



MISSION BOOKLET

Mission Control

Five circuits stand between you and a launch.

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Mission Control

Five circuits stand between you and a launch.

Ten circuits stand between the console and a launch, and each of them is a real one — this booklet is the flight manual for a mission you build yourself. The history beside each chapter is not decoration: every one of these tricks was somebody's problem first.

Safe and Armed

BEFORE

The console has two lamps, green SAFE and red ARMED. One switch must flip the whole console over, and the lamps' current must never run through the director's key.

AFTER

One coil, two circuits: the key moves a switch it never touches. The console has a NOT.

HOW PEOPLE GOT THERE

1892 Almon Strowger, an undertaker who suspected the operators were routing his calls to a rival, patented an automatic exchange in 1891; the first one went into service in La Porte, Indiana, in 1892. For the next eighty years the telephone network was built from relays: one coil closing contacts in a circuit it never touched, thousands at a time.

US patent 447,918; A History of Engineering and Science in the Bell System: Switching Technology (1925–1975)

Protect the Driver

BEFORE

The pad computer will throw the relays through a transistor. The first time we tried, the transistor died the moment the coil let go.

AFTER

A 1N4001 across every coil, cathode to +. The computer can drive the relays all day.

HOW PEOPLE GOT THERE

1910 The kickback that kills Q1 is the same physics that fires a spark plug. Charles Kettering's ignition of 1910 opened a coil's circuit with breaker points on purpose, and the collapsing field made the thousands of volts the plug needed. The diode across the coil is the opposite decision: give the current somewhere gentle to go.

Kettering's Delco ignition system, first fitted to the 1912 Cadillac (Smithsonian, National Museum of American History)

Abort Beam

BEFORE

A lamp shines across the pad into a light cell. If anything breaks the beam, the abort horn must sound, and it must not chatter at dusk.

AFTER

A sensor, two transistors, a relay and a buzzer: the pad has an alarm with hysteresis.

HOW PEOPLE GOT THERE

1969 During the Apollo 11 landing the guidance computer flashed a 1202 alarm and sounded the master alarm tone: it was overloaded and said so, then kept flying. The DSKY in front of the crew held its lit digits with a bank of small latching relays, so the computer could write a display and get back to work. An alarm that fires, holds and can be cleared is a relay's job.

Eldon Hall, *Journey to the Moon* (1996); Frank O'Brien, *The Apollo Guidance Computer: Architecture and Operation* (2010). The DSKY relay detail is O'Brien's account of the channel 10 relay word; the alarm tone in the headsets is standard but not primary-sourced here.

The Klaxon

BEFORE

Thirty seconds out, the pad crew need a horn everyone hears. No transistors, no capacitors: just a relay and a speaker.

AFTER

A relay that interrupts itself is an oscillator with a hinge. The pad has a klaxon.

HOW PEOPLE GOT THERE

1831 Joseph Henry rang a bell through more than a mile of wire in 1831 by pulling a striker with an electromagnet. The self-interrupting trembler bell, where the armature breaks its own circuit and swings back, followed around 1850, and every doorbell, fire alarm and telephone ringer for a century used it.

Smithsonian Institution Archives on Henry; the 1850 date is widely repeated (Wikipedia, Electric bell) but thinly attributed, so the text says "around".

Commit

BEFORE

One tap of LAUNCH must light the launch lamp and keep it lit after the hand comes off. The slide is ABORT.

AFTER

The relay feeds its own coil: one bit of memory. The lamp holds, and the rocket lifts.

HOW PEOPLE GOT THERE

1960 The first relay computers stored a number one relay per bit: Zuse's Z3 in 1941, Stibitz's Bell Labs machines from 1940. Launch sequencers were relay logic too. On 21 November 1960 Mercury-Redstone 1 lifted four inches, shut its engine down and fired its escape tower while the capsule stayed on the booster: a ground cable had pulled out in the wrong order and the relays did exactly what they were wired to do.

NASA SP-4201, This New Ocean: A History of Project Mercury (1966), on MR-1; Raúl Rojas on the Z3.

T-minus

BEFORE

The count cannot depend on anyone remembering to press anything. The pad needs a clock of its own.

AFTER

A chip that keeps its own time. The pad has a heartbeat.

HOW PEOPLE GOT THERE

1971 Hans Camenzind designed the 555 on contract for Signetics, alone, out of two comparators, a flip-flop and a discharge transistor he could have drawn on paper. It went on sale in 1972 and is still in production; it is widely described as the most-manufactured integrated circuit ever made, though nobody has a receipt for that.

Hans Camenzind, *Much Ado About Almost Nothing* (2007), his own account of the design; the production claim is repeated everywhere and sourced nowhere, so the text hedges it.

Range Safety

BEFORE

Range safety needs a tone the whole pad hears, and the crew must be able to set its pitch.

AFTER

Same circuit, a capacitor a hundred times smaller, and the knob is the pitch.

HOW PEOPLE GOT THERE

1952 Warning sirens were machines before they were circuits: the Chrysler Air Raid Siren of 1952 was a 180-horsepower engine spinning a rotor, the loudest siren ever built. What replaced it was an oscillator and a horn — a pitch you set with a resistor instead of a throttle.

Smithsonian and Chrysler records on the Chrysler Air Raid Siren (1952); the changeover to electronic sirens is a gradual one through the 1960s and 70s, so the text says "what replaced it" rather than naming a year.

Go / No-Go

BEFORE

Two stations must both report GO, and the console must decide, not the operator.

AFTER

A NAND and its inverter: AND. The console decides.

HOW PEOPLE GOT THERE

1961 Before Alan Shepard flew on 5 May 1961 the flight director polled his controllers one by one and each answered go or no-go. The poll is a human AND gate; the interlocks that enforced it on the pad were relay contacts in series, and within a decade they were logic gates doing the same job faster and without a hinge.

NASA SP-4201, This New Ocean: A History of Project Mercury (1966), on the MR-3 count and the go/no-go poll.

The Countdown Clock

BEFORE

The room needs a number it can read from the back wall.

AFTER

Four wires in, one digit out. The board can be read from the back row.

HOW PEOPLE GOT THERE

1970 Hewlett-Packard put the first LED numeric display, the 5082-7000, in its catalogue in 1969: seven little lamps and a decoder in one package. Through the early 1970s it pushed the glowing Nixie tube out of instruments, calculators and clocks, because it ran on logic voltages instead of 170 volts.

HP Journal, February 1969, on the 5082-7000; Smithsonian National Museum of American History on Nixie tubes. The displacement is a span of years, not a date.

Zero

BEFORE

Now make the clock count, and hold it when the director raises a hand.

AFTER

555, counter, display: the count runs to zero and the rocket lifts.

HOW PEOPLE GOT THERE

1941 Konrad Zuse's Z3, finished in Berlin in 1941, stored every bit in a relay — about 2,000 of them. The counters that ran real launch sequencers were built the same way, and the chip in front of you does that job in one package: a number that remembers itself and changes on an edge.

Raúl Rojas, "How to make Zuse's Z3 a universal computer" (IEEE Annals of the History of Computing, 1998).

Colophon

Generated from the modules the bench runs on: every circuit in this booklet is the circuit the simulator solves, and every word beside it is the word the manual panel prints.

Built 2026-09-15 from commit 953a47e.

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