(GENERAL) ELECTRIC DREAMS: RESTORING THE GE-120 A MILESTONE IN TRANSISTOR-BASED COMPUTING

Honeywell Bull

. ATTE



MUSIF- MIAI

- Two projects independently born from the south Italian hacker counter-culture, grown so close to become single entity
- Thousands of artefacts: mainframes, workstations, gaming consoles, peripherals
- A library of thousands of books, technical manuals, papers, officially part of the Italian national library service
- Currently at the end of a years-long move, inauguration of the new location coming soon



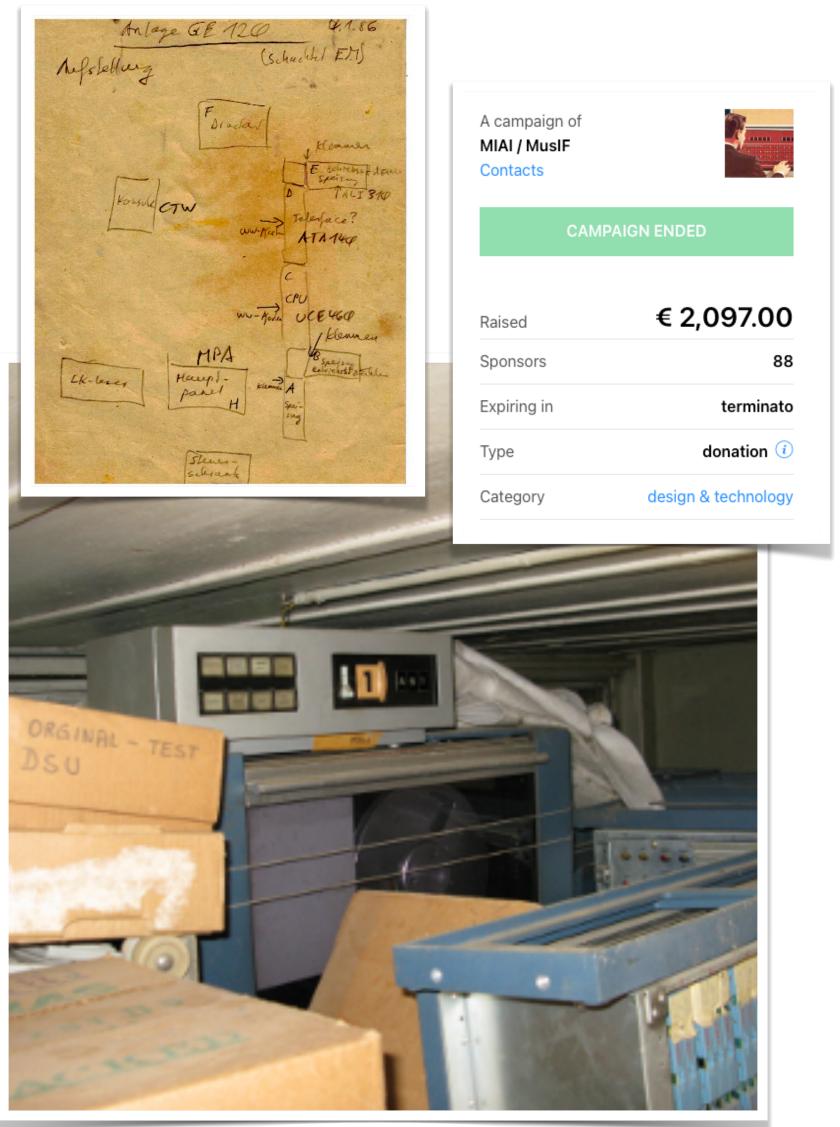
- Museums and their members are geographically distributed
- A yearly weekender event to meet each other and work on the machine
- Relatively slow progress but very focused sessions
- Part of the rich calendar of Italian summer hack events



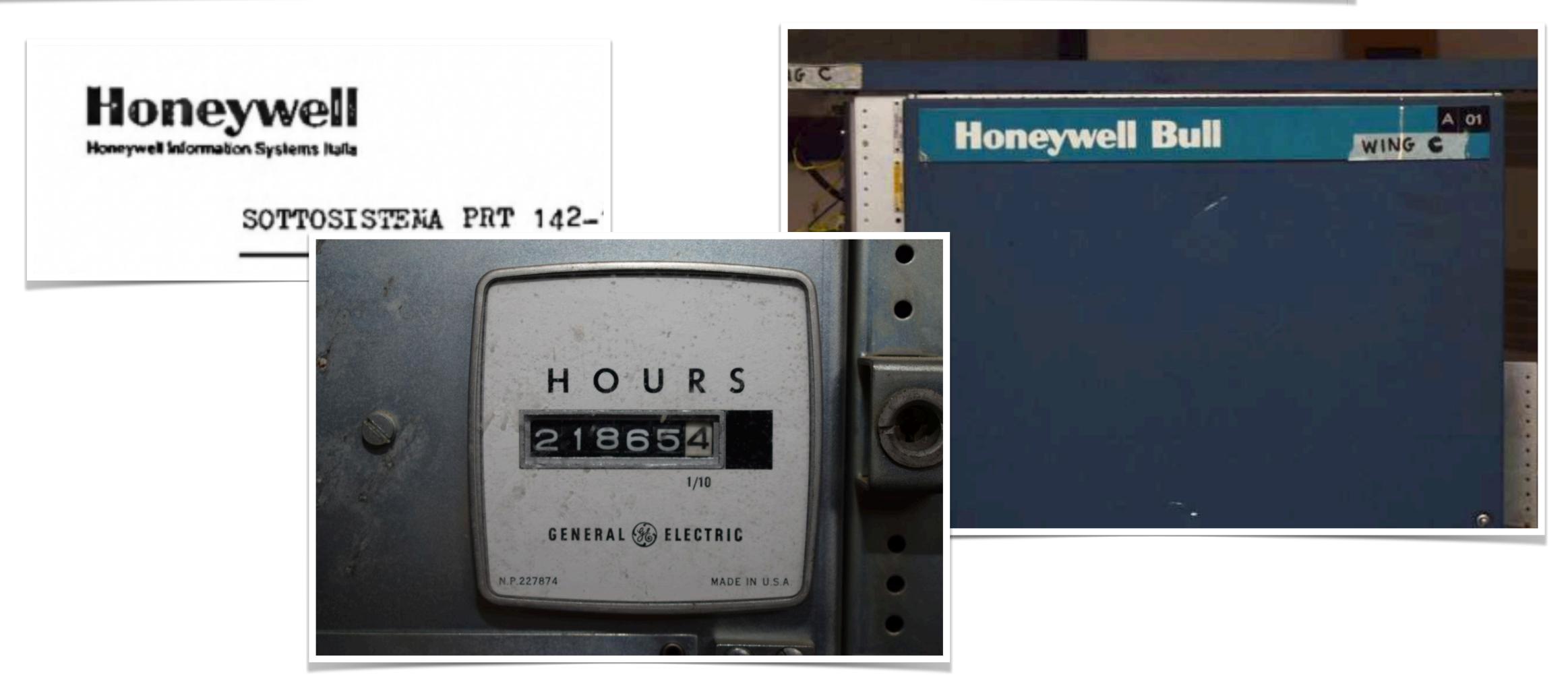


UNLOAD & LAY OF THE LAND

- Machine found by the friend organization ESoCoP - European society for computer preservation (esocop.org)
- Barn find
 - Commissioned at the Zurich airport until 1984
 - "Saved" by and obtained from one of its original operators, Markus
- Successful crowdfunding campaign • 88 sponsors and ~ 2000EUR raised.







DENOMINAZIONE U.E. Brinello asservimento alternate S.U. DESCRIPTION A.C. DISTRIBUTION CONTROL ASSY.

TECH SPECS

Honeywell Series 100

CHARACTERISTICS OF THE SERIES 100 SYSTEMS

	G-105	Model 5	Model 10	G-115	G-120	Model 15	G-130
DATE INTRODUCED	1969	1971	1971	1965	1969	1971	1968
MAIN STORAGE							
Cycle time, microseconds	7.5	6.5	6.5	6.5	4	4 or 2	2
Bytes fetched per cycle	1	1	1	1	1	1	1
Minimum capacity, bytes	4,096	4,096	8,192	4,096	12,288	16,384	16,384
Maximum capacity, bytes	8,192	12,288	12,288	16,384	24,576	65,536	32,768
PROCESSOR							
No. of instructions	39	39	39	39	67	67	67
No. of index registers	0	0	0	0	8	8	8
Instruction times, microseconds:					i.		
Add (5 digits, unpacked)	120	114	114	114	88	88 or 44	44
Add (5 digits, packed)	*	*	*	*	68	68 or 34	34
Multiply (5 digits)	*	*	*	*	1020	1020 or 510	510
Divide (10 by 5 digits)	*	*	*	*	1648	1648 or 824	824
Move (5 bytes)	120	104	104	104	68	68 or 34	34
Compare (5 bytes)	120	114	114	114	88	88 or 44	44
Branch	30	26	26	26	20	20 or 10	10
INPUT/OUTPUT CONTROL							
No. of I/O channels	2	2	2	2	3	3	3
No. of peripheral connectors	· · _	3 or 4	3 or 4	4	4	4	4
Maximum simultaneous I/O operations (unbuffered)	2	2	2	2	3	3	3
Magnetic tape capability	No	Yes	Yes	Yes	Yes	Yes	Yes
Disc storage capability	No	No	Yes	Yes	Yes	Yes	Yes
Data communications capability	Yes	Yes	Yes	Yes	Yes	Yes	Yes
STANDARD PERIPHERALS							
Card reader speed, cpm	-	300 or 400	300 or 400	-	-	400	_
Card punch speed, cpm	-	·	60–200		_	60-200	_
Line printer speed, Ipm	_	300 or 600	300 or 600	-	-		_
Disk storage, bytes	None	None	3 million	-	-	_	
Communications controller	_	Standard	Standard	_	_	_	

*Instruction not available.



INSTRUCTIONS OR BUST

- The full set of technical documentation, for all devices, including, of course, complete schematics
- Compromises were made in keeping the machine, the most peripheral devices are the most damaged
- Decided to focus on the CPU ignoring the rest





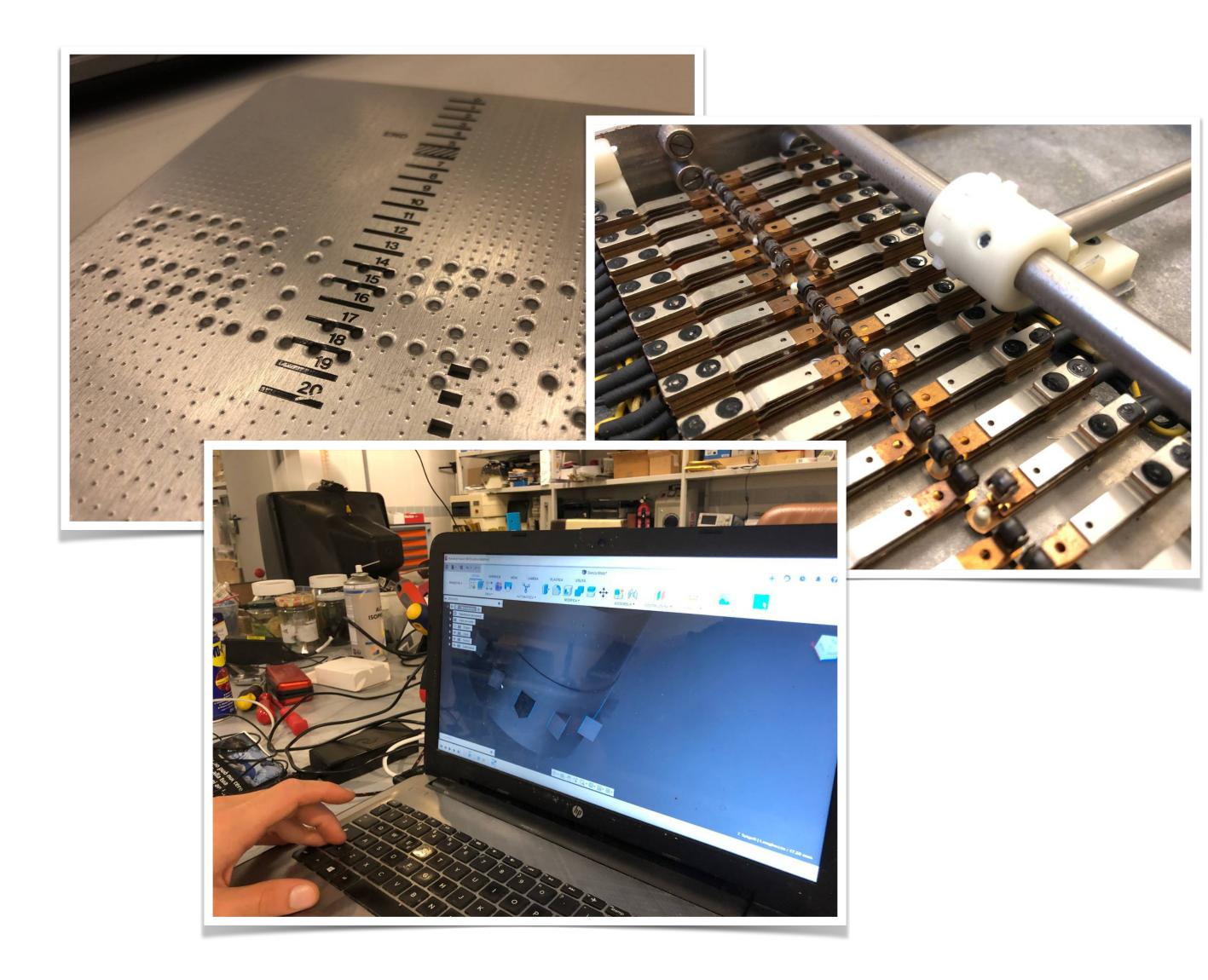
TESTING AND STUDYING

- We started studying the manuals, and found the test procedure for the CPU logic boards
 - Not confident to power up the machine so early
- We took quick mobile photos of the important materials we found.
 - Planned the digitalisation of all documentation
 - Started writing an emulator as away of further studying the machine during the year until the next event



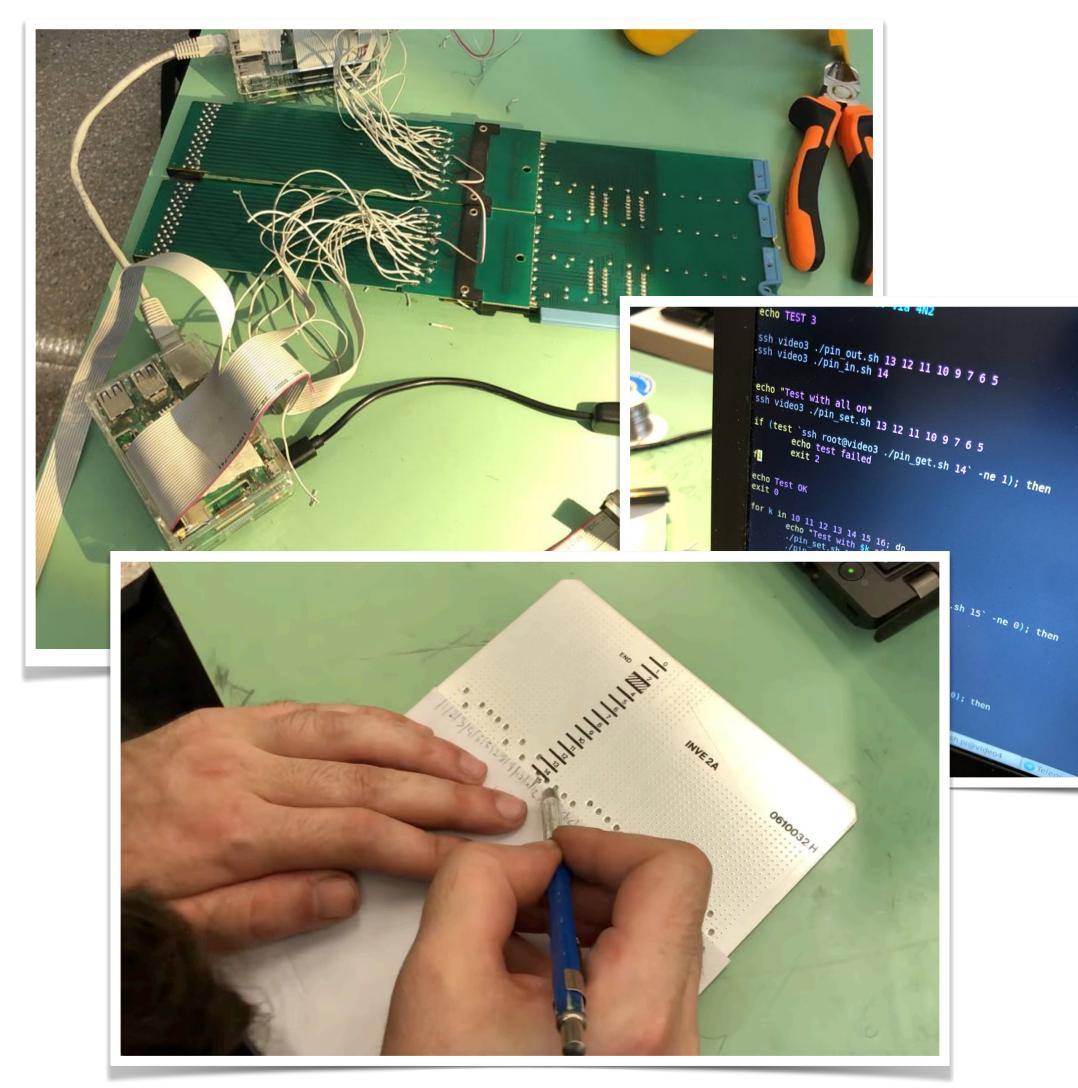
- Tests are encoded in punched metal plates
 - The feeder cog was broken
- People with mechanical skills restored the mechanism and recreated the broken piece

FIXING THE BOARD TESTER



TESTING THE BOARDS

- People with EE skills managed to reverse engineer the testing process and hacked up a testing rig using Raspberry PIs
- Even more people helped digitising the tests bit patterns
 "by hand"
- Finally confident to run electrons like this





DOCUMENTATION

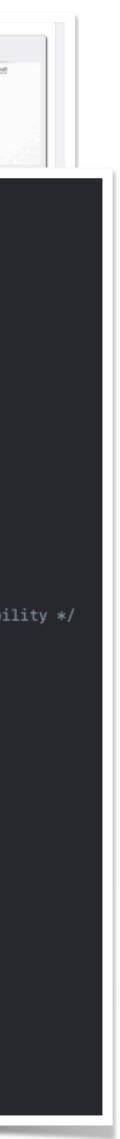
- After a year the full complement of documentation is fully scanned and uploaded to archive.org
 - 57 binders or ~13.5 GB worth of schematics and all sorts of esoteric minutiae
- With more documentation, the emulator has progressed up to communicate with the punched card reader peripheral

 Normalization
 Normalization

 2-1000 Minute
 2-1000 Minute

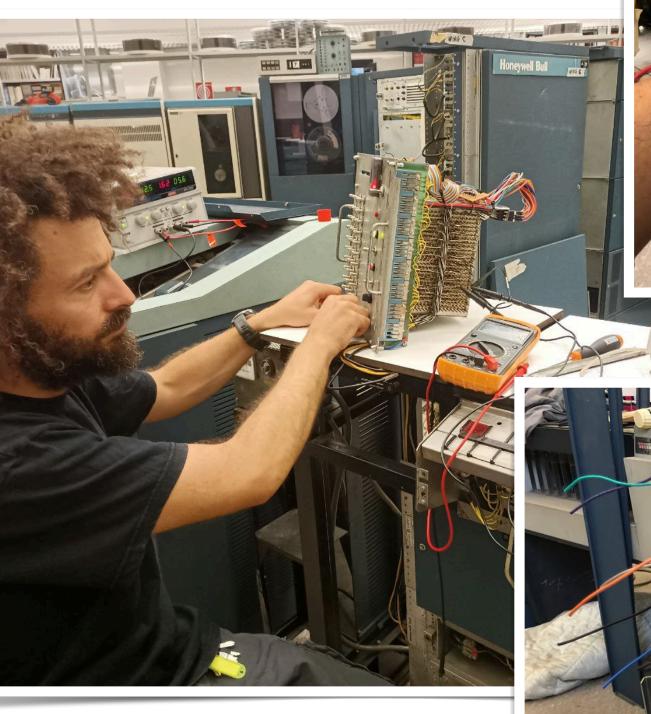
 2-1000 Minute
 2-1000 Minute
 GE-120 Technical GE-120 Service Bullettin archived archived Jul 20, 2024 **GE-120 Power Supply** GE-120 E Subsystem Subsyste archived Apr 21, 2024 archived. 28 ⊙ ★ 12 0

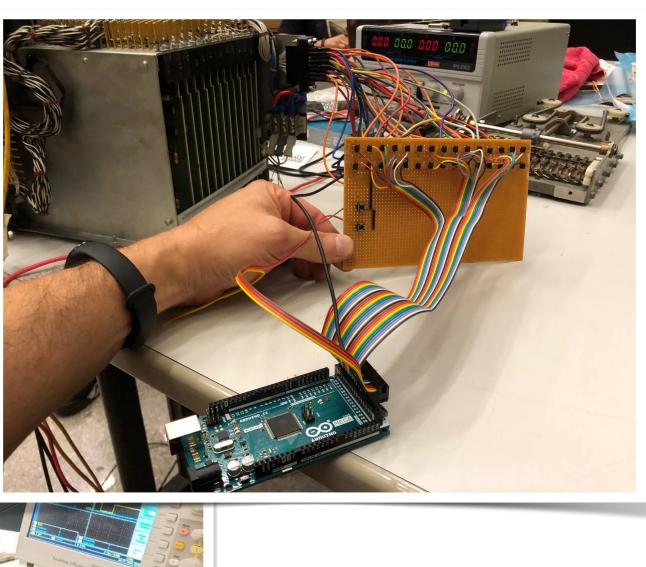
```
UTEST(load, load_1_button) {
         struct ge g;
         struct ge_console c;
         ge_init(&g);
         ge_clear(&g);
         ge_load_1(&g);
         ge_load(&g);
         ge_start(&g);
        ASSERT_CYCLE(0x00, "Display");
         ASSERT_CYCLE(0x80, "Initialisation");
        ASSERT_TRUE(BIT(g.ffFI, 6)); /* always true */
        ASSERT_EQ(g.ffFI, 0x40);
        ASSERT_CYCLE(0xc8, "PER-PERI 1");
        ASSERT_FALSE(BIT(g.rL2, 6)); /* false == input transfer */
        ASSERT_FALSE(BIT(g.rL2, 5)); /* false == increasing addresses */
        ASSERT_FALSE(BIT(g.rL2, 4)); /* false == input with packing */
        ASSERT_FALSE(BIT(g.rL2, 3)); /* false == channel 1 or 3 */
32
        ASSERT_FALSE(BIT(g.rL2, 2)); /* false == wait for peripheral availability */
        ASSERT_FALSE(BIT(g.rL2, 1)); /* always false */
        ASSERT_FALSE(BIT(g.rL2, 0)); /* false == channel 1 or 2 */
34
        ASSERT_EQ(g.rL2, 0x00);
        ASSERT_FALSE(BIT(g.ffFI, 4)); /* always false */
         ASSERT_FALSE(BIT(g.ffFI, 5)); /* connector and channel not busy */
        ASSERT_CYCLE(0xd8, "PER-PERI 2");
         ASSERT_EQ(g.rRE, 0x80); /* peripheral name: */
                                 /* 0x80 == connector 2 */
                                 /* 0x00 == connector 3 */
         ASSERT_CYCLE(0xd9, "PER-PERI 3");
         ASSERT_CYCLE(0xda, "PER-PERI 4");
         ASSERT_CYCLE(0xdb, "PER-PERI 5");
        ASSERT_TRUE(BIT(g.ffFI, 4)); /* always true */
48
        ASSERT_EQ(g.ffFI, 0x50);
49
50
        ASSERT_CYCLE(0xdc, "PER-PERI 6");
52
        ASSERT_EQ(g.rV1, g.rV3);
        ASSERT_EQ(g.rRO, 0x01);
53
        ASSERT_CYCLE(0xcc, "PER-PERI 7");
```

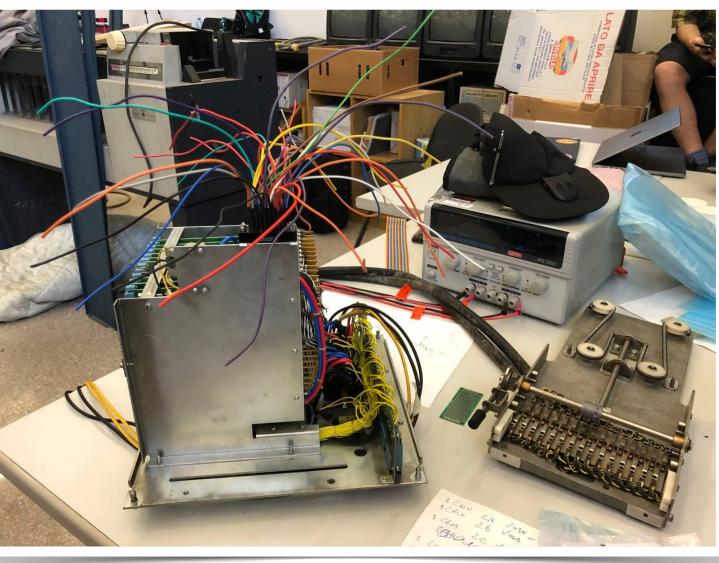


RESTORING THE BOARD TESTER

- To avoid more mechanical wear and tear, we interfaced the real board tester with an Arduino that emulates the entire library of test plates
- First time running the machine as it was designed to do







BOARDS TESTED

- Managed to test all logic boards of the CPU
- Had to use the disk controller as donor for some chips, but we fixed the few issues we found





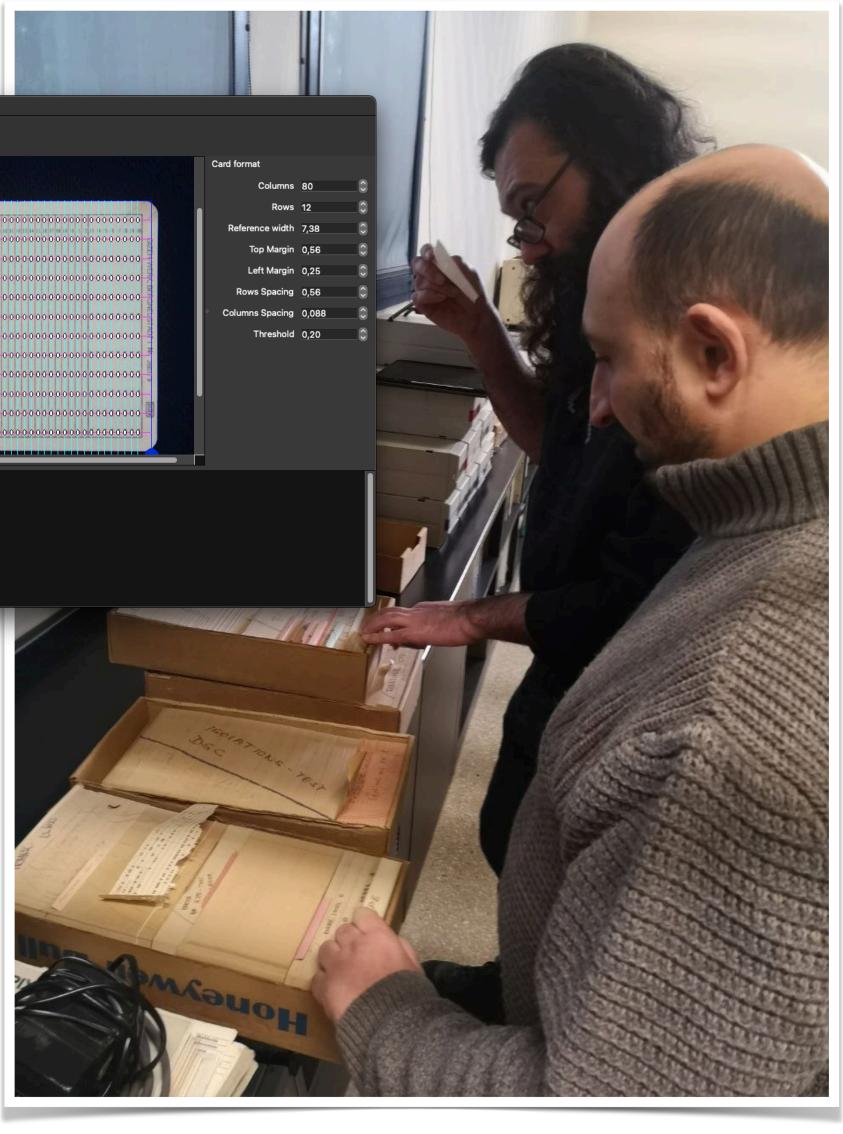
- Started looking at the punch card reader
- Digitizing the punch card software we have (looks like more testing for all peripherals)
- Planning a modern device to emulate the punch card reader to the CPU



ANSONSTEN GIBT ES KEINE LOESUN

ANGEN STEP	ELS FELTRE LEESAMRE.		
000000000000000000000000000000000000000	0 X 0 0 0 0 X X 0 X 0 0 0 X 0 0 0 X X 0	000000000000000000000000000000000000000	000000000000000000000
0000000 %0%0 000 % 00000	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	000000000000000000000000000000000000000	000000000000000000000
******	aa x aaaaaaaaaa xx aaaa	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	000000000000000000000
000000000000000000000000000000000000000	000000000000000000000000000000000000000	000000000000000000000000000000000000000	000000000000000000000
00000000 % 00 % 0000000 % 0	ao x o x ooooooxooxooox	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0000000000000000000000
	0000000000 00 000000 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
******************	00000 0 000000000 0 0000	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0000000000000000000000
*****	0 X 0 0 0 X 0 X X 0 0 0 X 0 0 0 X 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
000000000000000000000000000000000000000	000000000000000000000000000000000000000	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0000000000000000000000
00000000000000000000000000000000000000	000000000000000000800	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	00000000000000000000000
60000 0 0000000000000000000000000000000	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	00000000000000000000
000000000000000000000 0 00	000000 2 000000000000000000000000000000	00000000000000000000000000000000000000	00000000000000000000

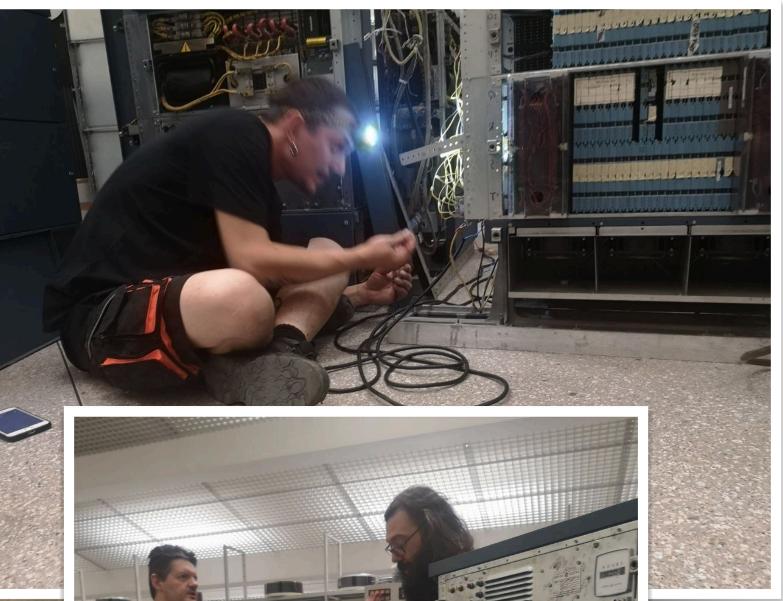
Card format	
Columns	80
Rows	·
Reference width	
Top Margin	
Left Margin	
Rows Spacing	
Columns Spacing	
Threshold	0,20

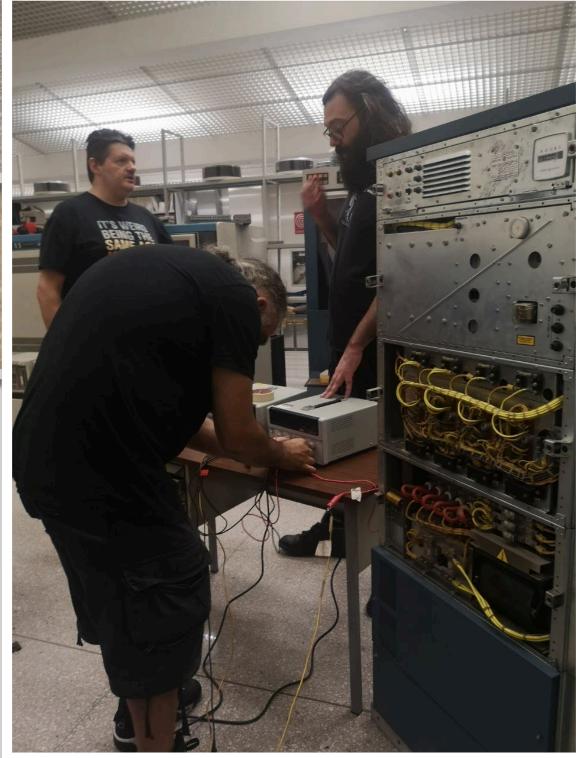


POWER-UP TESTS

- With all boards repaired, the attention was now on the backplane
 - Cleaning, fixing shorts caused by bent metal
 - Devised a power-up strategy
- Finally power to the entire CPU, but we don't have clock generation yet









- <u>https://miai.musif.eu</u> Museums Homepage
- <u>https://github.com/MusIF-MIAI</u> Repositories of all software mentioned
- <u>https://archive.org/details/@verdebinario</u> Full digitized documentation

- March 21st, 2025 New MIAI location opening!
- **Electric Dreams 5**

