HOW G-CODE TAUGHT MACHINES TO MOVE.

FROM PUNCHED CARDS TO G01.

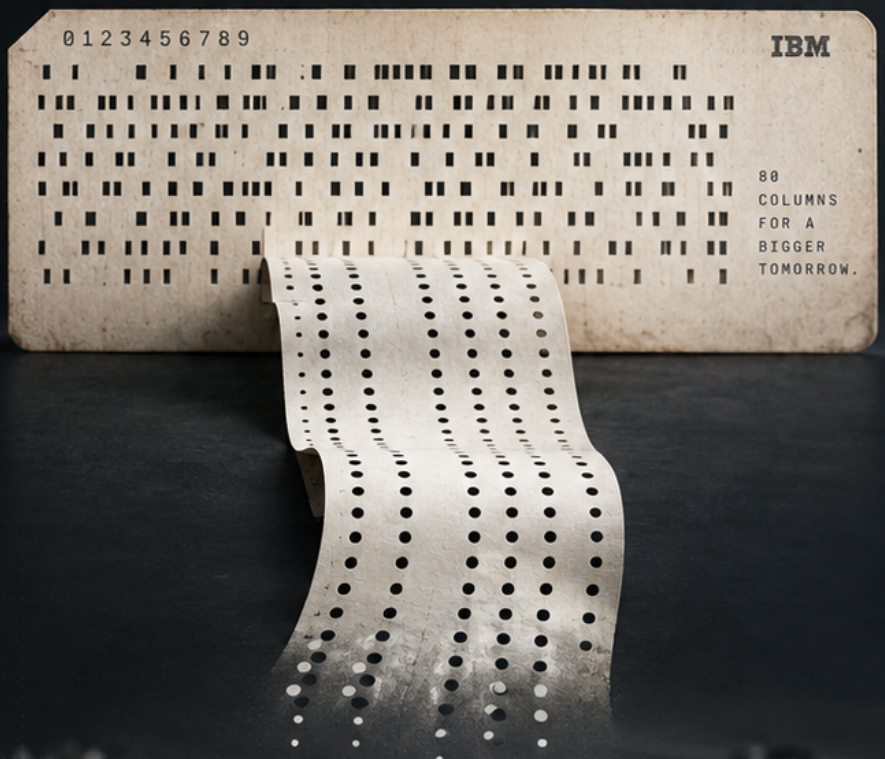
IDEAS
MATERIALS
TOOLS
PROGRESS
—

SAME
PRINCIPLES.
FURTHER
POSSIBILITIES.
—

PEOPLE
MACHINES
BETTER
THINGS
—

DATA
BECAME
MOTION.
—

SIMPLE
INSTRUCTIONS.
REAL
WORLD IMPACT.
—



THE LANGUAGE EVOLVED. THE IDEA SURVIVED.

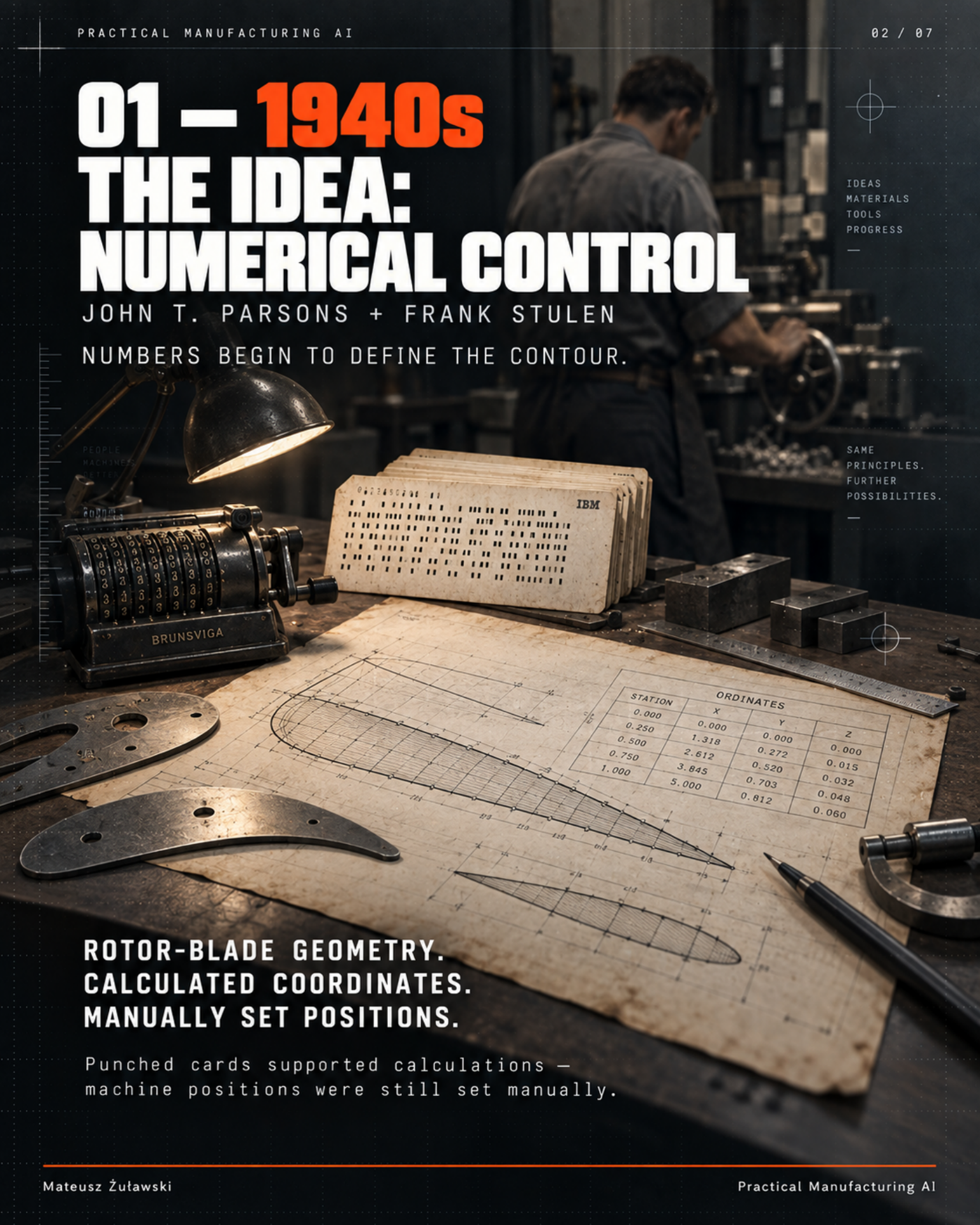
01 — 1940s
THE IDEA: NUMERICAL CONTROL

JOHN T. PARSONS + FRANK STULEN

NUMBERS BEGIN TO DEFINE THE CONTOUR.

IDEAS
MATERIALS
TOOLS
PROGRESS
—

SAME
PRINCIPLES.
FURTHER
POSSIBILITIES.
—



ROTOR-BLADE GEOMETRY. CALCULATED COORDINATES. MANUALLY SET POSITIONS.

Punched cards supported calculations — machine positions were still set manually.

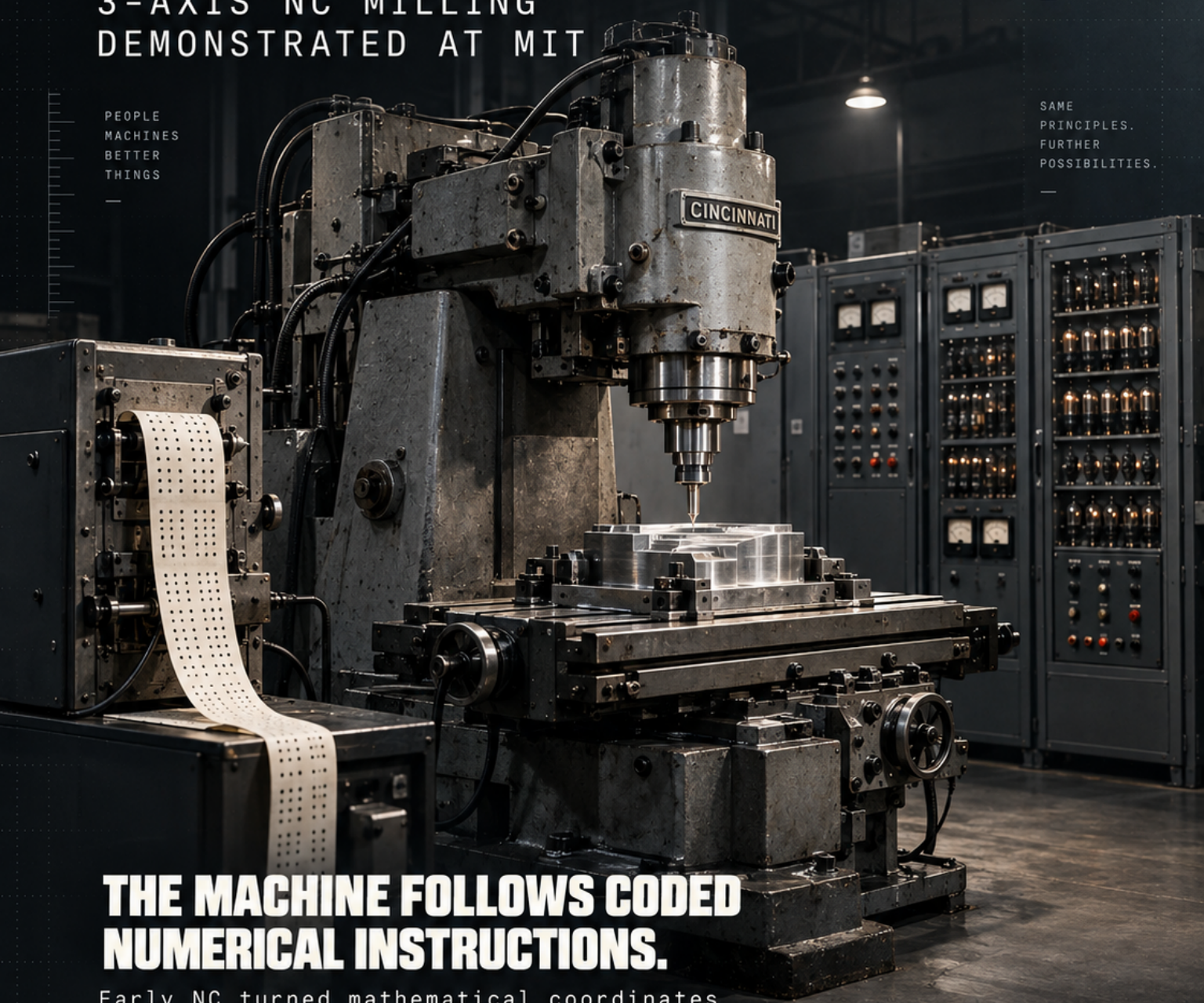
02 — 1949 → 1952
MIT + U.S. AIR FORCE

3-AXIS NC MILLING DEMONSTRATED AT MIT

IDEAS
MATERIALS
TOOLS
PROGRESS

PEOPLE
MACHINES
BETTER
THINGS

SAME
PRINCIPLES.
FURTHER
POSSIBILITIES.



THE MACHINE FOLLOWS CODED NUMERICAL INSTRUCTIONS.

Early NC turned mathematical coordinates into machine motion.

Historical reconstruction

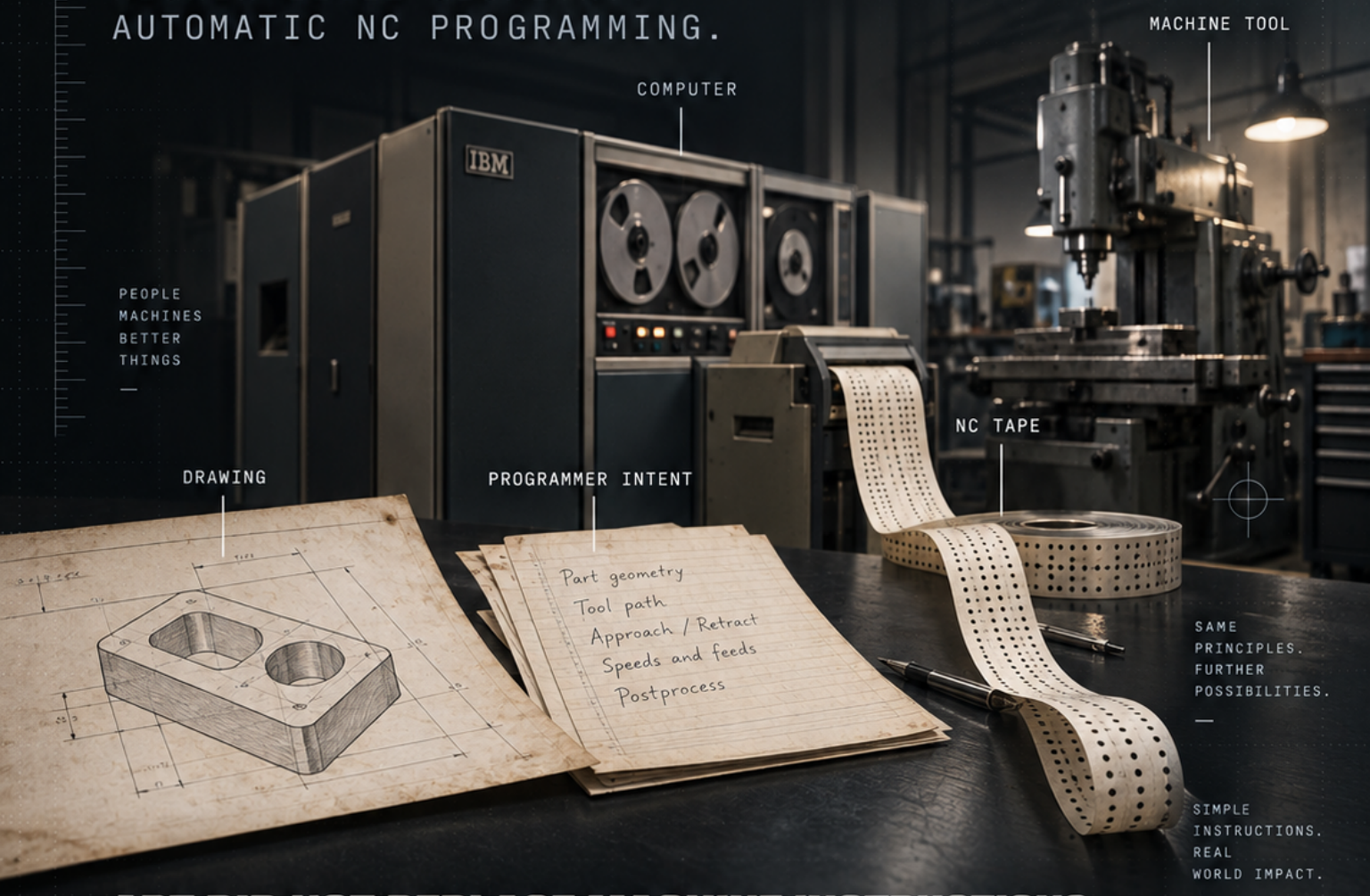
03 — LATE 1950s

APT

AUTOMATICALLY PROGRAMMED TOOL

HIGHER-LEVEL GEOMETRY.
AUTOMATIC NC PROGRAMMING.

IDEAS
MATERIALS
TOOLS
PROGRESS
—



PEOPLE
MACHINES
BETTER
THINGS
—

SAME
PRINCIPLES.
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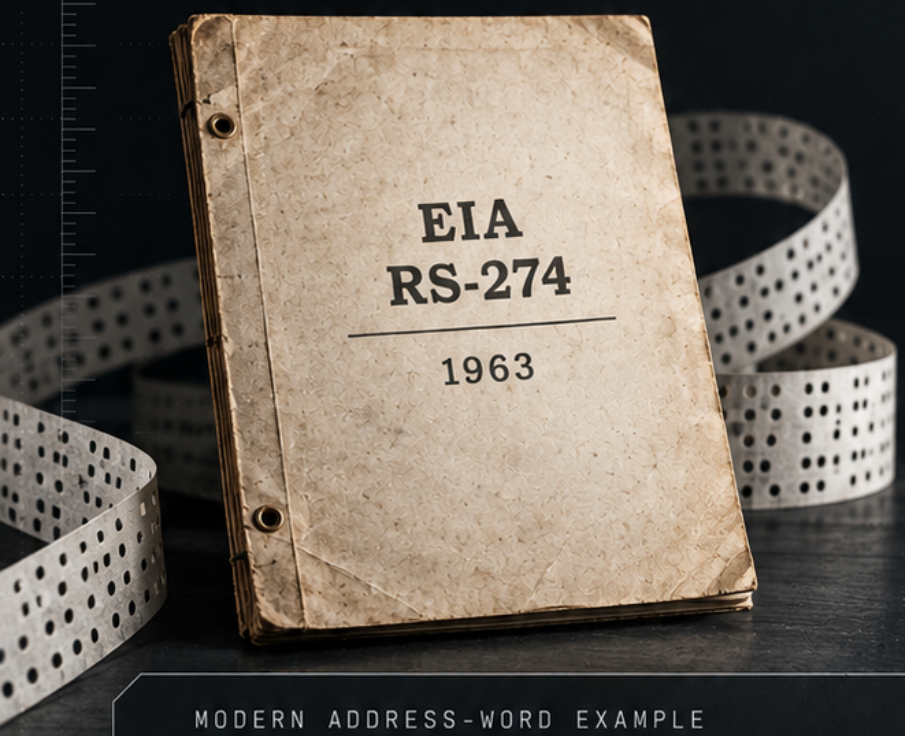
APT DID NOT REPLACE MACHINE INSTRUCTIONS. IT AUTOMATED THEIR GENERATION.

Geometry and tool motion were processed and postprocessed into machine-specific NC instructions.

04 — 1963
RS-274

EIA RS-274

A STANDARDISED ADDRESS-WORD FORMAT FOR NUMERICAL CONTROL.



N — BLOCK NUMBER

G — PREPARATORY FUNCTION

X Y Z — AXIS POSITION

F — FEED

S — SPINDLE SPEED

M — MISCELLANEOUS FUNCTION

MODERN ADDRESS-WORD EXAMPLE

```
N10 S2500 M03
N20 G00 X0 Y0
N30 G01 Z-5.000 F250
```

Illustrative excerpt — not a complete program.

A FOUNDATION FOR THE G-CODE FAMILY.

Later revisions and ISO standards followed.

05 — CNC TODAY
SAME DNA. DIFFERENT MACHINE.



ILLUSTRATIVE MILLING EXCERPT

```
G21 G17 G90 G94
G54
T1 M06
S2500 M03
G00 X0 Y0
G43 H01 Z5.000
G01 Z-5.000 F250
G02 X40.000 Y0 I20.000 J0
```

Illustrative excerpt, not a ready-to-run program.

G00 — RAPID

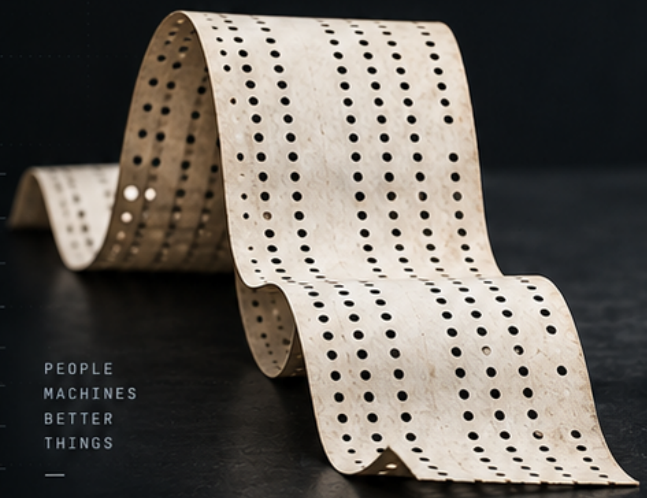
G01 — LINEAR

G02 / G03 — CIRCULAR

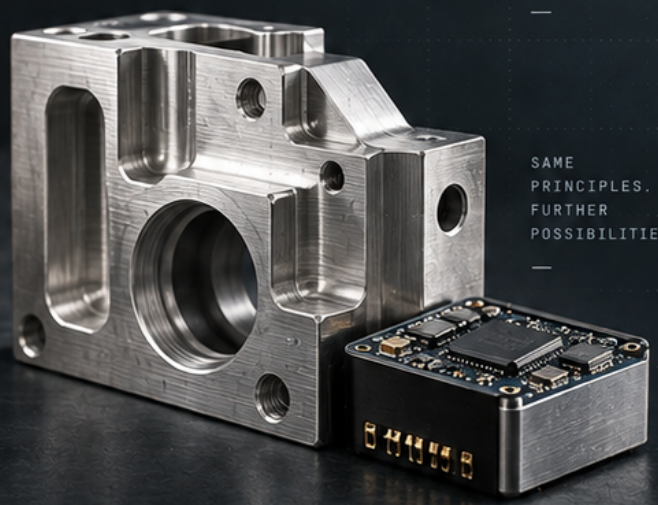
DIALECTS AND IMPLEMENTATIONS VARY BY CONTROL AND MACHINE BUILDER.

THEN → NOW

IDEAS
MATERIALS
TOOLS
PROGRESS



PEOPLE
MACHINES
BETTER
THINGS



SAME
PRINCIPLES.
FURTHER
POSSIBILITIES.

THEN

PUNCHED TAPE
LITTLE OR NO PROGRAM MEMORY
EARLY NC
LABOUR-INTENSIVE DATA PREPARATION

NOW

SOLID-STATE MEMORY
CAD/CAM
MULTI-AXIS CNC
DIGITAL WORKFLOW

THE MOTION LANGUAGE
STILL LOOKS FAMILIAR.

THE HARDWARE CHANGED. THE LOGIC SURVIVED.

More than six decades later, G-code still tells machines where to move.

SAVE THIS CAROUSEL.
FOLLOW MATEUSZ ŻUŁAWSKI

PRACTICAL MANUFACTURING AI

MANUFACTURING
CONNECTS
PEOPLE
AND PROGRESS

HOW G-CODE TAUGHT MACHINES TO MOVE

FROM PUNCHED CARDS TO G01

THE LANGUAGE EVOLVED. THE IDEA SURVIVED.

PRECISION
IDEAS
MACHINES
REAL RESULTS

01 — 1940s

THE IDEA: NUMERICAL CONTROL

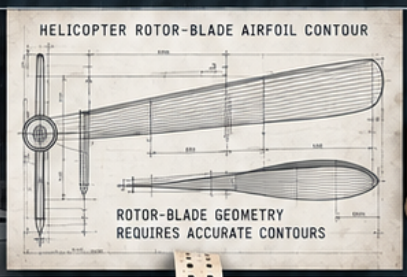
JOHN T. PARSONS + FRANK L. STULEN

NUMBERS BEGIN TO DEFINE THE CONTOUR.

PUNCHED-CARD CALCULATION GENERATED COORDINATES FOR HELICOPTER ROTOR-BLADE CONTOURS. THE MACHINE POSITIONS WERE STILL SET MANUALLY.



PARSONS
STULEN
1940s





CALCULATE COORDINATES
↓
TRANSFER TO MACHINE
↓
MANUAL POSITIONING
↓
CONTOUR TEMPLATE

02 — 1949 → 1952

MIT + U.S. AIR FORCE

3-AXIS NC MILLING DEMONSTRATED AT MIT.

THE MACHINE FOLLOWS CODED NUMERICAL INSTRUCTIONS.



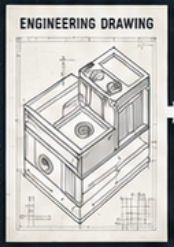
CALCULATE THE PATH
↓
ENCODE THE PATH
↓
CONTROL THE MACHINE

03 — LATE 1950s

APT

AUTOMATICALLY PROGRAMMED TOOL

HIGHER-LEVEL GEOMETRY IS TRANSLATED INTO DETAILED MOTION.



APT SOURCE LANGUAGE

```
P1 = POINT / 0.0,0
P2 = POINT / 40,20,0
L1 = LINE / P1,P2
C1 = CIRCLE / P2,28
```

DEFINE GEOMETRY, NOT MACHINE MOVES.







FROM GEOMETRY TO MOTION.

APT DID NOT REPLACE MACHINE INSTRUCTIONS. IT AUTOMATED THEIR GENERATION.

04 — 1963

EIA RS-274

STANDARDISED ADDRESS-WORD FORMAT FOR NUMERICAL CONTROL.

A FOUNDATION OF THE LANGUAGE FAMILY LATER ASSOCIATED WITH [illegible]

EIA ELECTRONIC INDUSTRIES ASSOCIATION

EIA STANDARD
RS-274
Numerical Control Programming for Automatic Machine Tools

JUNE 1963

THE ADDRESS WORDS

N	→	BLOCK / SEQUENCE NUMBER
G	→	PREPARATORY FUNCTION
X Y Z	→	AXIS POSITION
F	→	FEED
S	→	SPINDLE SPEED
M	→	MISCELLANEOUS FUNCTION

ADDRESS-WORD STRUCTURE — ILLUSTRATIVE

```
N10  S2500 M03
N20  G00 X0 Y0
N30  G01 Z-5.000 F250
N40  G02 X40.000 Y0.000 I20.000 J0.000
```

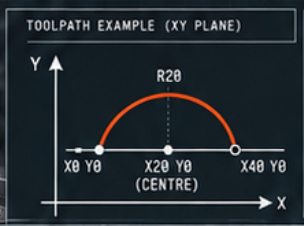
STANDARDISATION TURNED IDEAS INTO INDUSTRY.

05 — CNC TODAY

SAME DNA. DIFFERENT MACHINE.

MODERN CONTROLS. HIGHER PRECISION. THE SAME FUNDAMENTAL LANGUAGE.





G00 — RAPID POSITIONING
G01 — LINEAR FEED
G02 — CLOCKWISE CIRCULAR INTERPOLATION
G03 — COUNTER-CLOCKWISE CIRCULAR INTERPOLATION



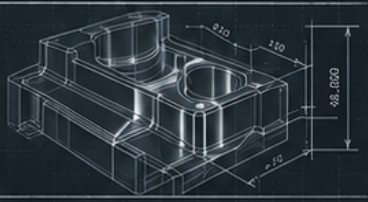
THEN

PUNCHED TAPE
LIMITED MEMORY
NUMERICAL CONTROL
MANUAL DATA PREPARATION



NOW

SOLID-STATE MEMORY
CAD/CAM
MULTI-AXIS CNC
DIGITAL WORKFLOW



THE MOTION LANGUAGE STILL LOOKS FAMILIAR.

THE HARDWARE CHANGED. THE LOGIC SURVIVED.

MORE THAN SIX DECADES LATER, G-CODE STILL TELLS MACHINES WHERE TO MOVE.

SAVE THIS POSTER.

THE HISTORY OF G-CODE — IN ONE PLACE.

FOLLOW MATEUSZ ŻUŁAWSKI

PRACTICAL MANUFACTURING AI