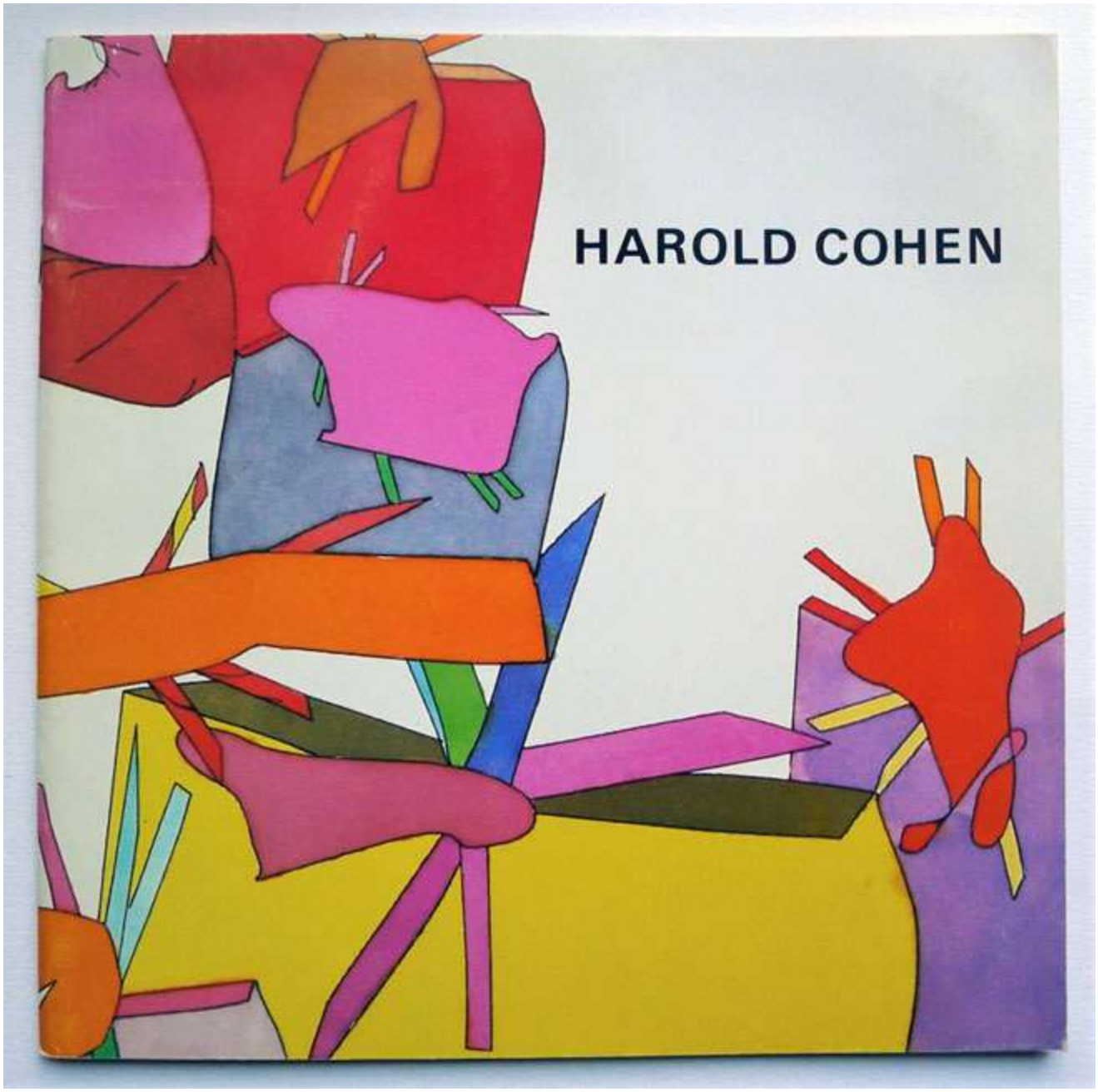
Islamic X Pattern Constructor, Keith Critchlow, 1982

3D CG A3 ink drawing (low quality desktop plotter).



Harold Cohen, Tate Gallery, 1983

AARON 2, University of California San Diego.

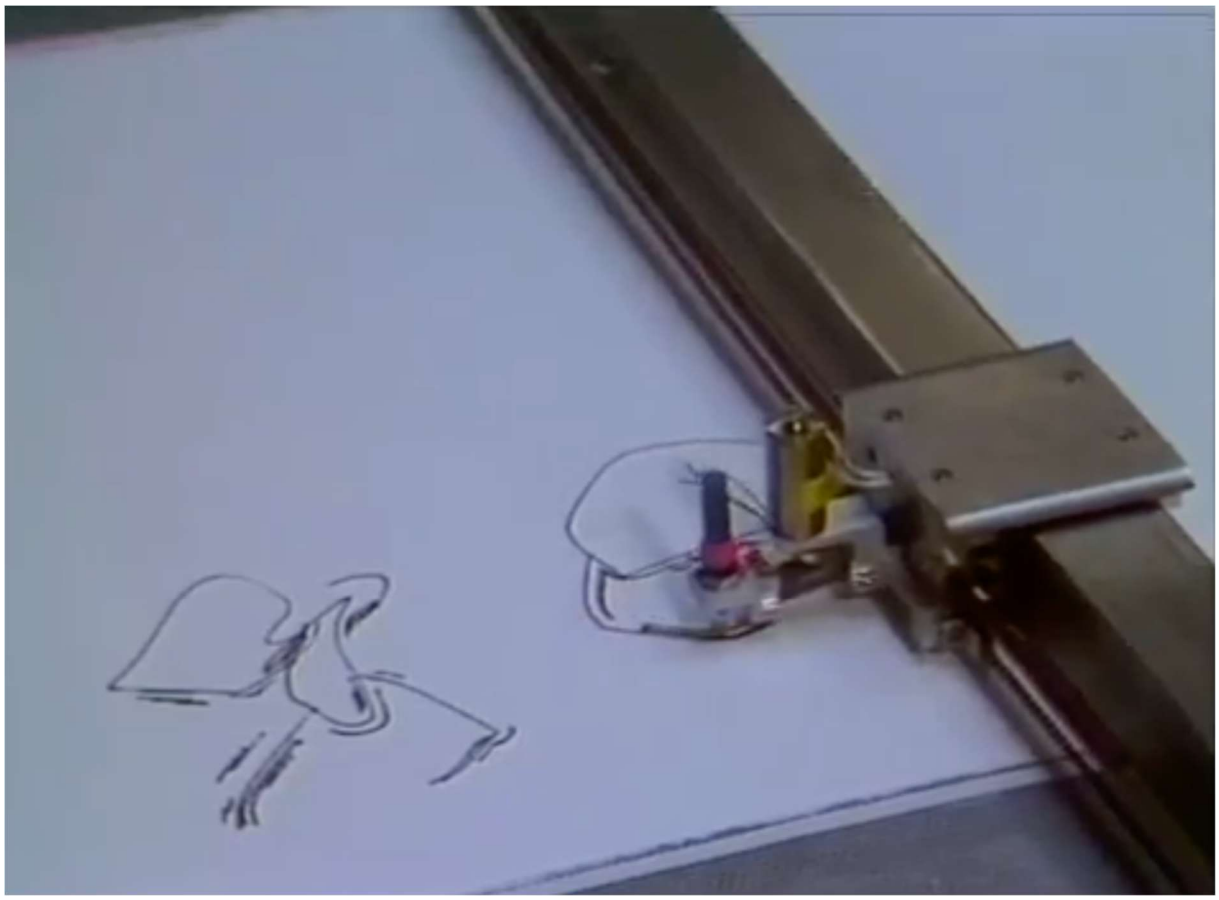


Harold Cohen (1928–2016) was a British artist whose innovations at the forefront of technology changed the face of computer art. Unfolding where art and artificial intelligence intersect, Cohen's artistic practice was punctuated by his famed invention of AARON, a computer programme designed to create art independently. Cohen's work attracted global attention and was exhibited at major institutions such as Tate London and San Franciso Museum of Modern Art.

Harold was introduced to me by the Prof. Peter de Francia, and he recruited me to be his assistant for the 1983 Tate Exhibition. The pay was generous and paid for my 2nd year of RCA tuition fees. I spent the summer working in the Tate on AARON and tending the plotters. Sold one of Harold's "drawings" to Christopher Lee!

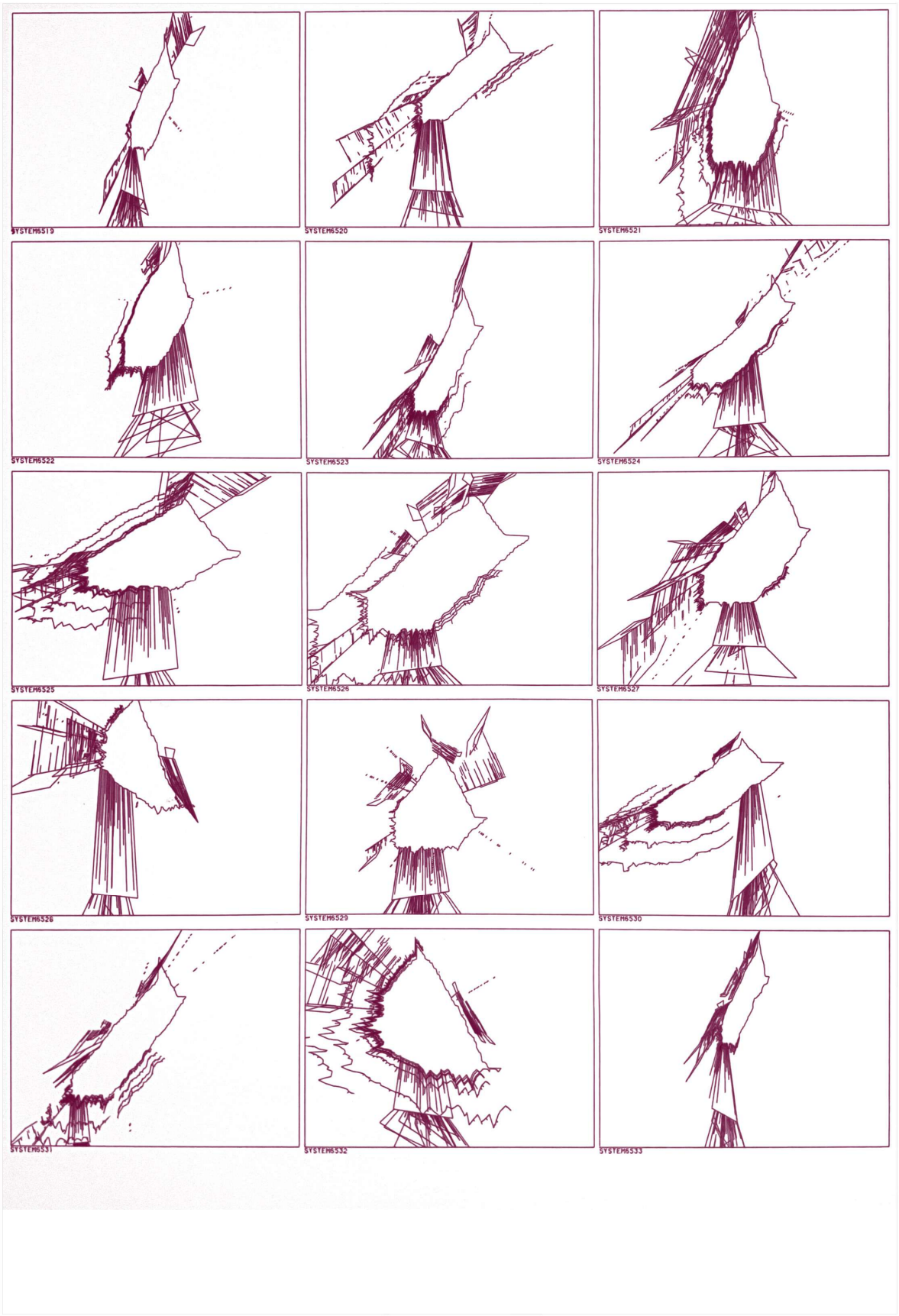
Drawing and pen-plotter, Harold Cohen, Tate Gallery, 1983

AARON 2, University California San Diego



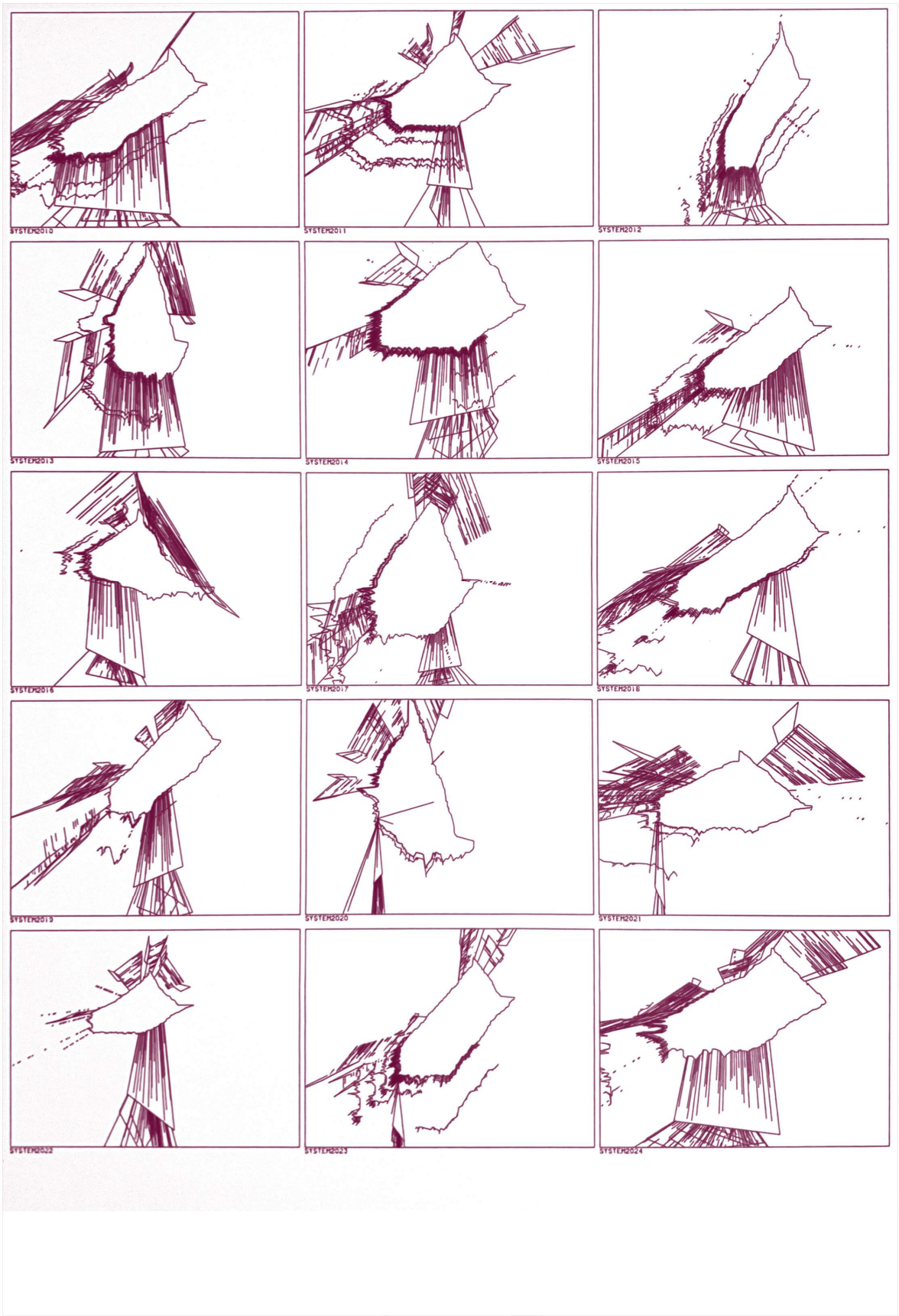
Variations on an Object 1, Harold Cohen, 1983

MU PICASO without HLR 3D CG A2 ink drawing.



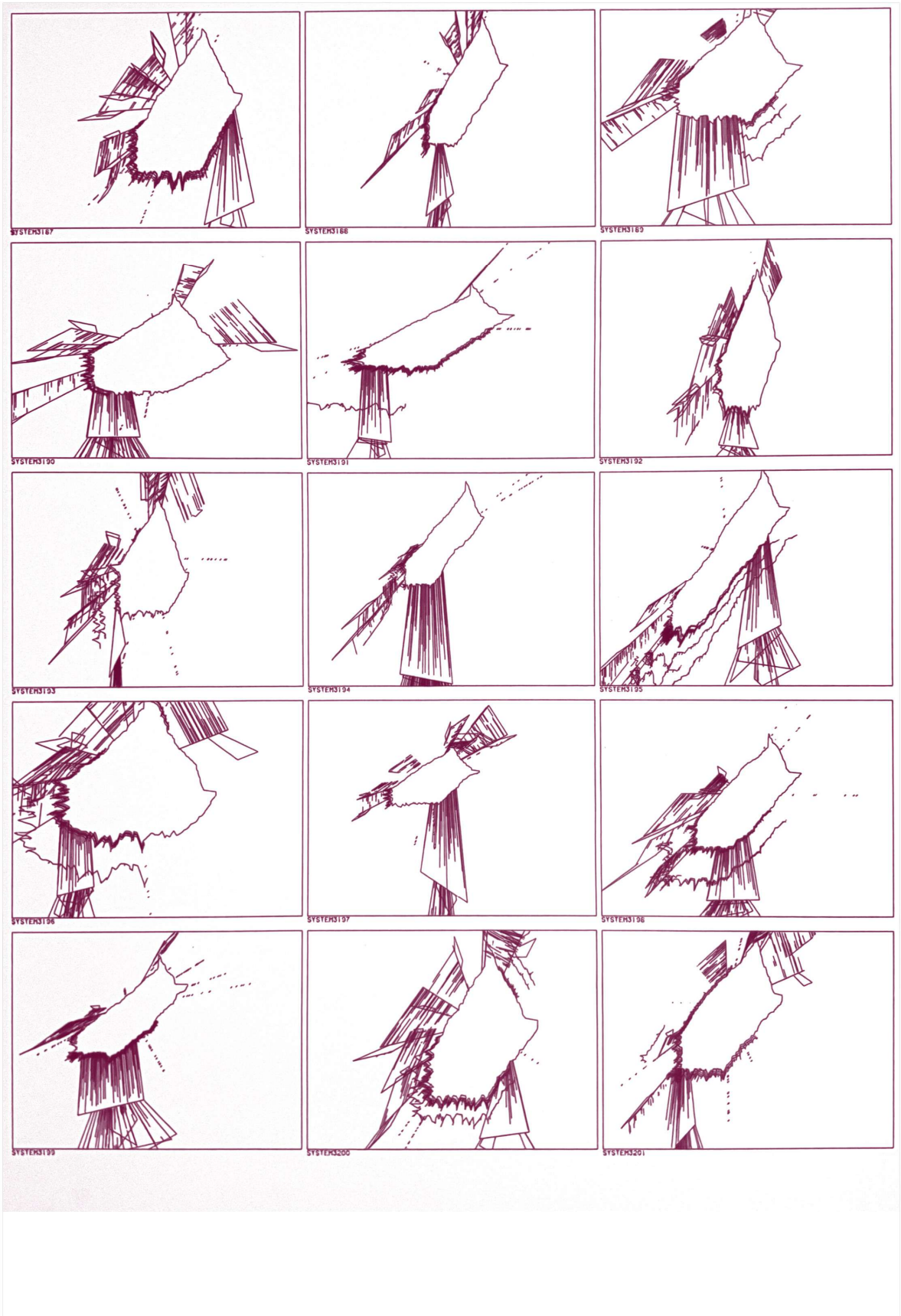
Variations on an Object 2, Harold Cohen, 1983

MU PICASO without HLR 3D CG A2 ink drawing.



Variations on an Object 3, Harold Cohen, 1983

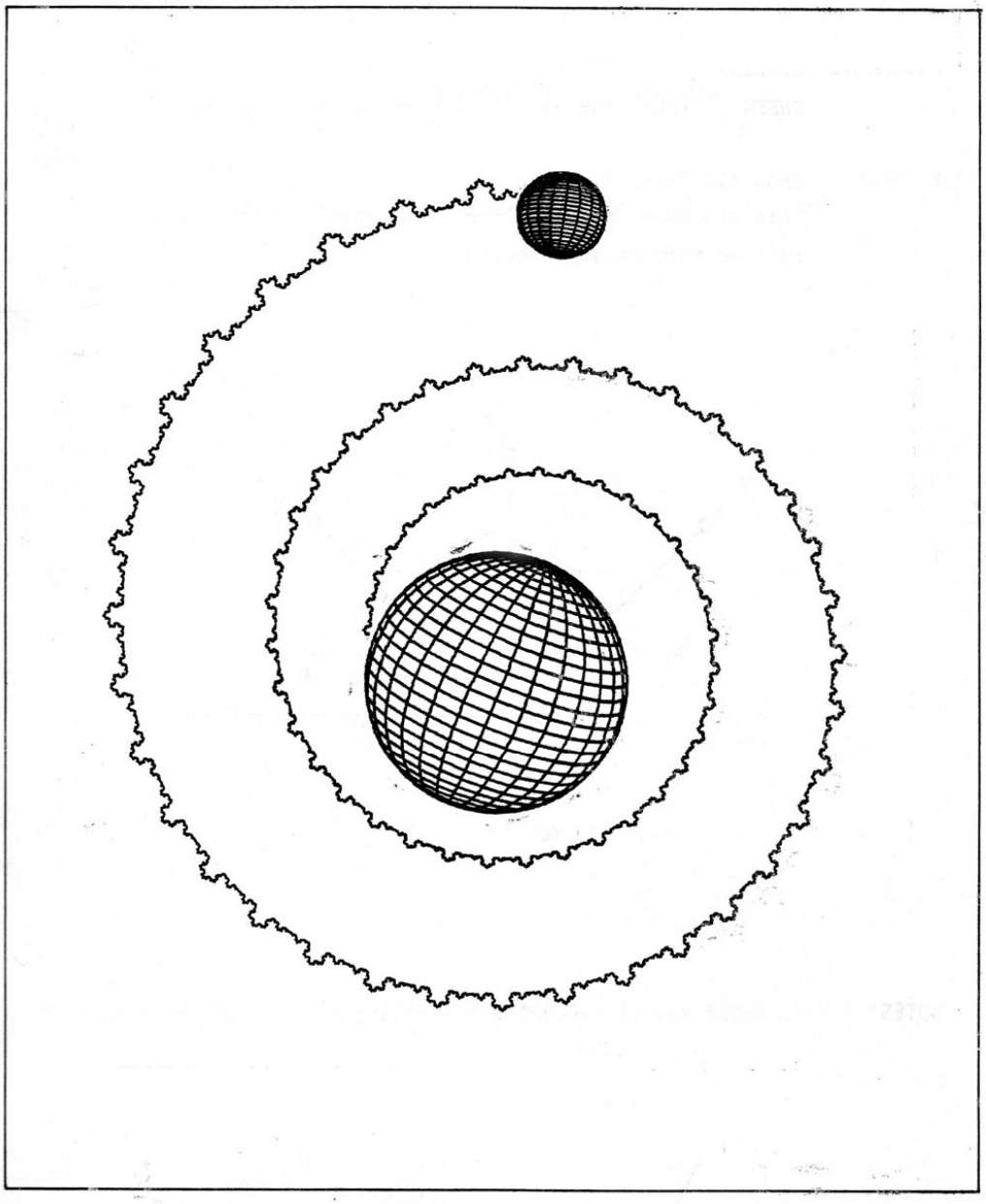
MU PICASO without HLR 3D CG A2 ink drawing.



Middlesex Polytechnic

THE PICASO SYSTEM

John A. Vince



CAMPUS

Computing at Middlesex Polytechnic User Services

1983

PICASO, Middlesex University, 1983 to 1984

Wireframe animation without Hidden Line Removal (HLR)

Whilst working for Prof. John Vince, I finally had access to high-speed industrial plotters and provided with a state-of-the-art green screen text monitor, the DEC legendary VT100.

The V(ideo) T(erminal)100 was introduced in August 1978 by Digital Equipment Corporation (DEC) with a 12” (30cm) CRT display which provided 80 characters x 24 lines.

As a Graphics Analyst I spent most of my time working on PICASO and doing private animation work. I couldn’t “see” what I was animating – I had to visualise it in my mind’s eye. If I had a particularly tough visualisation challenge, I could book or beg time on “the” (only one in the entire University) Tektronix 4014 graphics terminal.

Thid was a part of a family of text-and-graphics computer terminals based on storage-tube technology created by US company Tektronix. Several members of the family were introduced during the 1970s, the best known being the 11-inch 4010 and the 19-inch 4014 (shown).

When I was satisfied that I had sufficiently prepared the animation I would plot every n^{th} frame onto A2 paper, as per the arrays of animation frame sequences shown in the rest of this document.

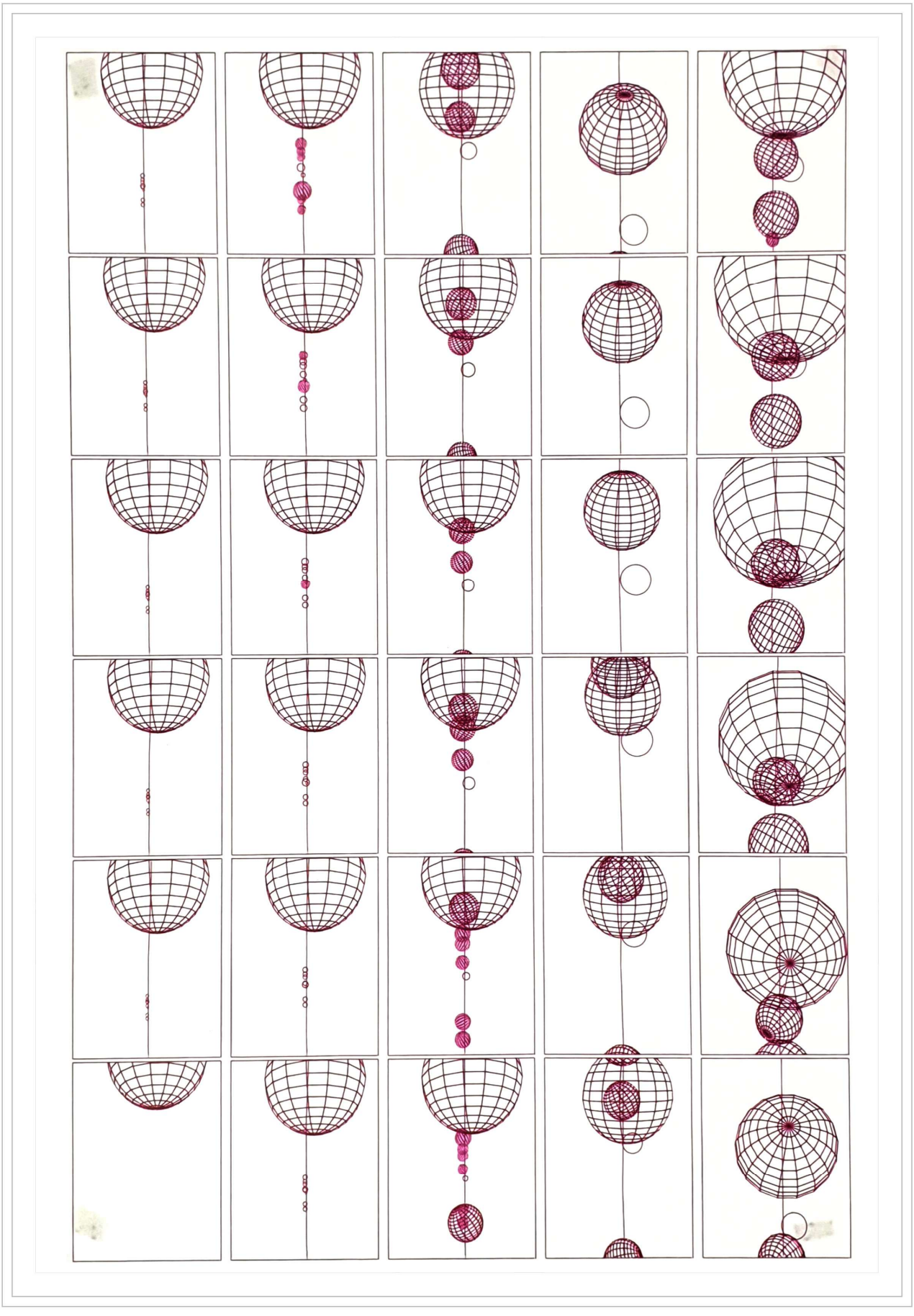
The final animation would be plotted one frame at a time either onto an A3 or A2 animation cel, made of celluloid (cellulose acetate) with a tissue backing and holes punched approx. 1” or more inside along the bottom edge.

These holes allowed for the cell to be mounted onto a peg bar, and this ensured precise cel-to-cel registration. Whilst plotting the final cels, these would have to be allowed to dry before being stacked in sequence into a cel box.

As they were stacked, I would be able to judge the animation frame-to-frame changes by looking through the cel at the previous cel – partly obscured by the tissue, and through that I can just see the previous, previous, cel.

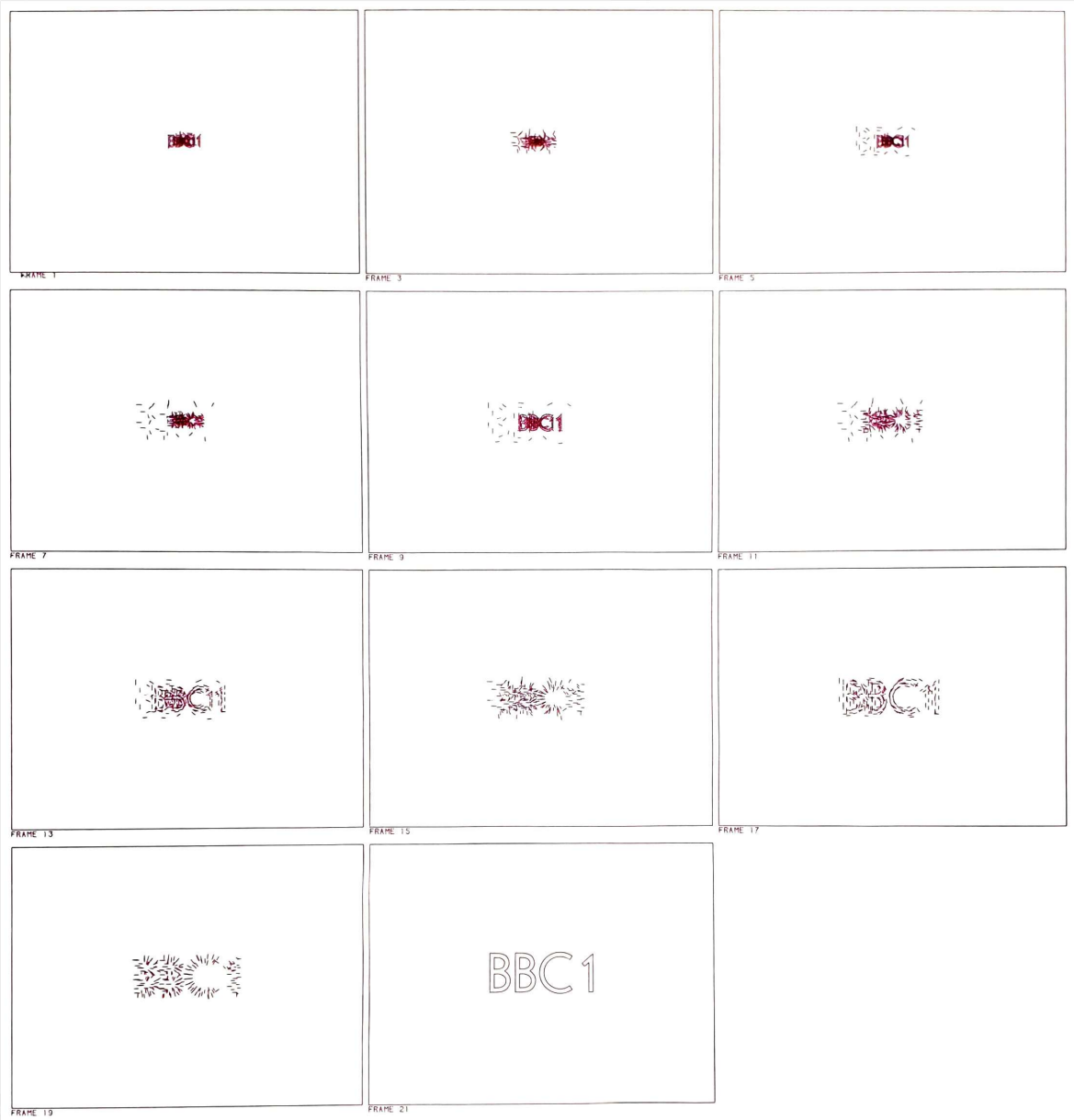
UK Indoor Bowling Championships, Mark Allen, BBC1,1983

MU PICASO without HLR 3D CG A2 ink drawing.



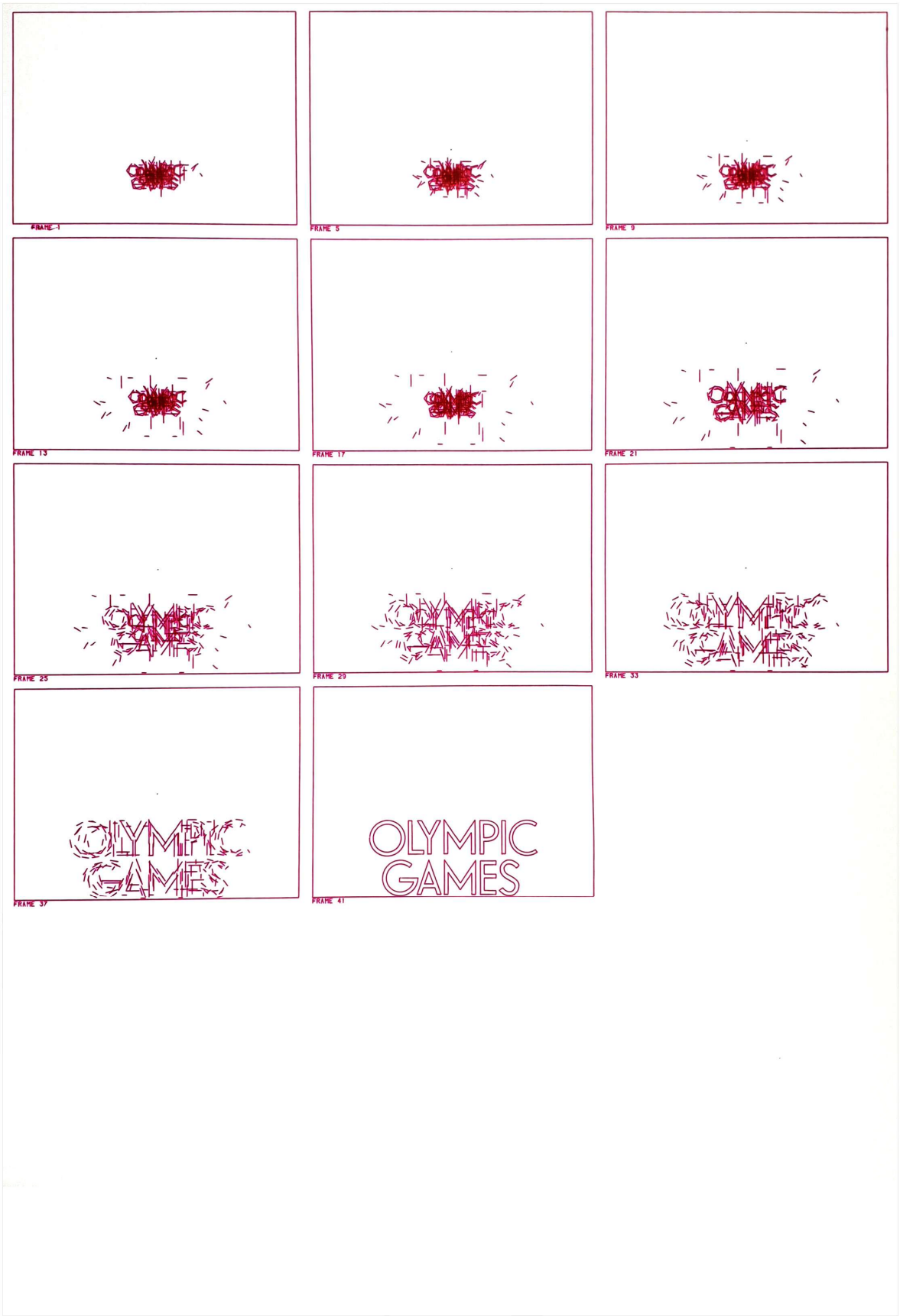
BBC 1 Channel Ident, BBC1, 1983

MU PICASO without HLR 3D CG A2 ink drawing.



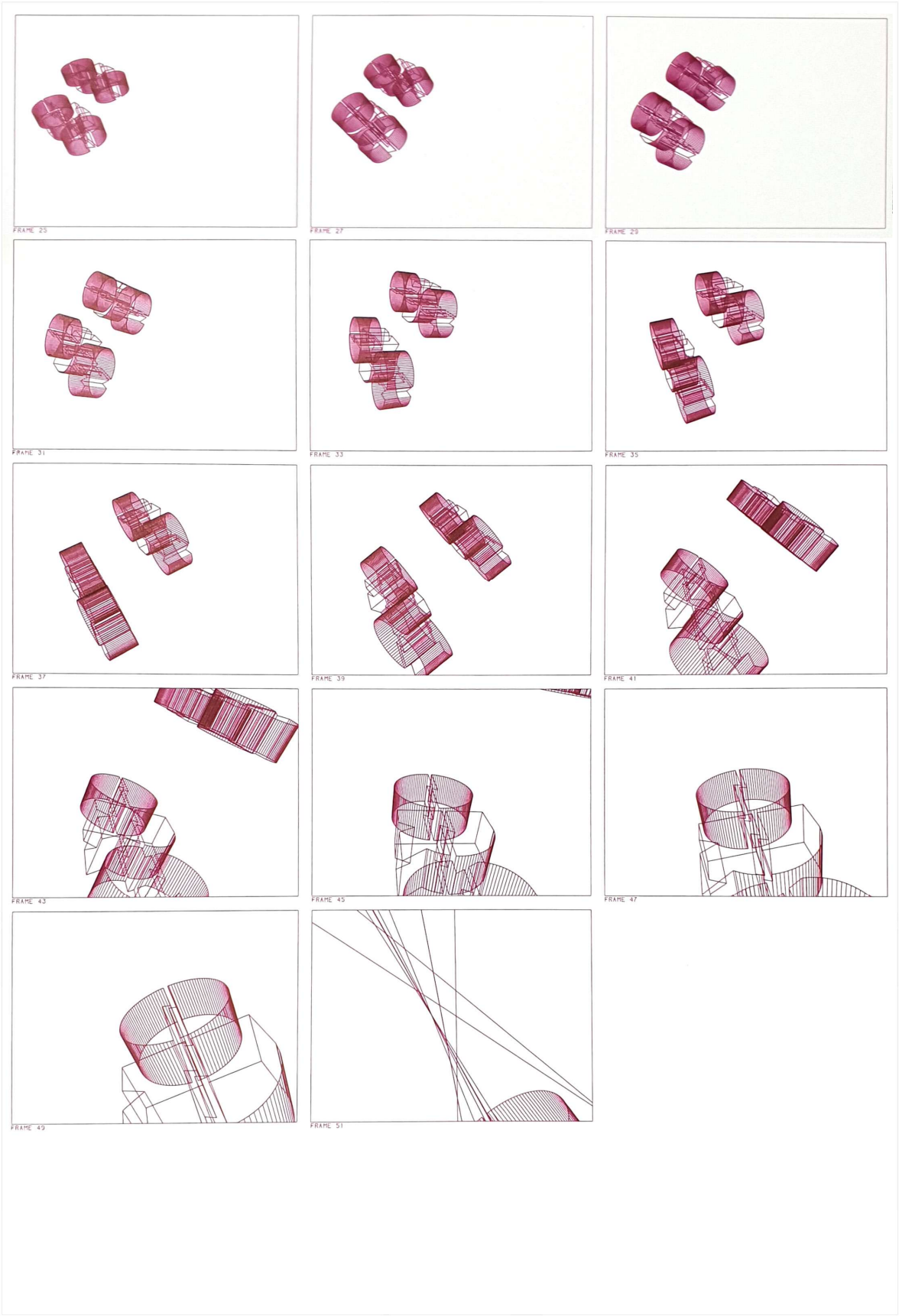
Olympics Ident, BBC1, 1983

MU PICASO without HLR 3D CG A2 ink drawing.



Oxford Road Show, Logo, BBC2, 1983

MU PICASO without HLR 3D CG A2 ink drawing.



Hidden Line Removal (HLR), 1982 to 1984

MU ICARUS

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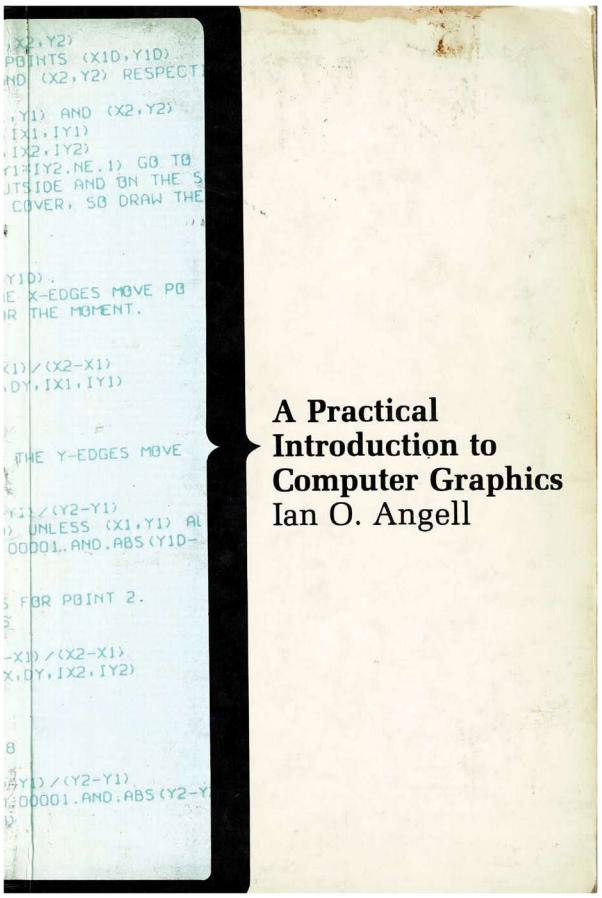

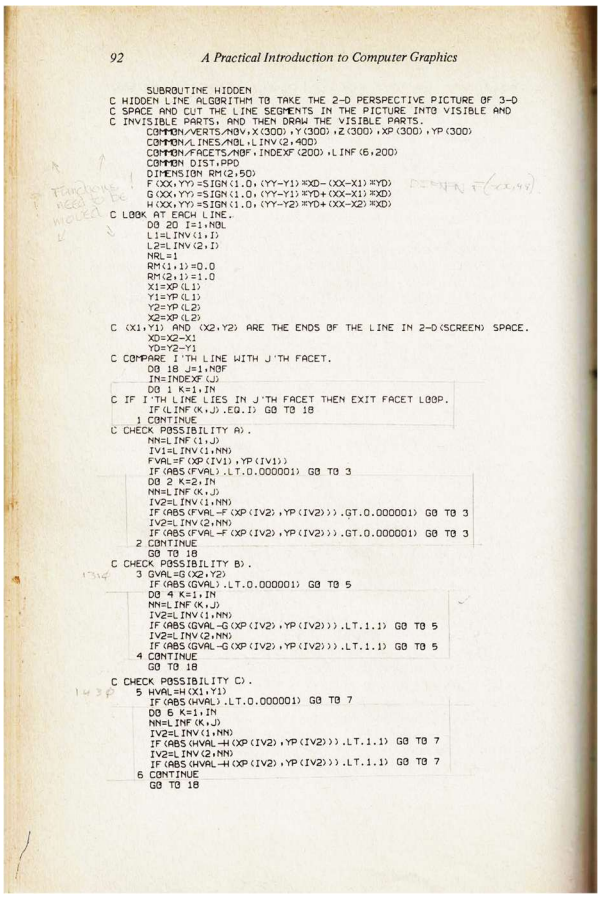

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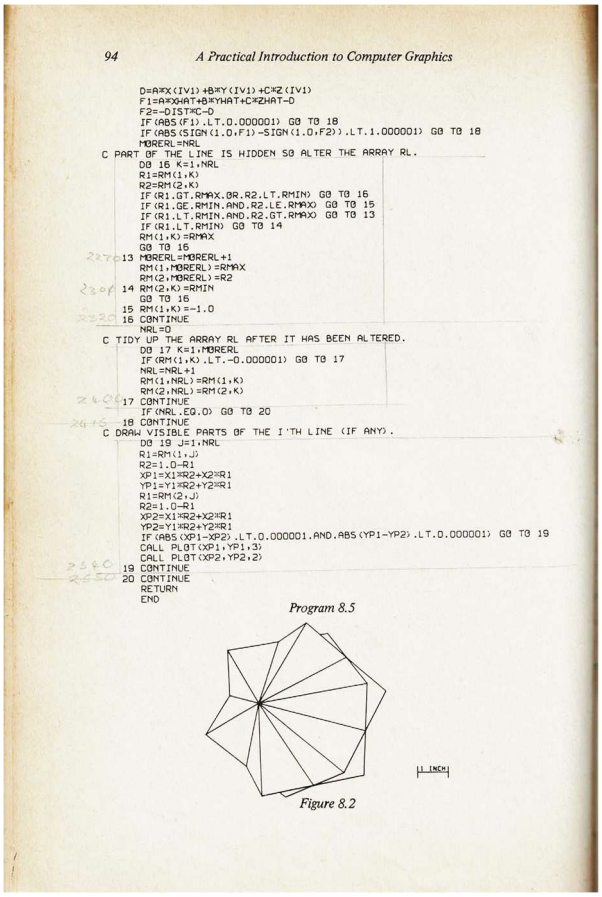
```
      SUBROUTINE HIDDEN
C HIDDEN LINE ALGORITHM TO TAKE THE 2-D PERSPECTIVE PICTURE OF 3-D
C SPACE AND CUT THE LINE SEGMENTS IN THE PICTURE INTO VISIBLE AND
C INVISIBLE PARTS, AND THEN DRAW THE VISIBLE PARTS.
      COMMON/VERTS/NOV,X(300),Y(300),Z(300),XP(300),YP(300)
      COMMON/LINES/NOL,LINV(2,400)
      COMMON/FACETS/NOF,INDEXF(200),LINF(6,200)
      COMMON DIST,PPD
      DIMENSION RM(2,50)
      F(XX,YY)=SIGN(1.0,(YY-Y1)*XD-(XX-X1)*YD)
      G(XX,YY)=SIGN(1.0,(YY-Y1)*YD+(XX-X1)*XD)
      H(XX,YY)=SIGN(1.0,(YY-Y2)*YD+(XX-X2)*XD)
C LOOK AT EACH LINE.
      DO 20 I=1,NOL
      L1=LINV(1,I)
      L2=LINV(2,I)
      NRL=1
      RM(1,1)=0.0
      RM(2,1)=1.0
      X1=XP(L1)
      Y1=YP(L1)
      Y2=YP(L2)
      X2=XP(L2)
C (X1,Y1) AND (X2,Y2) ARE THE ENDS OF THE LINE IN 2-D (SCREEN) SPACE.
      XD=X2-X1
      YD=Y2-Y1
C COMPARE I'TH LINE WITH J'TH FACET.
      DO 18 J=1,NOF
      IN=INDEXF(J)
      DO 1 K=1,IN
C IF I'TH LINE LIES IN J'TH FACET THEN EXIT FACET LOOP.
      IF(LINF(K,J).EQ.I) GO TO 18
    1 CONTINUE
C CHECK POSSIBILITY A).
      NN=LINF(1,J)
      IV1=LINV(1,NN)
      FVAL=F(XP(IV1),YP(IV1))
      IF(ABS(FVAL).LT.0.000001) GO TO 3
      DO 2 K=2,IN
      NN=LINF(K,J)
      IV2=LINV(1,NN)
      IF(ABS(FVAL-F(XP(IV2),YP(IV2))).GT.0.000001) GO TO 3
      IV2=LINV(2,NN)
      IF(ABS(FVAL-F(XP(IV2),YP(IV2))).GT.0.000001) GO TO 3
    2 CONTINUE
      GO TO 18
C CHECK POSSIBILITY B).
    3 GVAL=G(X2,Y2)
      IF(ABS(GVAL).LT.0.000001) GO TO 5
      DO 4 K=1,IN
      NN=LINF(K,J)
      IV2=LINV(1,NN)
      IF(ABS(GVAL-G(XP(IV2),YP(IV2))).LT.1.1) GO TO 5
      IV2=LINV(2,NN)
      IF(ABS(GVAL-G(XP(IV2),YP(IV2))).LT.1.1) GO TO 5
    4 CONTINUE
      GO TO 18
C CHECK POSSIBILITY C).
    5 HVAL=H(X1,Y1)
      IF(ABS(HVAL).LT.0.000001) GO TO 7
      DO 6 K=1,IN
      NN=LINF(K,J)
      IV2=LINV(1,NN)
      IF(ABS(HVAL-H(XP(IV2),YP(IV2))).LT.1.1) GO TO 7
      IV2=LINV(2,NN)
      IF(ABS(HVAL-H(XP(IV2),YP(IV2))).LT.1.1) GO TO 7
    6 CONTINUE
      GO TO 18
```



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```
      D=A*X(IV1)+B*Y(IV1)+C*Z(IV1)
      F1=A*XHAT+B*YHAT+C*ZHAT-D
      F2=-DIST*C-D
      IF(ABS(F1).LT.0.000001) GO TO 18
      IF(ABS(SIGN(1.0,F1)-SIGN(1.0,F2)).LT.1.000001) GO TO 18
      MORERL=NRL
C PART OF THE LINE IS HIDDEN SO ALTER THE ARRAY RL.
      DO 16 K=1,NRL
      R1=RM(1,K)
      R2=RM(2,K)
      IF(R1.GT.RMAX.OR.R2.LT.RMIN) GO TO 16
      IF(R1.GE.RMIN.AND.R2.LE.RMAX) GO TO 15
      IF(R1.LT.RMIN.AND.R2.GT.RMAX) GO TO 13
      IF(R1.LT.RMIN) GO TO 14
      RM(1,K)=RMAX
      GO TO 16
   13 MORERL=MORERL+1
      RM(1,MORERL)=RMAX
      RM(2,MORERL)=R2
   14 RM(2,K)=RMIN
      GO TO 16
   15 RM(1,K)=-1.0
   16 CONTINUE
      NRL=0
C TIDY UP THE ARRAY RL AFTER IT HAS BEEN ALTERED.
      DO 17 K=1,MORERL
      IF(RM(1,K).LT.-0.000001) GO TO 17
      NRL=NRL+1
      RM(1,NRL)=RM(1,K)
      RM(2,NRL)=RM(2,K)
   17 CONTINUE
      IF(NRL.EQ.0) GO TO 20
   18 CONTINUE
C DRAW VISIBLE PARTS OF THE I'TH LINE (IF ANY).
      DO 19 J=1,NRL
      R1=RM(1,J)
      R2=1.0-R1
      XP1=X1*R2+X2*R1
      YP1=Y1*R2+Y2*R1
      R1=RM(2,J)
      R2=1.0-R1
      XP2=X1*R2+X2*R1
      YP2=Y1*R2+Y2*R1
      IF(ABS(XP1-XP2).LT.0.000001.AND.ABS(YP1-YP2).LT.0.000001) GO TO 19
      CALL PLOT(XP1,YP1,3)
      CALL PLOT(XP2,YP2,2)
   19 CONTINUE
   20 CONTINUE
      RETURN
      END
```

Program 8.5

1 INCH

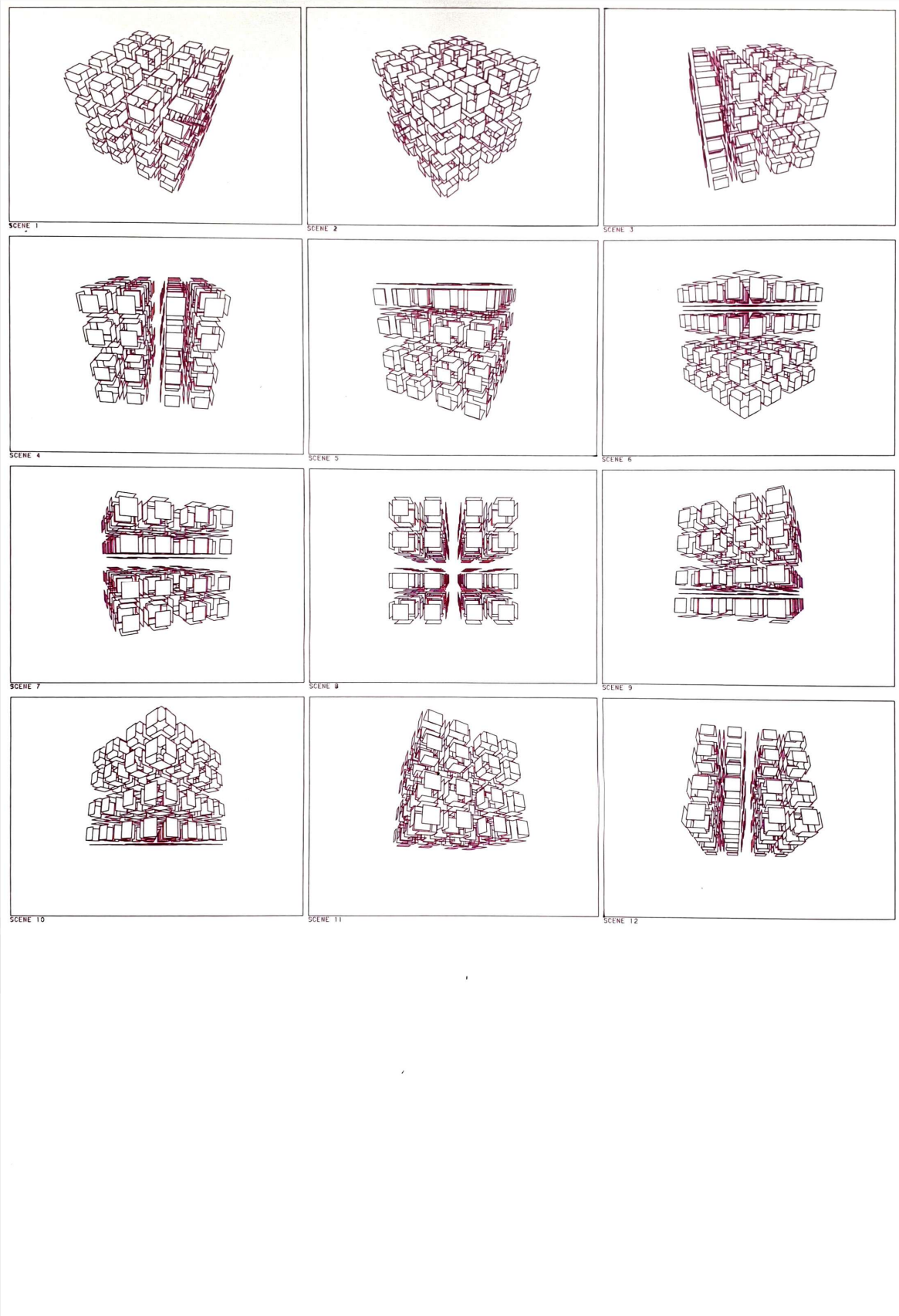
Figure 8.2

It became immediately obvious on my starting work for Prof. John Vince, that I needed to create a Hidden Line Removal (HLR) module for PICASO, to remove lines (or line parts) of an object that were hidden either by itself or other objects. See left “Oxford Road Show, Logo”.

In late 1982 I had chanced upon a book by Ian O. Angell that covered all the maths that I needed, and much else besides, and which included a in-depth introduction in FORTRAN to HLR, and a standalone demo program. You can still see the pencil notes around the code where I have analysed the demo prior to writing my own version. This became known as ICARUS (Interactive Colour Animation Rendering Using Subroutines) and became the basis for all my 1983/84 graphics.

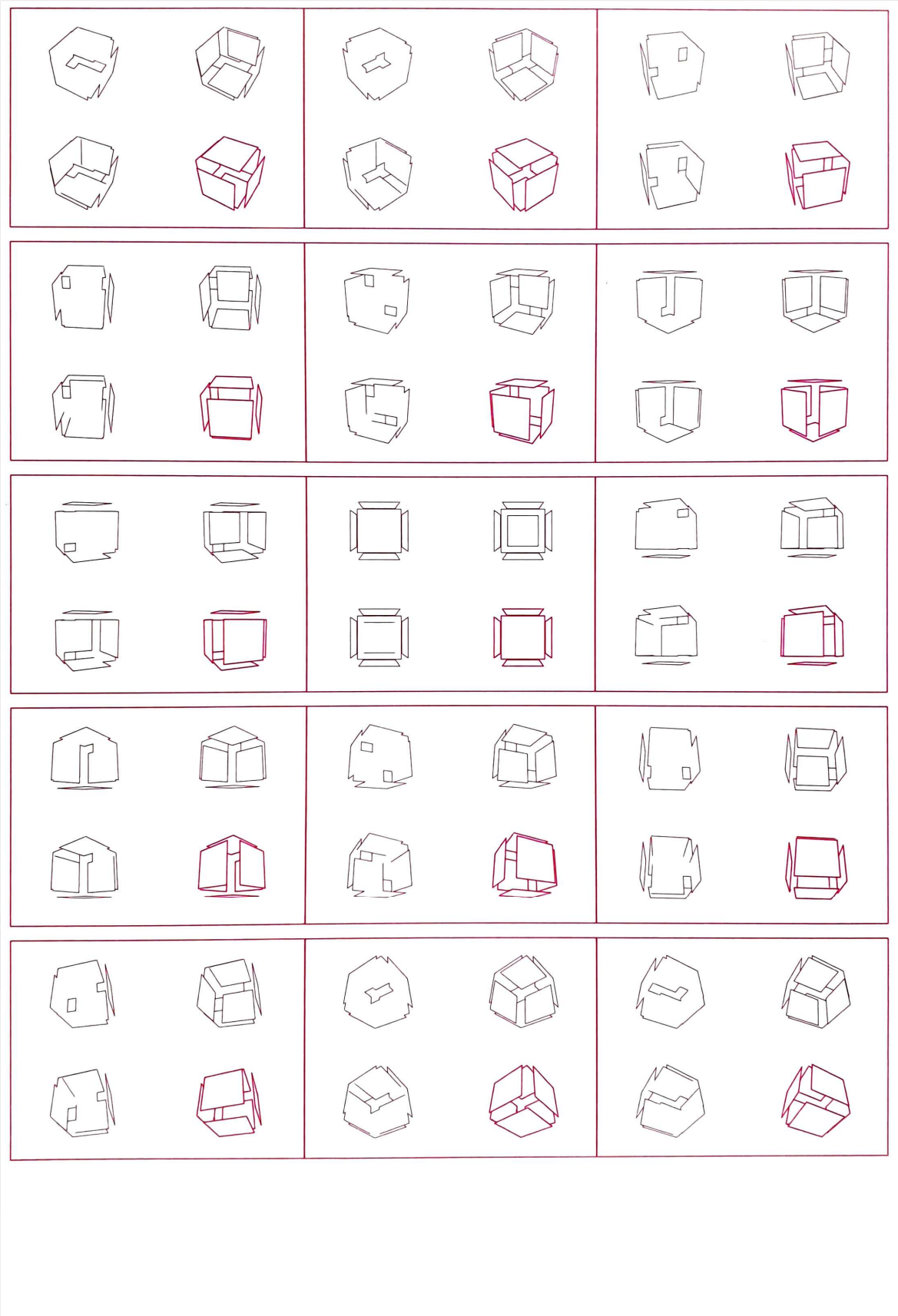
HLR Cube Arrays, 1983

MU ICARUS with HLR 3D CG A2 ink drawing.



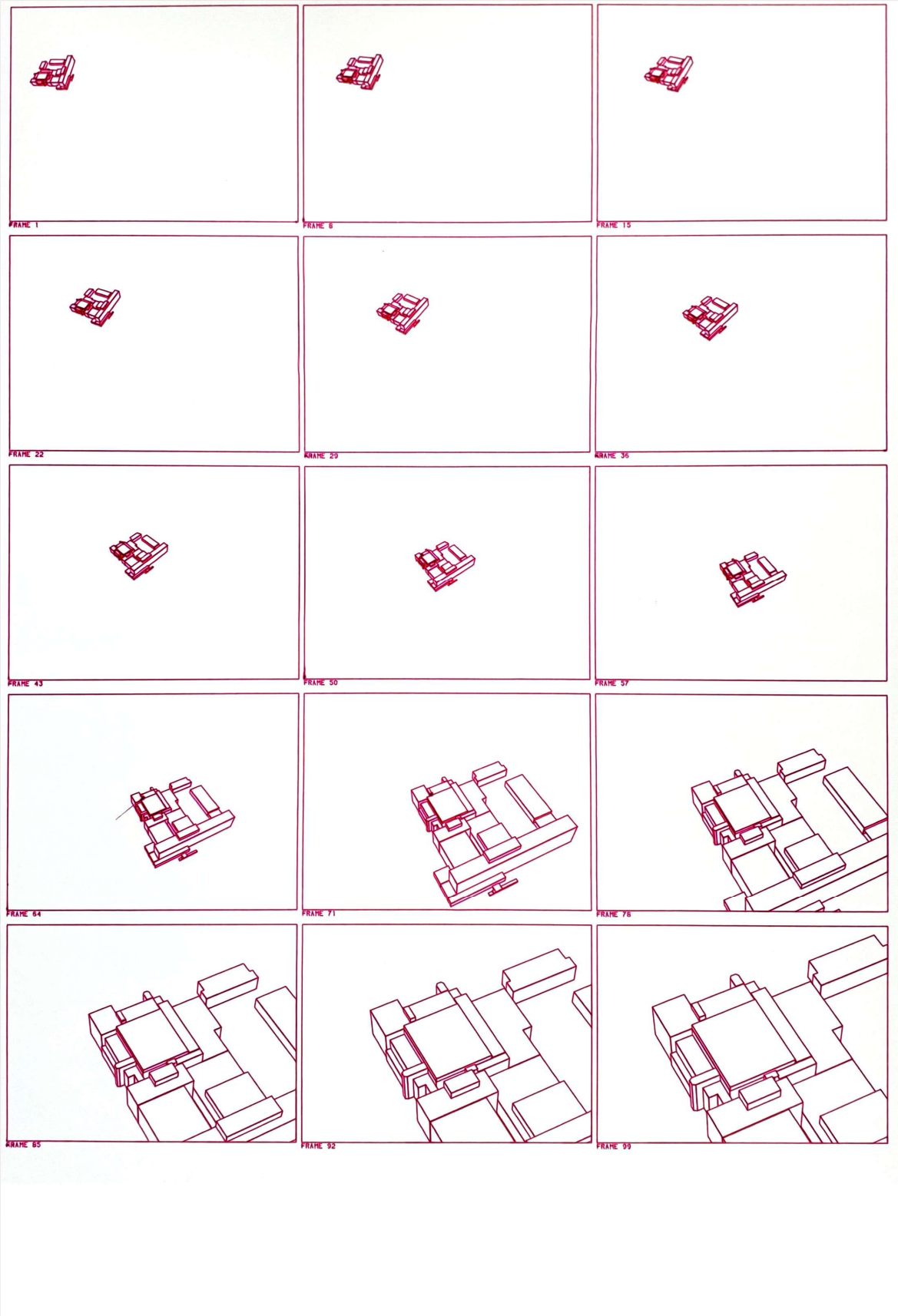
HLR, Silhouette & Inside Out Cube Variants, 1983

MU ICARUS with HLR 3D CG A2 ink drawing.



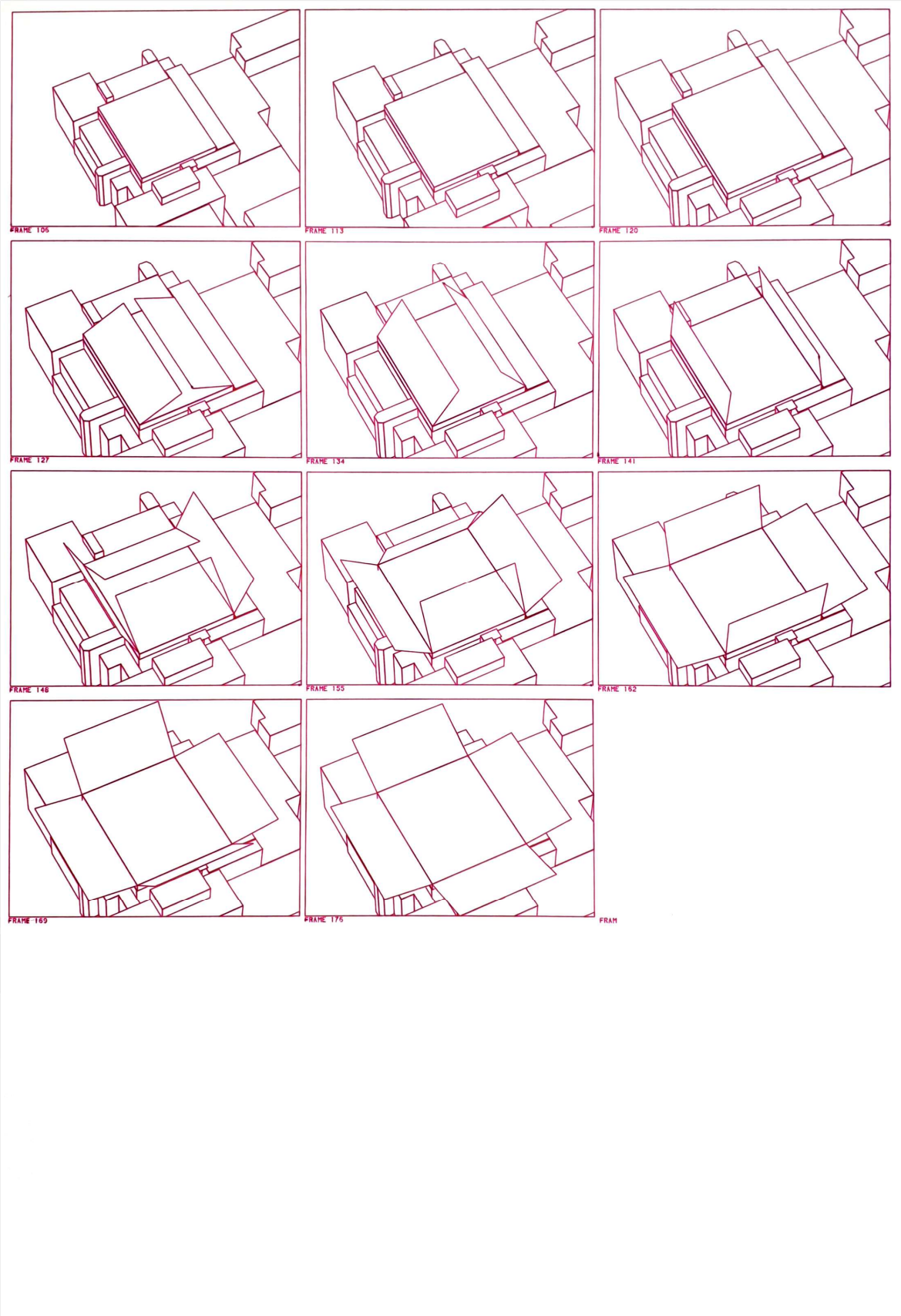
Oxford Road Show, Oxford Studios 1, BBC2, 1983

MU ICARUS with HLR 3D CG A2 ink drawing.



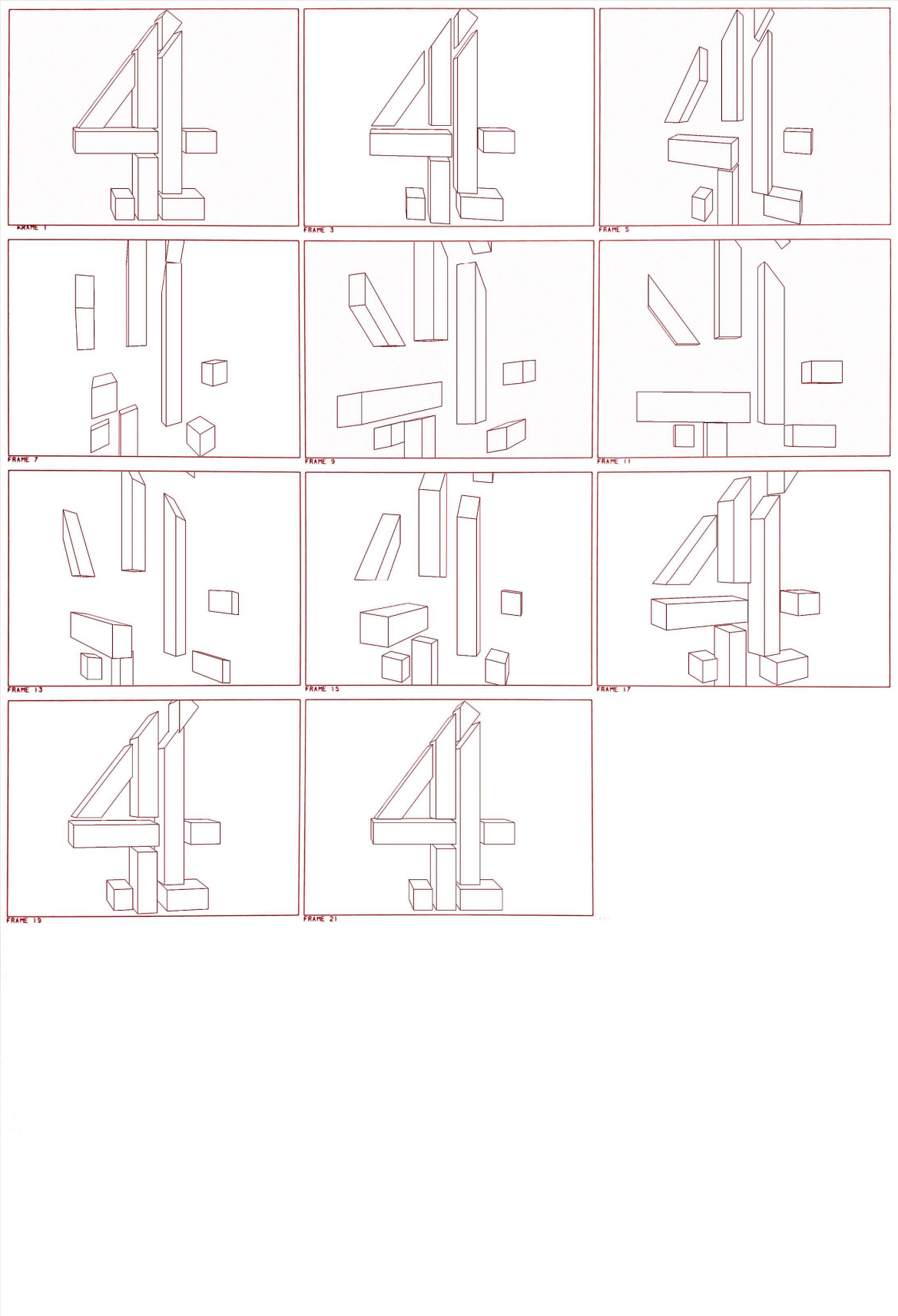
Oxford Road Show, Oxford Studios 2, BBC2, 1983

MU ICARUS with HLR 3D CG A2 ink drawing.



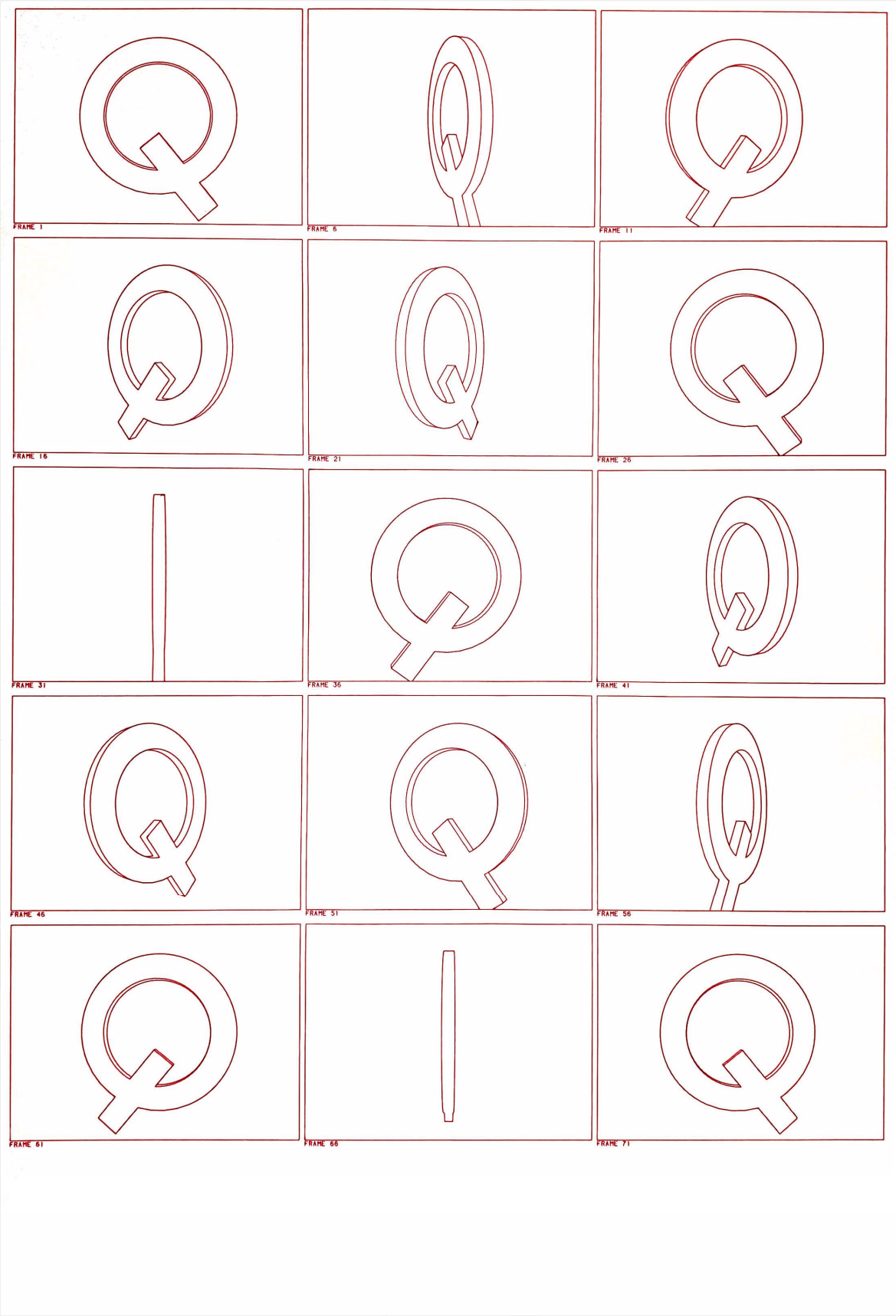
Channel 4 Logo (HLR TEST), Martin Lambie-Nairn, 1983

MU ICARUS with HLR 3D CG A2 ink drawing.



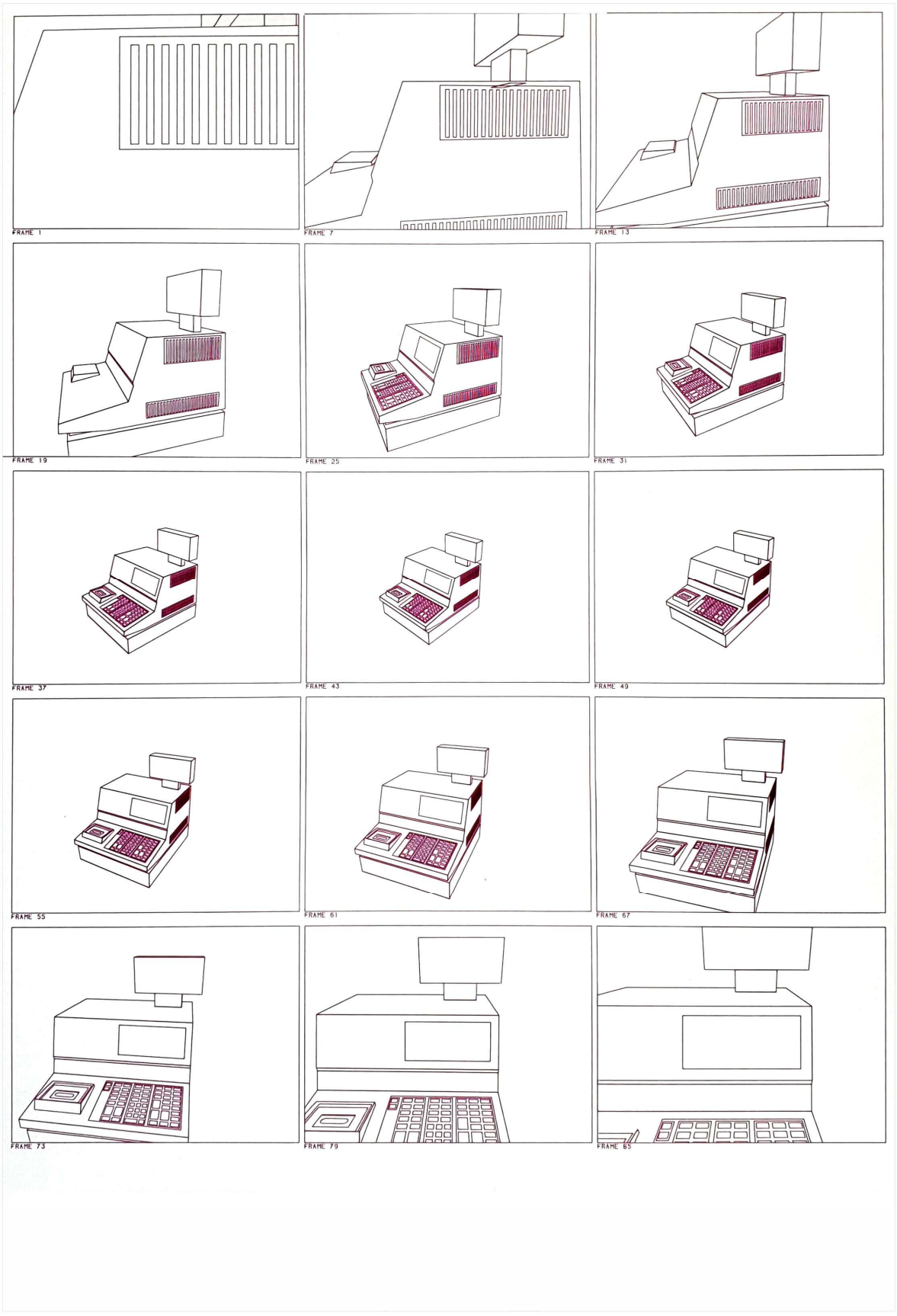
Question of Education, Titles, 1984

MU ICARUS with HLR 3D CG A2 ink drawing.



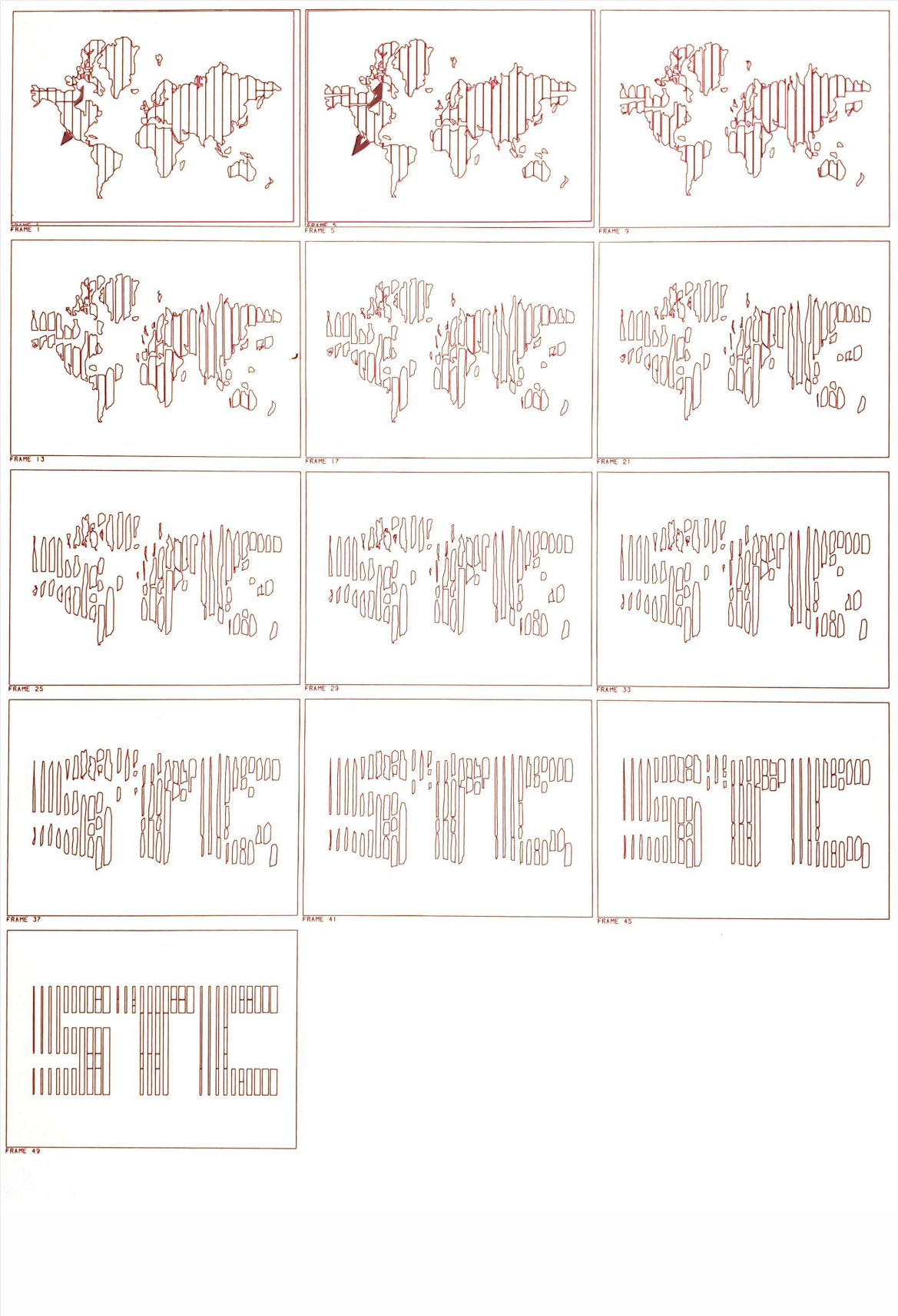
Cash Is King, Titles, 1984

MU ICARUS with HLR 3D CG A2 ink drawing.



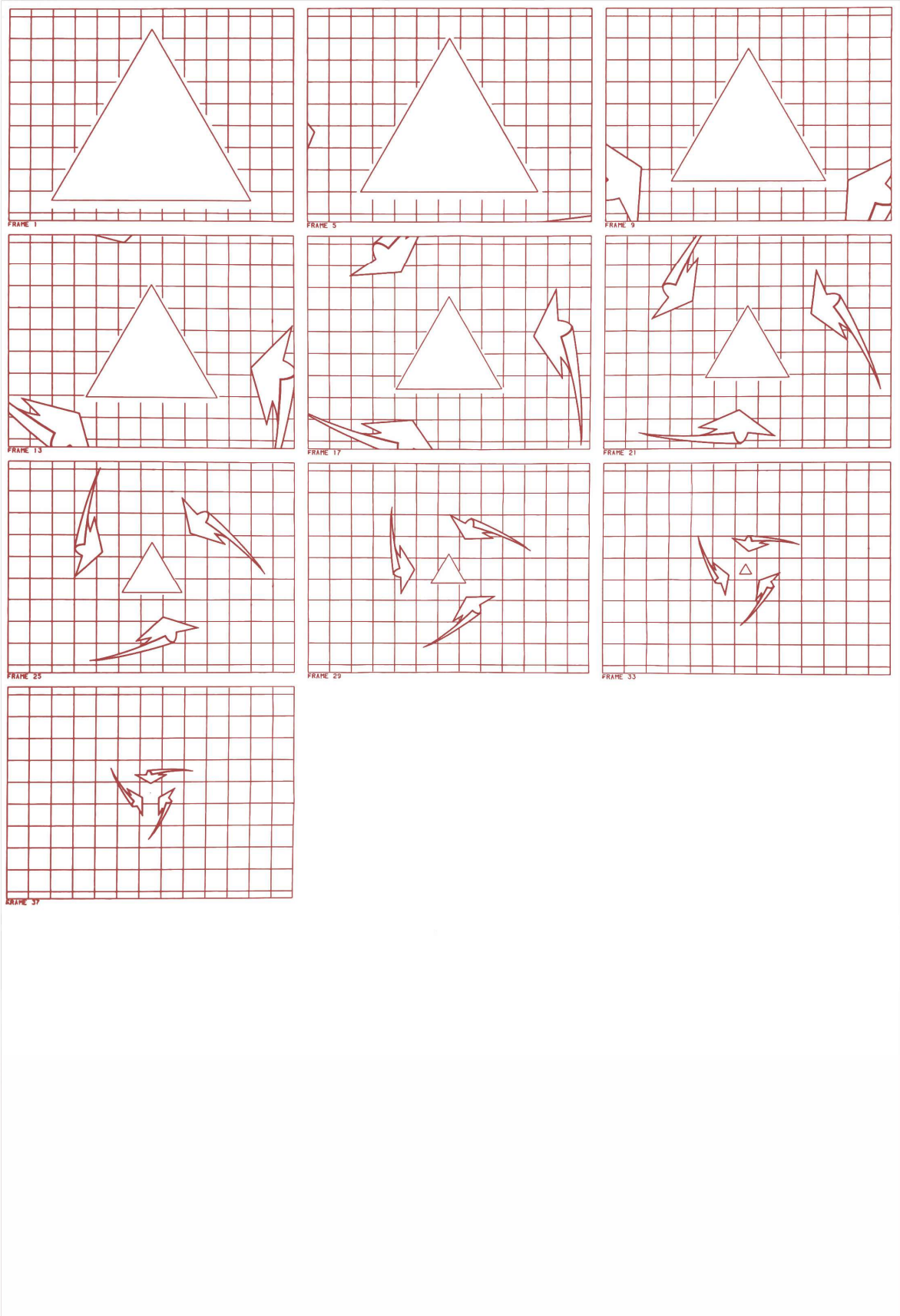
Corporate Logo, STC, 1984

MU PICASO without HLR 3D CG A2 ink drawing.



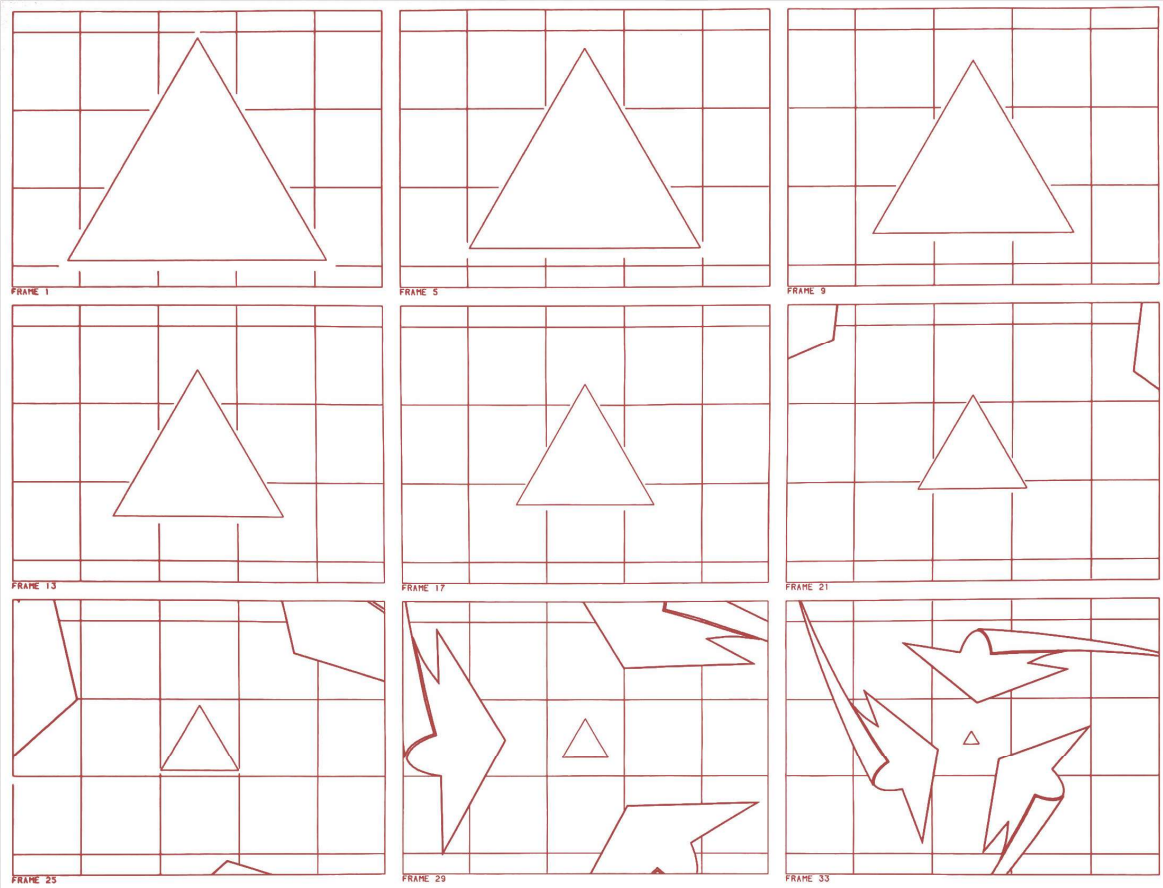
JOBSUSS Intro, RTE, 1984

MU ICARUS with HLR 3D CG A2 ink drawing.



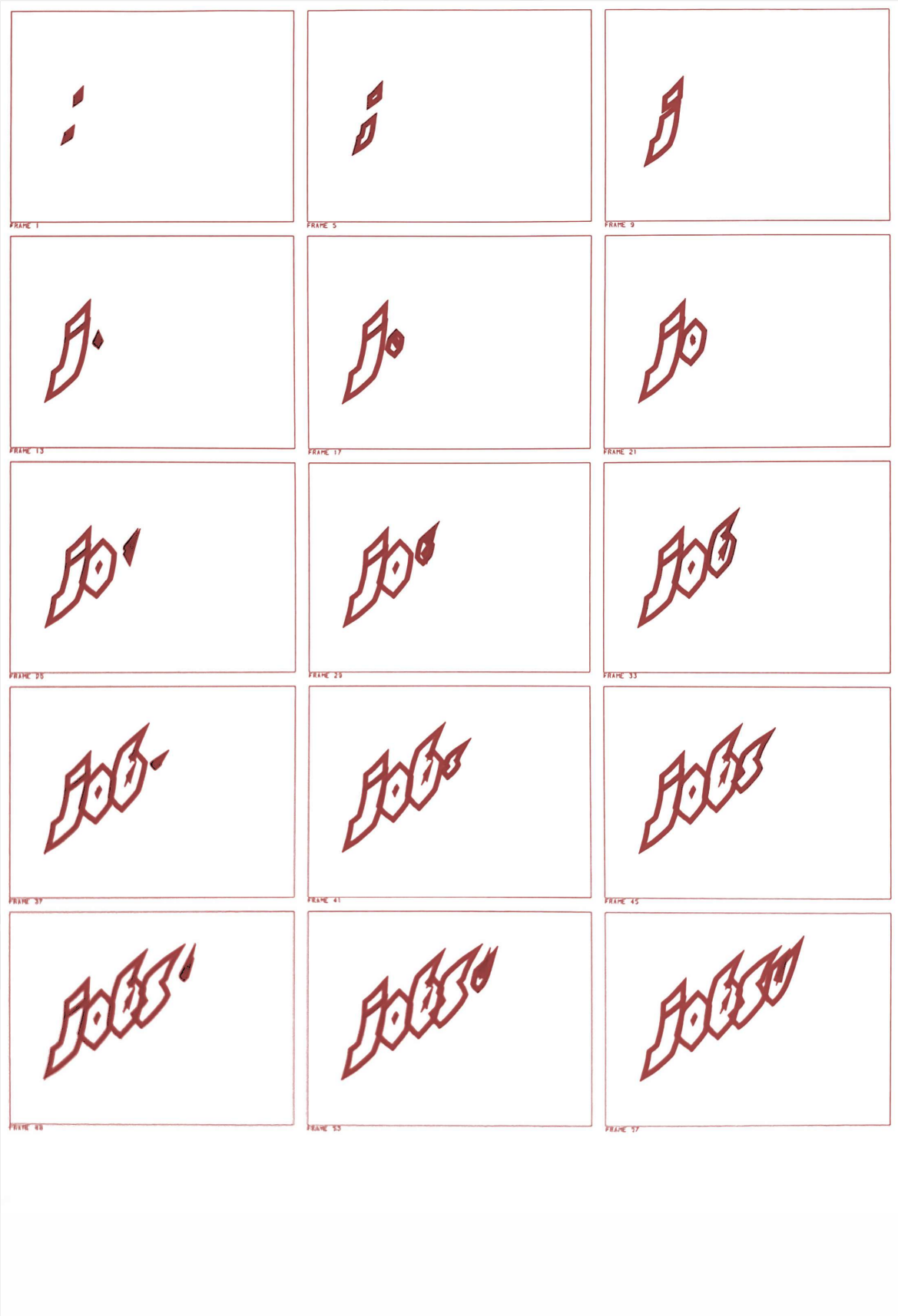
JOBSUSS Outro, RTE, 1984

MU ICARUS with HLR 3D CG A2 ink drawing.



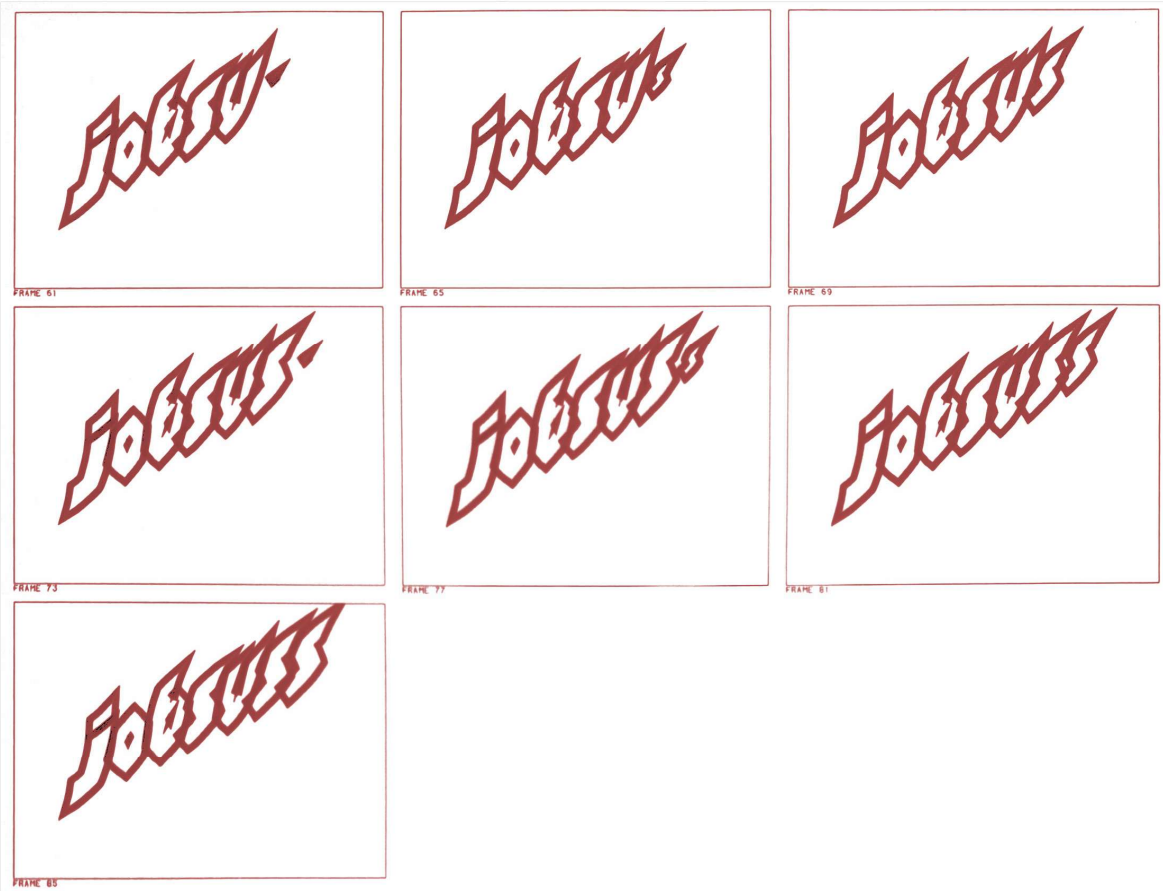
JOBSUSS Logo 1, RTE, 1984

MU ICARUS with HLR 3D CG A2 ink drawing.



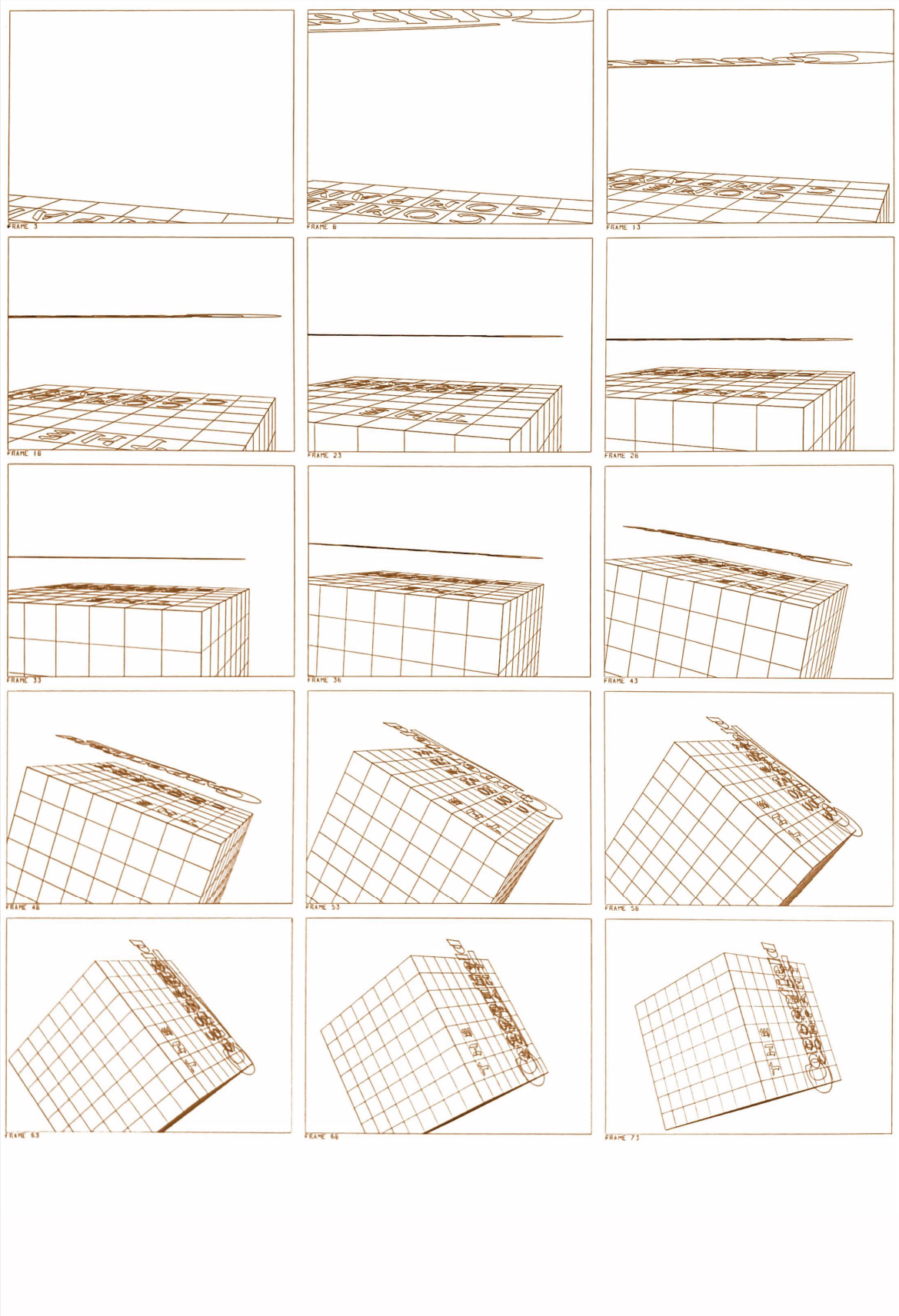
JOBSUSS Logo 2, RTE, 1984

MU ICARUS with HLR 3D CG A2 ink drawing.



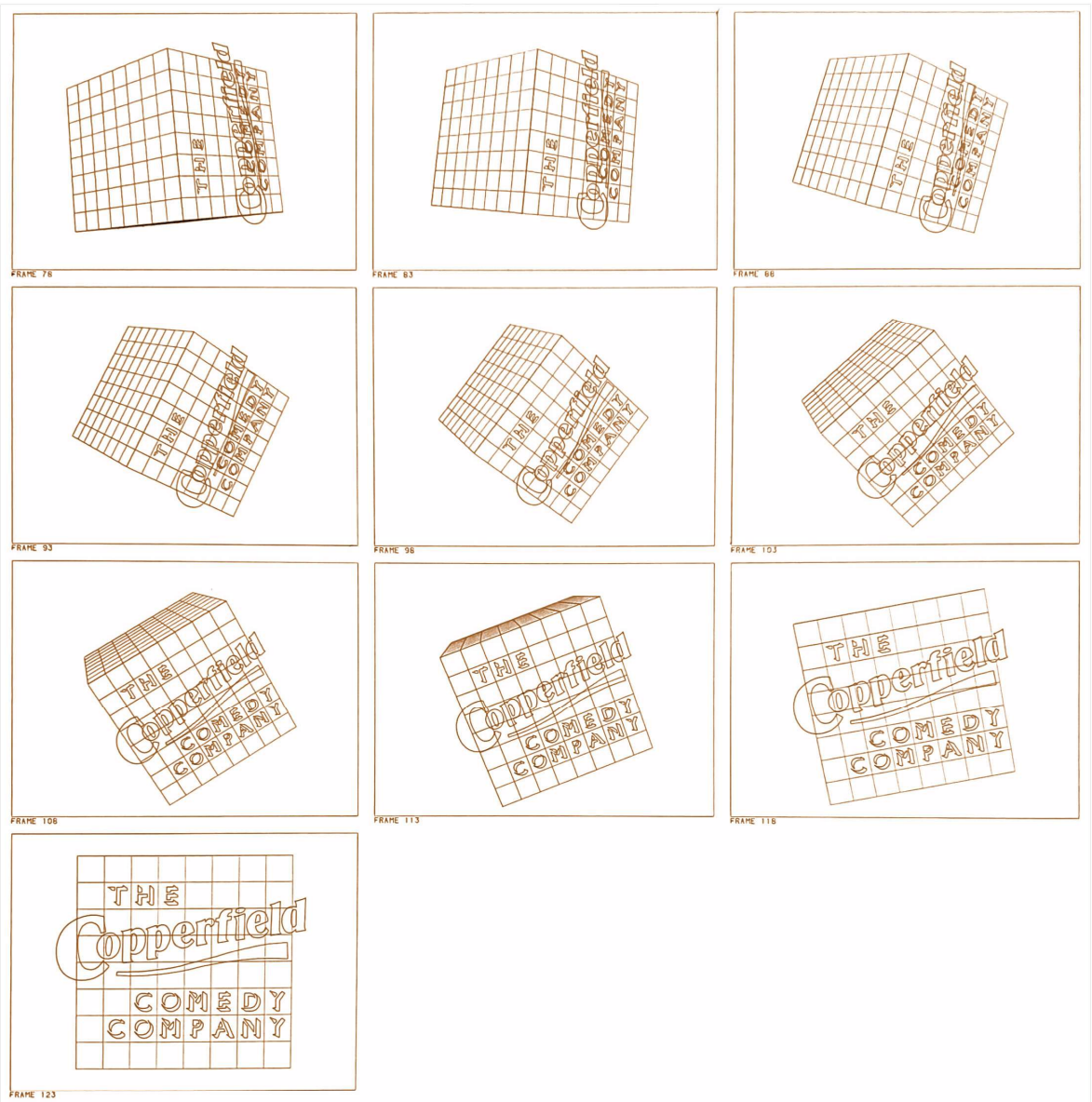
Copperfield Comedy Company, Titles 1, BBC1, 1984

MU ICARUS with HLR 3D CG A2 ink drawing.



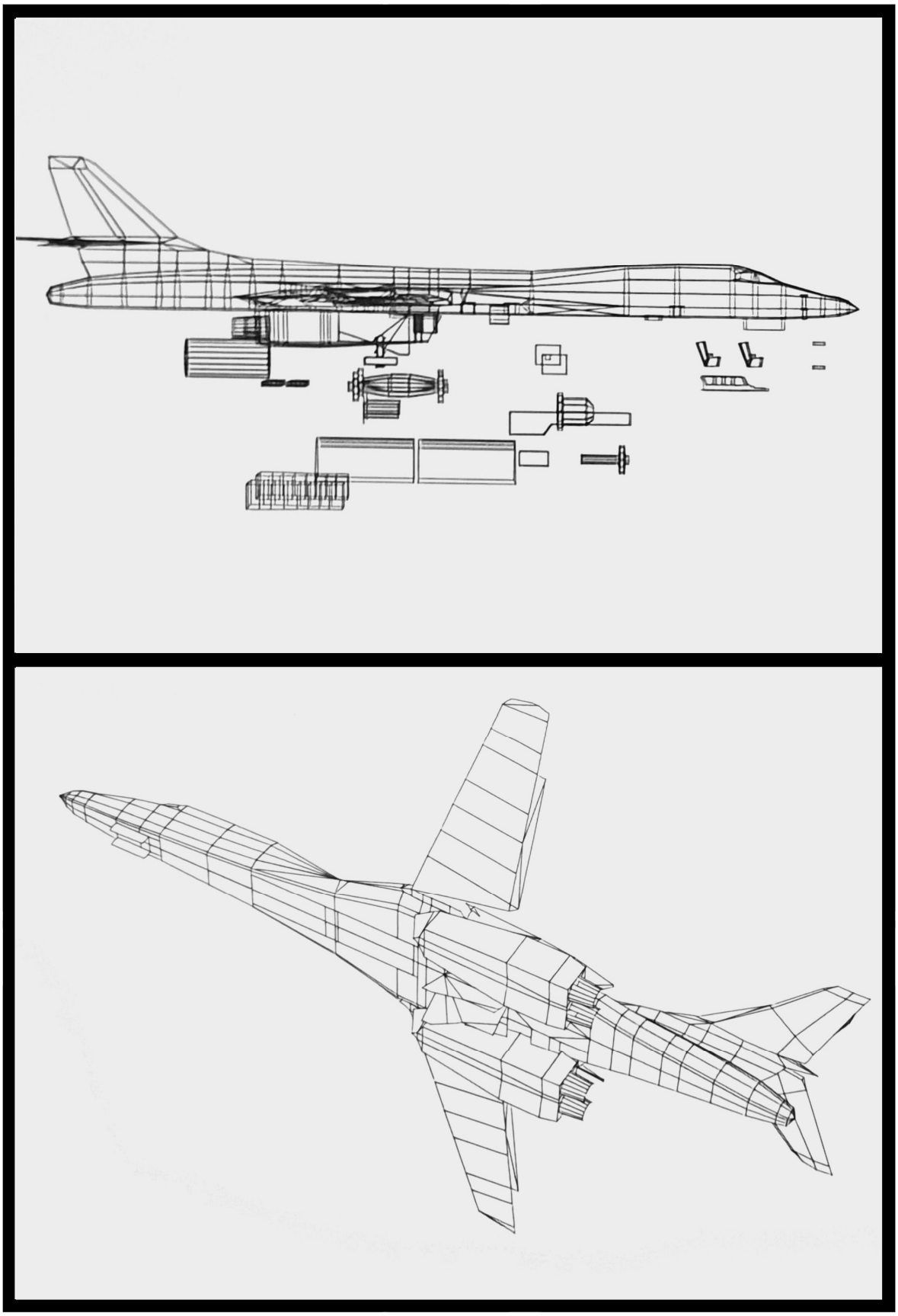
Copperfield Comedy Company, Titles 2, BBC1, 1984

MU ICARUS with HLR 3D CG A2 ink drawing.



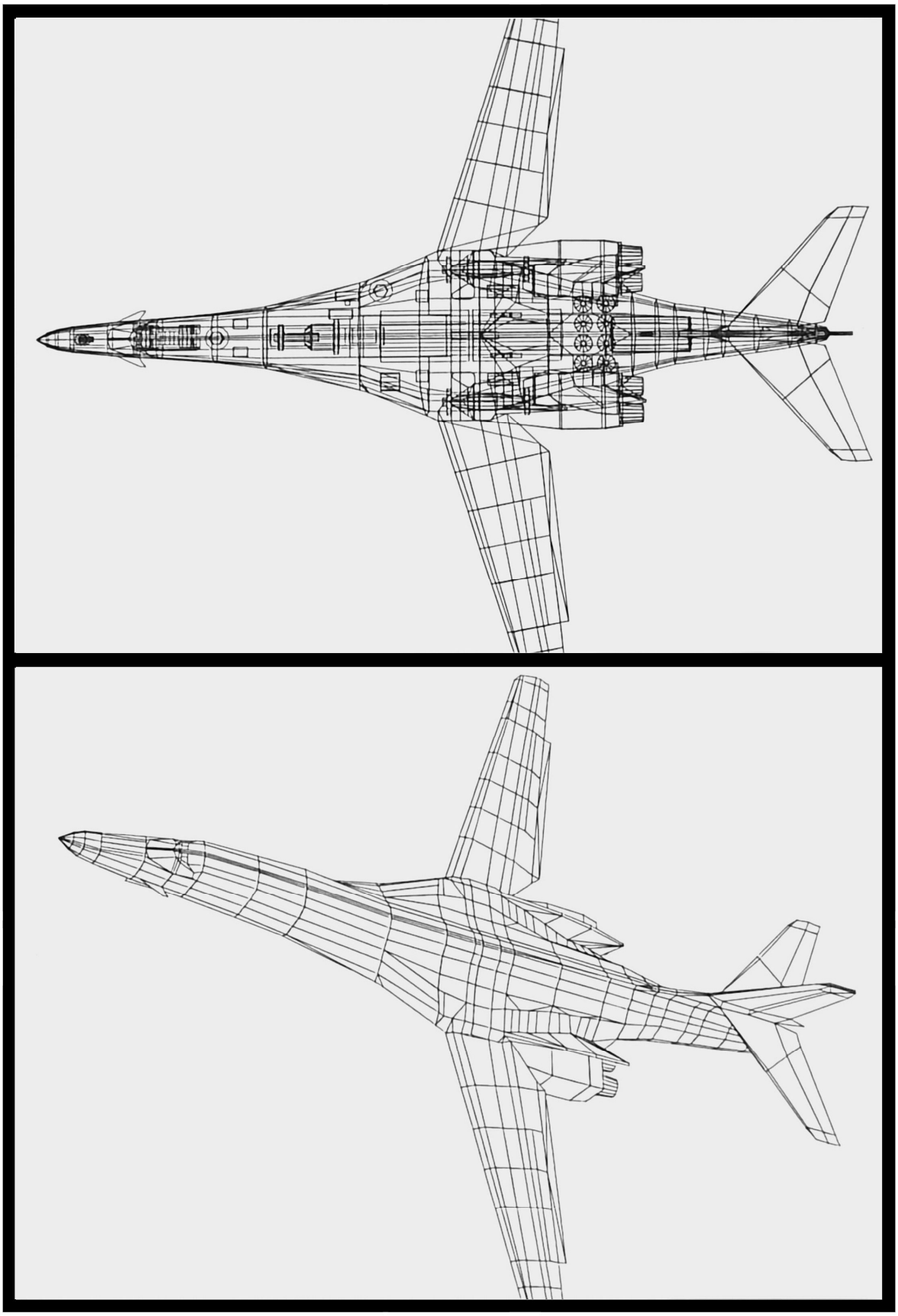
B-1B Lancer, Infographics, 1984

MU ICARUS with HLR 3D CG A3 ink drawing.



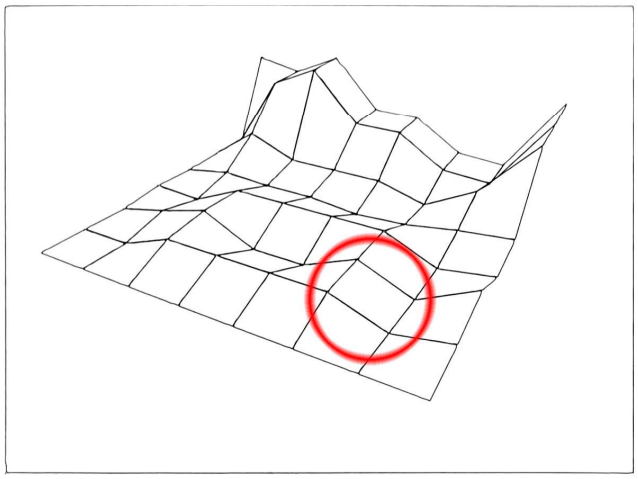
B-1B Lancer, Infographics, 1984

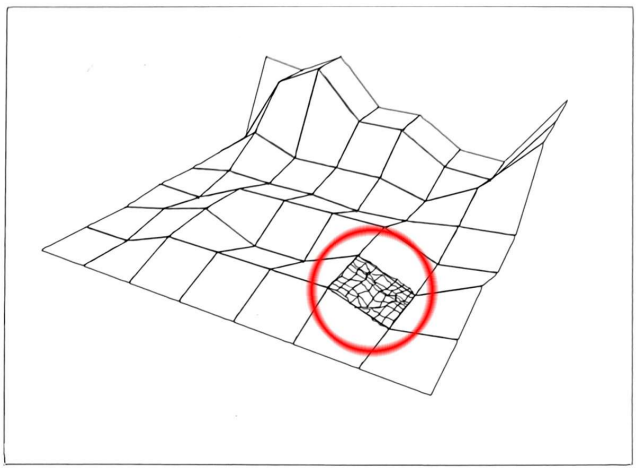
MU ICARUS with HLR 3D CG A3 ink drawing.

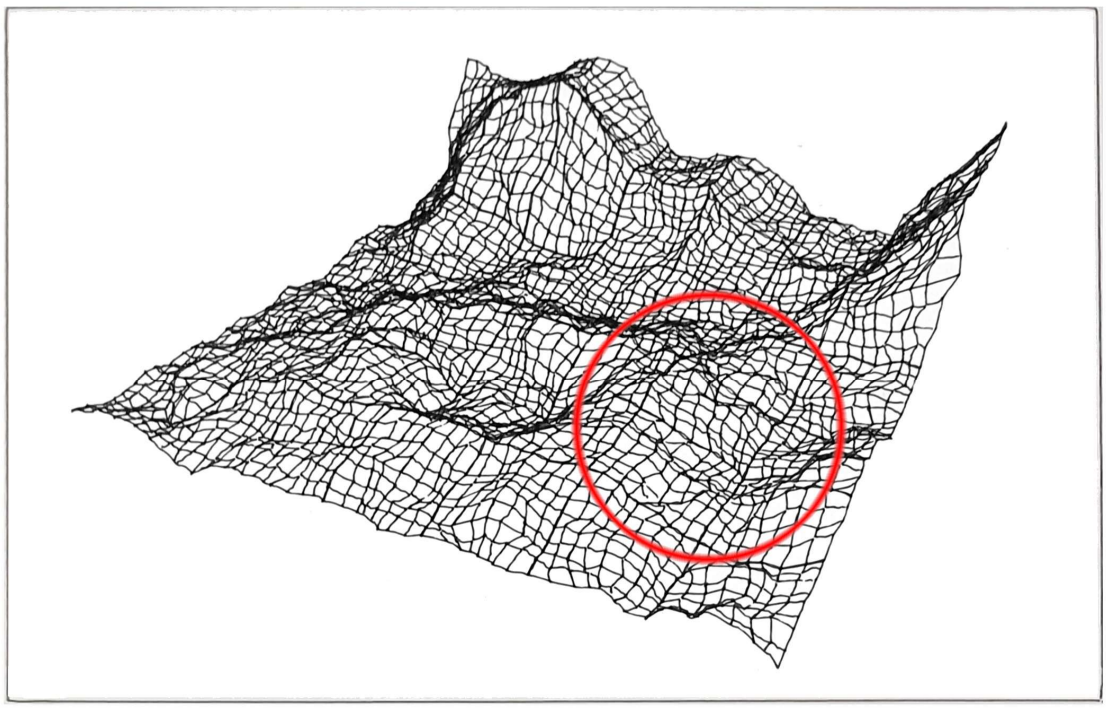


Blended Multi Part Surfaces 1, Fractals, 1984

MU ICARUS with HLR 3D CG A3 ink drawing.

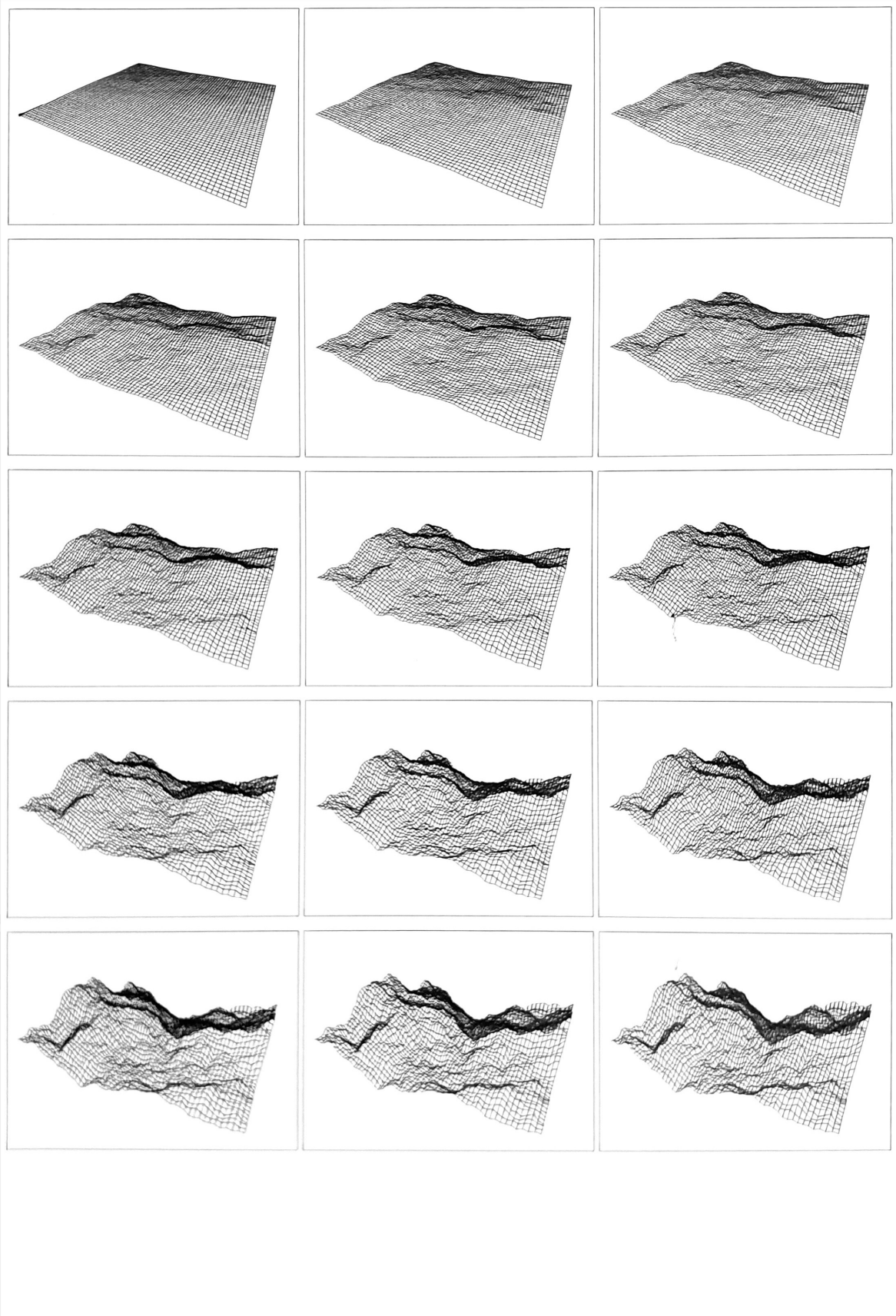






Blended Multi Part Surfaces 2, Fractals, 1984

MU PICASO without HLR 3D CG A2 ink drawing.

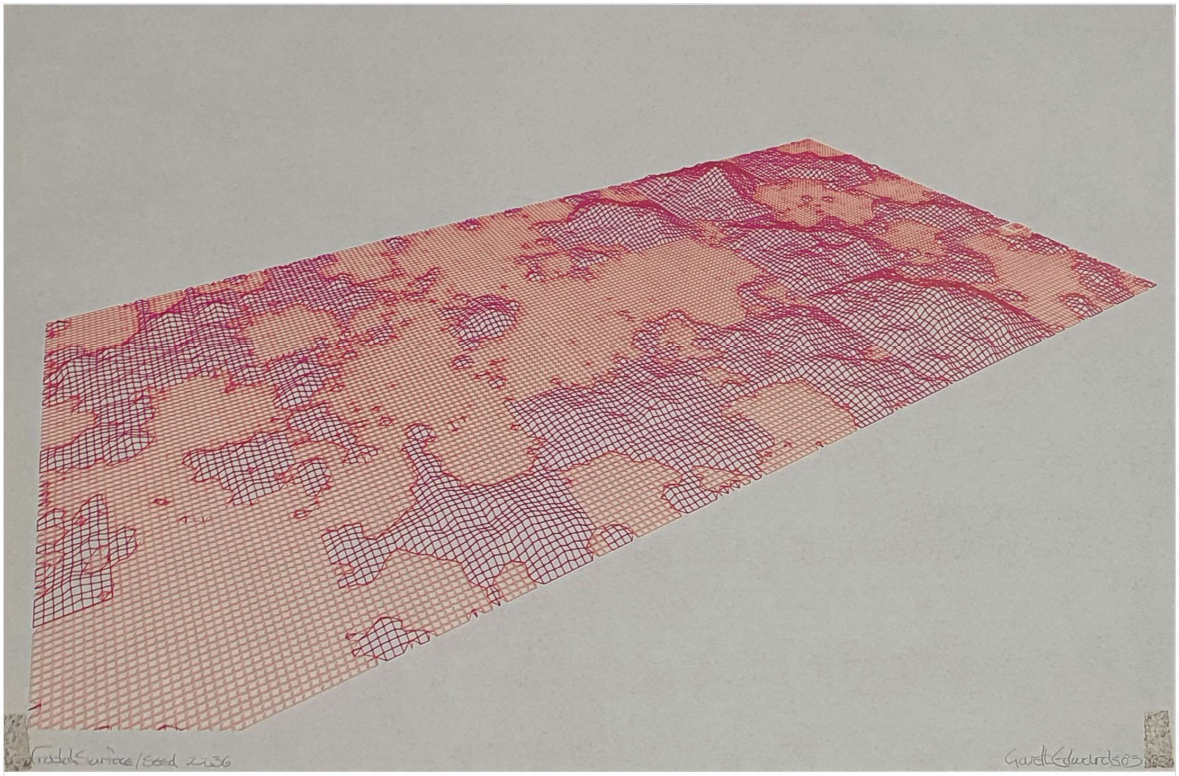


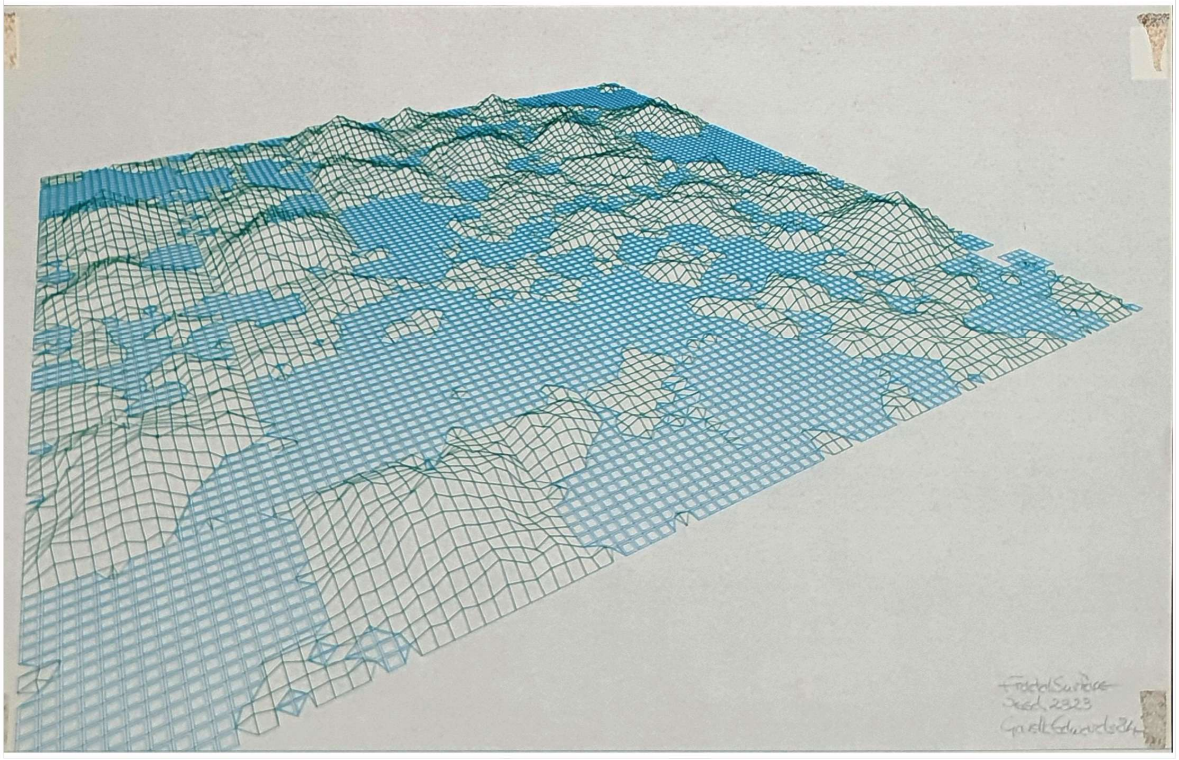
Blended Multi Part Surfaces 3, Fractals, 1984

MU PICASO without HLR 3D CG A2 ink drawing.

Blended Multi Part Surfaces 4, Fractals, 1984

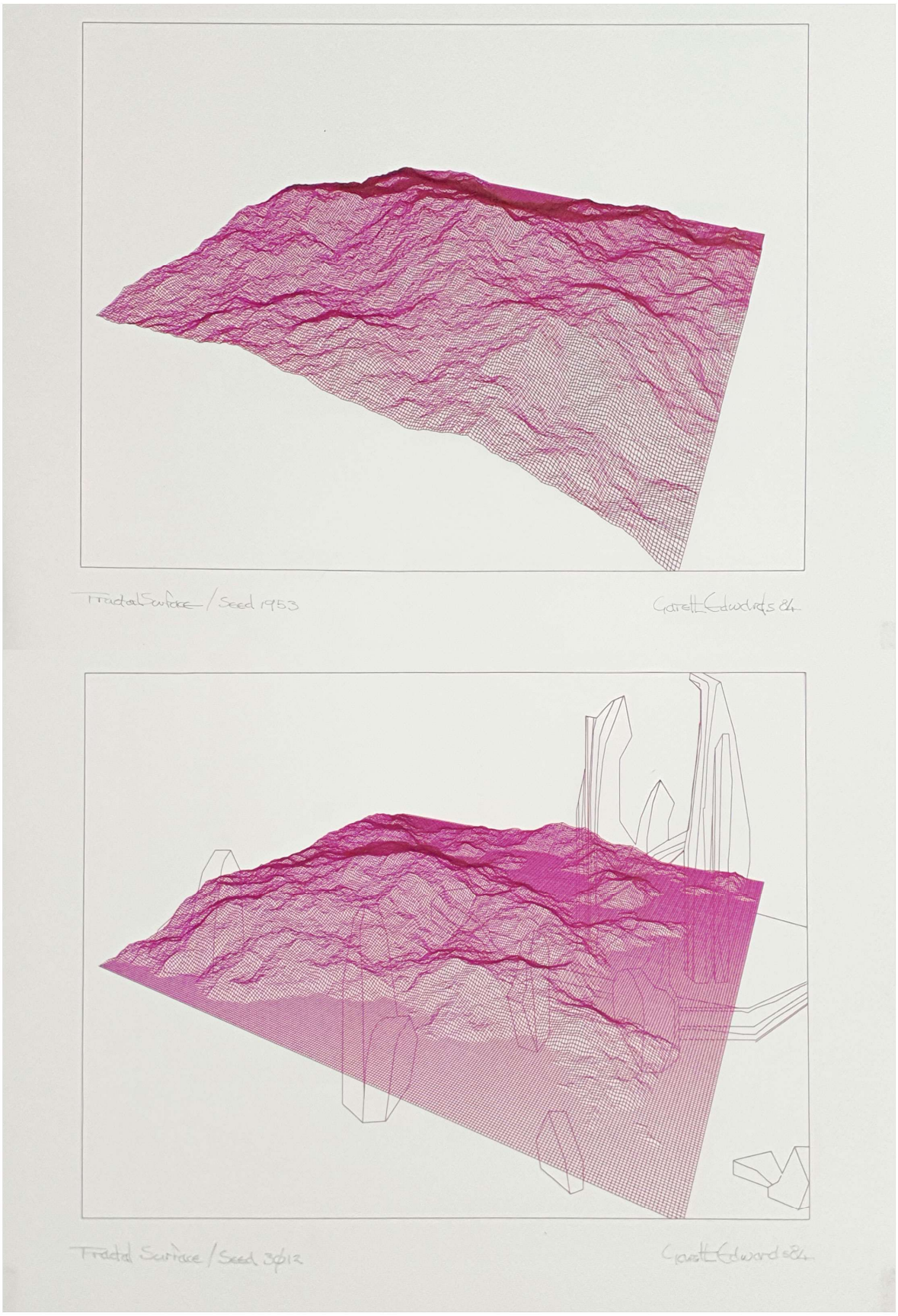
MU PICASO without HLR 3D CG A2 ink drawing.





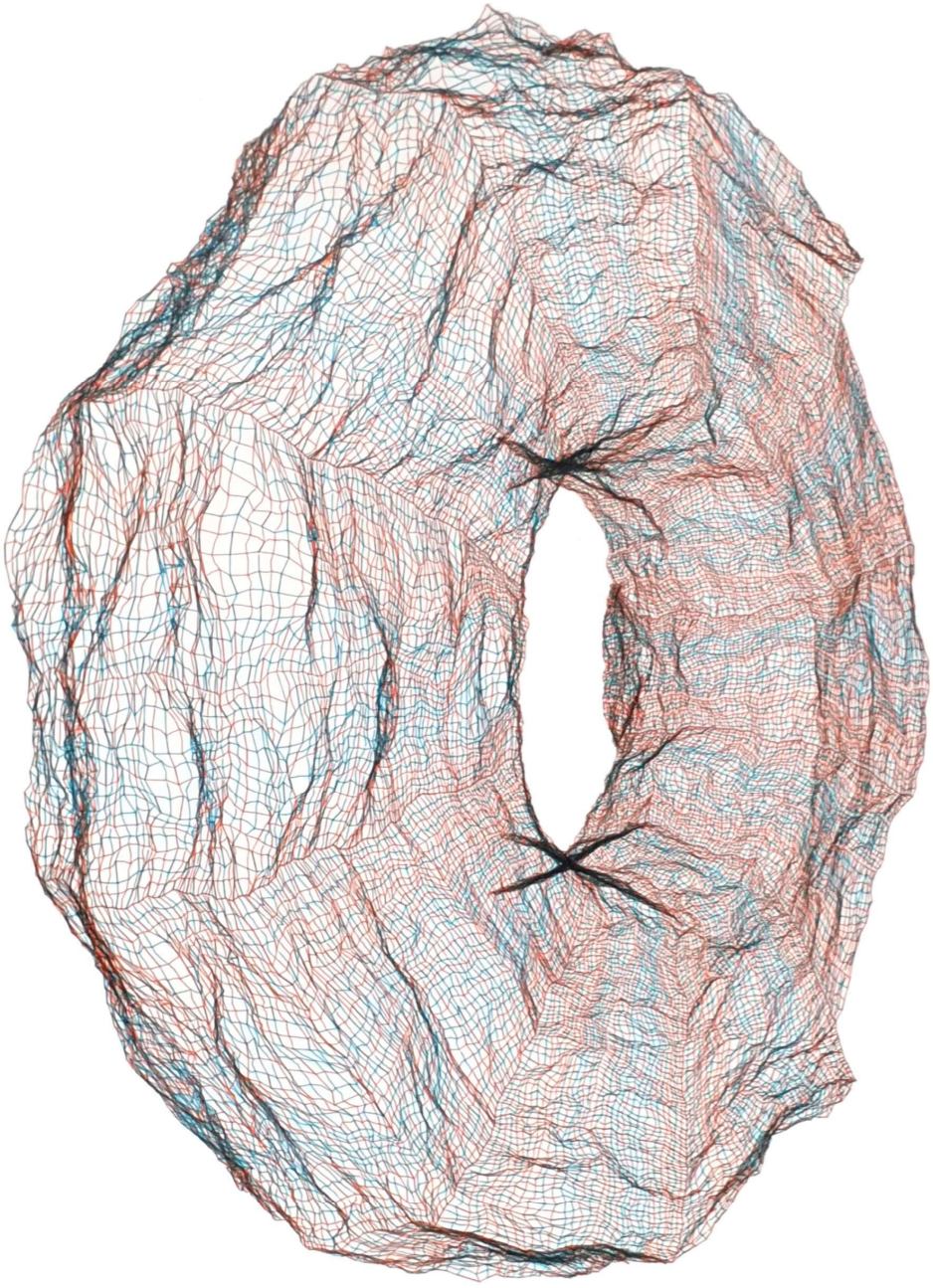
Blended Multi Part Surfaces 5, Fractals, 1984

MU PICASO without HLR 3D CG A2 ink drawing.



Blended Multi Part Donut, Fractals, 1984

MU PICASO without HLR 3D CG A2 ink drawing.



Blended Multi Part Face 1, Fractals, 1984

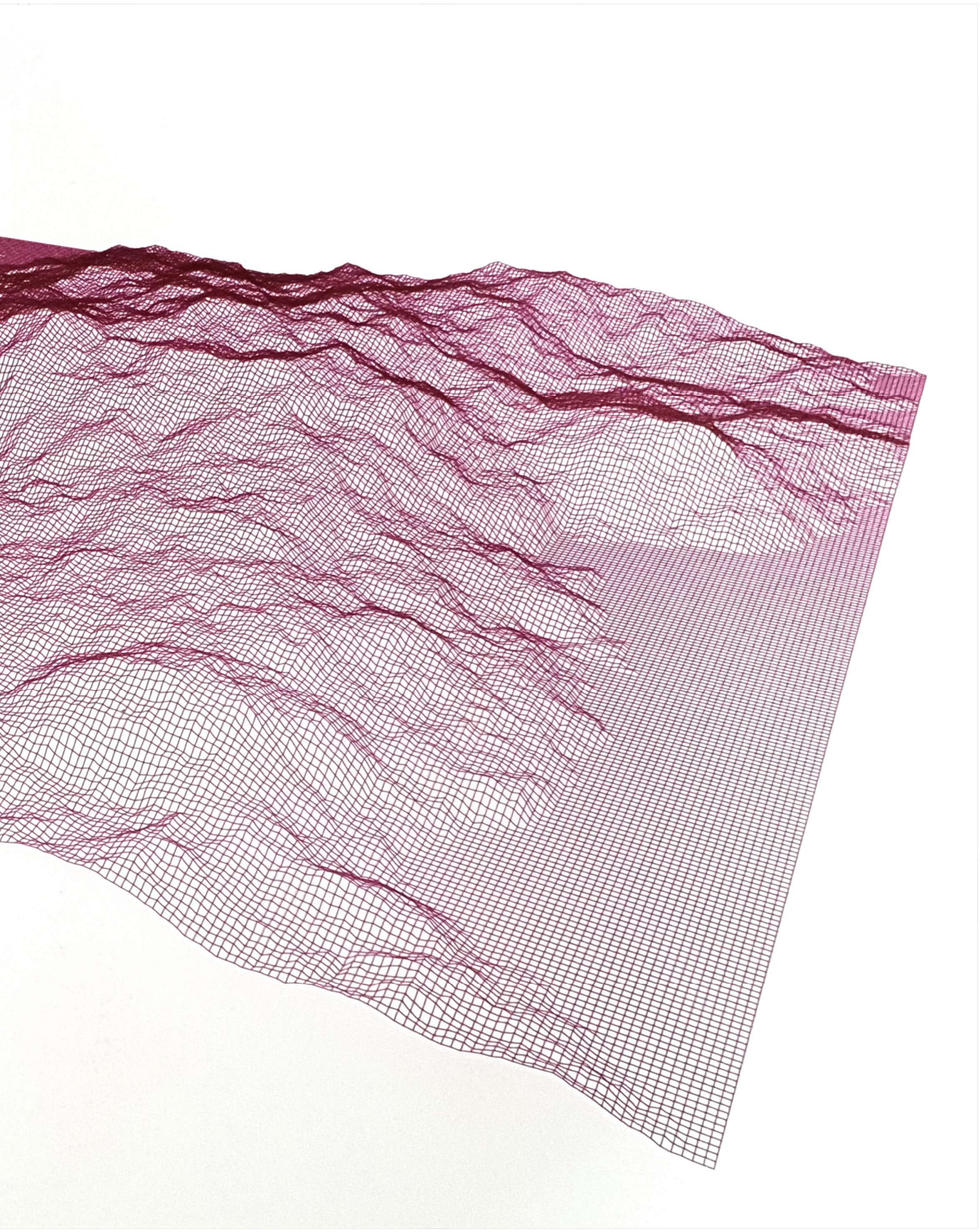
MU PICASO without HLR 3D CG A2 ink drawing.

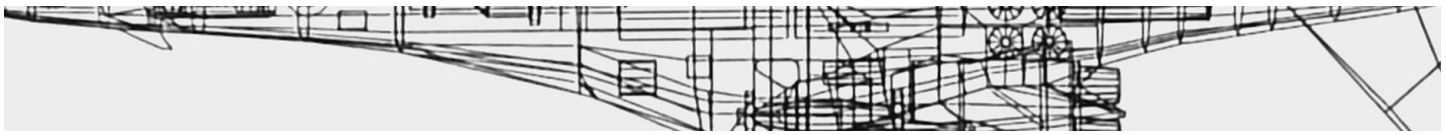
Blended Multi Part Face 2, Fractals, 1984

MU PICASO without HLR 3D CG A2 ink drawing.

Blended Multi Part Surfaces, Fractals, 1984

MU PICASO without HLR 3D CG A2 ink drawing.





Persona Dramatis

Gray's School of Art, Aberdeen

After 5 years as an undergraduate and one year as a post-graduate student, Gray's had become my home.

My Lecturers and Tutors were all excellent, in particular Bill Littlejohn and Joyce Cairns.

William (Bill) Hunter Littlejohn RSA (1929-2006) An acclaimed Scottish artist known for his evocative still life's relating to the landscape of north-east Scotland.

Joyce W. Cairns. Studied painting at Gray's School of Art, Aberdeen, The Royal College of Art, London and at Goldsmiths College, University of London. In 1976 she returned to Aberdeen where she taught Drawing and Painting at Gray's School of Art. In 2018 she was elected President of the Royal Scottish Academy, a post which she held for four years.

Royal College of Art, Painting School, London

The RCA worked hard to introduce me to the leading digital artists & creative thinkers.

These included:

Harold Cohen: Creator of AARON, a computer program designed to produce paintings and drawings autonomously, which set it apart from previous programs

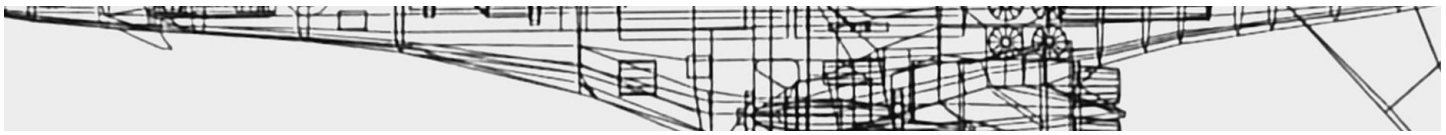
Edward Ihnatowicz: Cybernetic art sculptor active in the late 1960s and early 1970s. His sculptures – most famously *Sound Activated Mobile* (SAM) - explored the interaction between his robotic works and the audience.

Annabel Jankel: British film and TV director, and the co-creator of the pioneering cyber-character Max Headroom.

Keith Critchlow: British artist, lecturer, author, sacred geometer, professor of architecture, and a co-founder of the Temenos Academy in the UK.

Rocky Morton: English music video, television, and film director. He is the co-creator of the TV series Max Headroom and co-director of the Max Headroom.

Jasia Reichardt: Curated Cybernetic Serendipity, an exhibition of cybernetic art shown at the Institute of Contemporary Arts, London.



Royal College of Art, Painting School, London, continued…

Jeremy (Jed) Gardiner: Fellow student, and now a much-respected contemporary landscape painter. His talent, inspirational ambition and chutzpa, landed him various scholarships and awards (including the Winston Churchill to MIT).

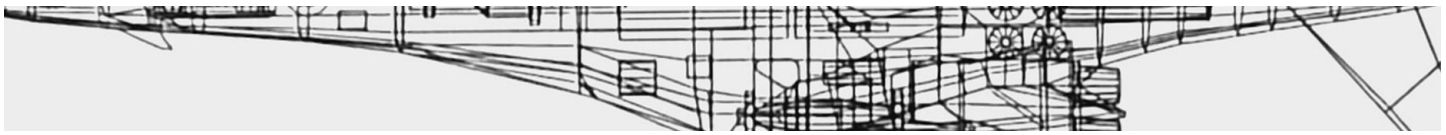
William Latham: Fellow student, authored *Evolutionary Art and Computers and* worked together with Stephen Todd, generating 3D computer models of organic life forms, using genetic algorithm-based techniques to mutate base forms into artistic creations.

Middlesex University, London

Professor John Vince: He began working in computer graphics at Middlesex Polytechnic in 1968. His research activities centred on computer animation software and resulted in the PICASO and PRISM animation systems. While at Middlesex, he designed the UK's first MSc course in computer graphics and developed a popular program of short courses in computer animation for television designers.

In 1986 he joined Rediffusion Simulation as a Research Consultant and worked on the development of real-time computer systems for commercial flight simulators. In 1992 he was appointed Chief Scientist of Thomson Training Simulation Ltd. In 1995 he became Professor of Digital Media at the National Centre for Computer Animation at Bournemouth University and in 1999 was made Head of Academic Group for Computer Animation. He was awarded a DSc by Brunel University in recognition of his work in computer graphics. He has written and edited more than 45 books on computer graphics, computer animation, computer science and virtual reality.

As noted in Terms, PICASO is a very early computer animation software developed by John Vince. It stands for Picture Computer Algorithms Subroutine Orientated



Keywords & Terms

Fractals
A fractal is a geometric shape that displays detailed structure at arbitrarily small scales, often having a "fractional dimension". They are characterized by self-similarity, where parts of the fractal are similar to the whole, even when magnified. Fractals can be found in both nature (coastlines, snowflakes, trees) and in abstract mathematical models (Mandelbrot set).

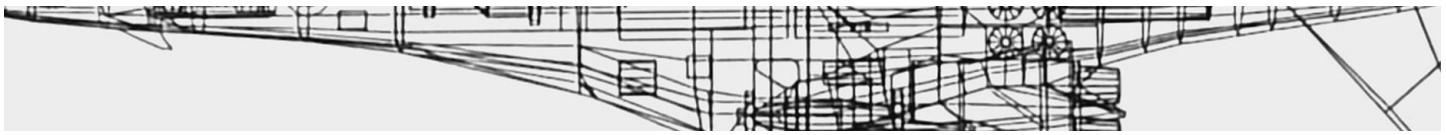
Gray's School of Art (GSA)
Located in Aberdeen, Scotland. Part of Robert Gordon University, it is one of the oldest established fine art institutions in Scotland and one of Scotland's five art schools today and ranked among the Top 20 Schools of Art and Design in the United Kingdom.

Hidden Line Removal (HLR)
A computer graphics technique that removes lines in a 3D model that would be obscured by other objects in the scene, as if viewed from a specific perspective. It essentially identifies and removes lines that would not be visible if the object were solid and opaque. HLR is commonly used to create clearer and more accurate 2D drawings from 3D models, particularly in industries requiring technical illustrations.

ICARUS – Interactive Colour Algorithms Rendering Using Subroutines
Originally written in FORTRAN, and in 1984 and later in the C and C++ programming languages, this computer graphics system was designed for professionals in the Film & TV industries. Like PICASO, it's inspirational predecessor (see below), its underlying philosophy was to reduce diverse advanced image synthesis requirements to easy to access and use modules. The range of modules included hidden line removal (complimentary to PICASO for use with pen plotters), glow renderers (e.g., Doctor Who in 1987), and photo-realistic radiosity and raytracing rendering (competing against PIXAR, etc.).

Middlesex University (MU)
Middlesex University, London, is a public research university based in Hendon, northwest London, England. At the time of this documents narrative, I was based at the Bounds Green site, providing one day a week support and teaching at the Art School at the Cat Hill site.

PICASO - Picture Computer Algorithms Subroutine Orientated
A FORTRAN-based computer graphics system designed to simplify the interface between programmer and graphical challenges. The underlying philosophy behind PICASO was to reduce these to modules. PICASO also provided an animation framework, and interfaces to pen plotters.



Pen Plotter

- Flatbed plotters are called “flatbed” because, compared to roller plotters, they use a beam that moves the tools over the material rather than having the material move under the beam, and the same material is placed on a flat surface.

- Vertical plotters draw by moving a pen in the X & Y over a vertical surface. In some plotters the drawing surface moves in Y, and the pen moves in X.

Royal College of Art, London (RCA)
The RCA is a research university in London, United Kingdom. It is the only entirely postgraduate art & design university in the UK.

Robert Gordon’s University, Aberdeen (RGU)
Robert Gordon University, commonly called RGU, is a public university in the city of Aberdeen, Scotland.

Scott Sutherlands School of Architecture, Aberdeen (SSSA)
The Scott Sutherland School of Architecture and Built Environment is one of the three oldest of its kind in the UK, with a heritage that extends back to the 19th Century.

Wireframe
In 3D computer graphics, a **wireframe** model (also spelled **wire-frame** model) is a visual representation of a three-dimensional (3D) physical object. It is based on a polygon mesh or a volumetric mesh, created by specifying each edge of the physical object where two mathematically continuous smooth surfaces meet, or by connecting an object's constituent vertices using (straight) lines or curves.

The object is projected into screen space and rendered by drawing lines at the location of each edge. The term "wire frame" comes from designers using metal wire to represent the three-dimensional shape of solid objects.