INDUSTRIES OF INDIA

THE TELEVISION

Ray, Raster, Empire



KETINENI RAMARAO

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INDUSTRIES OF INDIA · AN ITEM STUDY

The Television

Ray, Raster, Empire

Ketineni Ramarao

Industries of India · November 2026

ABOUT THIS STUDY

Industries of India is a research effort to map all industries, approached through study and theory. The GICS tree is the map; each item on it is its own industry. This book treats the television as one such item:

not a brand, not a broadcast network, but the object itself, the machine that turns an electrical signal into a moving image, and the industries that grew up to make it, feed it, and live off it.

The item comes first, globally and without geographic bias. An India layer belongs to a later study, once the item stands on its own.

All figures cited in the text are traceable to the source companion that accompanies this book. Forecasts are labelled as forecasts. Images in this book are AI-generated illustrations unless credited otherwise; they illustrate ideas, not evidence.

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PROLOGUE

The Box in the Corner

By the middle of the 2010s, about seventy-nine percent of the world's households had one.[7] No machine for communication has ever spread so thoroughly, not the printing press, not the telephone, not the radio it displaced; only the mobile phone, which arrived a lifetime later, has gone further. And yet the television is so ordinary that nobody photographs it. It hangs in the corner of the room like a window the house grew, and the strangest thing about it is that we do not find it strange.

Consider what the object actually is. A pane of glass thinner than a picture frame, inside which several million microscopic shutters open and close in silence, sixty or a hundred and twenty times a second, orchestrated by a silicon chip executing instructions written on another continent. Behind the shutters, light; in front, a moving world. The picture arrives as pulses down a fibre, or packets from a satellite's footprint, or, still, after a century, as a radio wave snatched from the air by a wire. Somewhere upstream, a camera the size of a toaster, or a server farm the size of a factory, did the reverse work of turning the world into numbers. Between the two stands a hundred and forty years of argument: over discs and electrons, over patents and standards, over who pays, who watches, and who decides.

This book is about that argument, because this series is about the things the modern world runs on, and the television is one of the strangest of them. Not a tool, exactly: nobody ploughs with it. Not infrastructure, exactly: the lights stay on without it. It is closer to a utility for attention, a pipe laid into nearly every home on Earth, through which the world delivers itself to itself. Wars have been ended and elections turned by what came down this pipe. Industries have been built, advertising, consumer electronics, semiconductors, satellites, streaming, that are each, on their own, among the largest in the world, and all of them trace to the same property of the same glass: people will watch it.

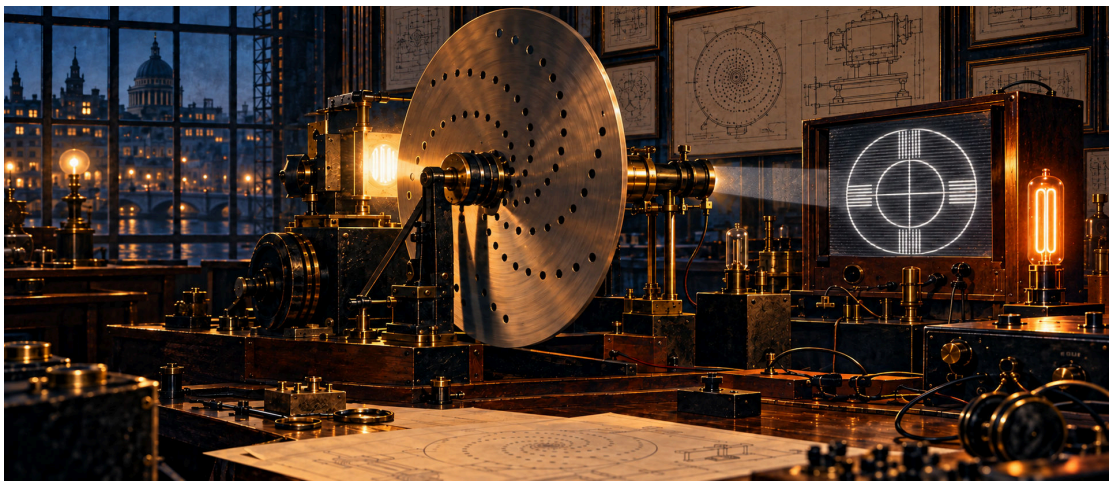
The method is the series' own. We start with the materials and the physics, because the industries that grow around a thing are shaped by what the thing is made of. We follow the thing into its factories, because a television is manufactured before it is watched, and the geography of its manufacture, from Camden to Tokyo to Seoul to Shenzhen, is a map of the world economy's last fifty years. And we follow the money out the other side, into the strange economy of signals and attention that the set feeds. The television turns out to be three industries stacked on one object: a display industry, a set industry, and a signal industry, and each has its own champions, casualties and laws of motion.

One warning before the story begins, because the story is full of inventors. The television has more fathers than any machine in this series, Nipkow, Baird, Jenkins, Farnsworth, Zworykin, Tihanyi, and a hundred others, and the quarrels over priority filled courtrooms for decades. This book is not a court. It tells who did what, when, and what it became, and it lets the paternity suits rest where the patent offices left them. What matters here is not whose name is on the object but what the object did: how a parlor trick of spinning discs and selenium cells became the window through which humanity spends, on average, several hours of every day of its life. It began, as so many industries begin, with a discovery nobody wanted, in a cable hut, in 1873.

PART I

Seeing at a Distance

Before television was electronics it was an idea with no machine to carry it: that a scene in one place could be taken apart, line by line, sent down a wire, and reassembled somewhere else. For forty years the only tools were spinning disks, selenium cells and stubbornness. The mechanical decades produced pictures you could just recognise, and, more importantly, a working concept of scanning that every electronic system since has inherited.



1

PART I - THE MECHANICAL DREAM

Selenium and the Spinning Disc

The television was imagined before it could be built, and the imagining took forty years. Between the discovery that made it conceivable and the machines

that made it real stands a generation of inventors working with the wrong materials, and the wrong physics, toward the right idea.

The story's first scene is a transatlantic cable hut in Ireland in 1873. A telegraph operator named Joseph May was testing resistances with selenium, a metalloid element used as an insulator, when he noticed that his readings wandered with the light falling on the apparatus. Willoughby Smith, the engineer overseeing the laying of the cable, investigated and confirmed it: selenium's resistance drops when light strikes it. The observation, published that year, landed like a seed in the fertile ground of late-Victorian electrical imagination.[1] If a current could report light, then light could be sent down a wire, and if light could be sent down a wire, then so, in principle, could a picture. Within a few years, writers across Europe and America were speculating about "seeing by telegraph": the Writers and cartoonists of the 1880s and 1890s filled in the rest: families in their parlours watching distant opera, a mother speaking with her faraway children while watching them on a screen, the video call, imagined a century and a half early.[1] The fantasy was precise. The physics to deliver it was not.

The first problem was the brute one: a picture is not one fact but thousands. A telegraph wire carries one signal at a time; an image carries a different brightness at every point. The only way to squeeze a picture onto a wire was to cheat, to cut it into pieces and send the pieces one after another, trusting the eye's slowness to reassemble them. Facsimile machines had already proved the cheat worked for still images: Alexander Bain's electrochemical fax of 1843, Frederick Bakewell's demonstration of 1851, and Giovanni Caselli's pantelegraph, which from 1856 was sending handwriting and drawings down French telegraph lines in commercial service, all scanned an image line by line, a point at a time.[1] But a page stands still while it is scanned, and life does not. Television needed scanning at a speed no mechanism had ever attempted: the whole image, every point, many times a second.

The cheat's perfect instrument was patented in Berlin in 1884 by a 23-year-old student, Paul Gottlieb Nipkow. His disc is one of those ideas so simple it is hard to believe anyone had to invent it: a flat wheel pierced by a spiral of small holes, one hole per line of the picture. Spin the disc, and each hole sweeps a different line across the scene; put a selenium cell behind it, and the cell reports, in sequence, the brightness of every point, one revolution per picture. Put an identical disc in front of a lamp at the far end, modulate the lamp with the cell's current, and the receiver rebuilds the image, point for point, in step with the transmitter.[1] Nipkow called it an "electric telescope". He built nothing, the selenium cell was too slow and too weak, the lamp too dim, the amplifiers nonexistent, and let the patent lapse in 1890, reportedly for want of the fee. He had nevertheless settled the architecture of television for the next forty years: scan, transmit, rescan. Every television anyone would watch until the 1930s was, at heart, Nipkow's disc.

The decades after the patent are a catalogue of near-misses that map the era's real constraint. In 1885 Henry Sutton in Ballarat, Australia, designed a "telephane", Nipkow disc, selenium cell, Kerr-effect light valve, and published it internationally by

1890; it was never built.[1] In 1900, at the International Electricity Congress in Paris, a Russian scientist named Constantin Perskyi read a paper surveying these electromechanical schemes and gave the whole field its name in passing: *television*.[1] In 1909 the German physicist Ernst Ruhmer actually got crude images through a wire, 25 selenium cells for 25 pixels, simple shapes sent from Brussels to Liège and billed, with pardonable exaggeration, as "the world's first working model of television apparatus"; the publicity flushed out the French pair Rignoux and Fournier, whose 64-cell matrix and Kerr-cell receiver proved slightly less crude.[1] In 1911 Boris Rosing in St Petersburg, with his student Vladimir Zworykin, went the other way: a mechanical scanner at the transmitter but a cathode-ray tube at the receiver, producing what Zworykin later admitted were "very crude images". The selenium cell, he noted, was "very laggy".[5] Two of the three ingredients of electronic television, the camera problem unsolved, the tube waiting in the receiver, were already on Rosing's bench, and the student would carry them to America.

What unblocked the era was not a better disc but a better electron. Lee de Forest's triode of 1907, the first practical amplifier, turned the feeble whisper of a photocell into a signal that could drive a lamp, a line, a loudspeaker.[1] Photocells improved, neon lamps arrived that could flicker fast enough to paint a picture, and by the mid-1920s the mechanical scheme, so long a fantasy, was suddenly buildable in a workshop. The men who built it, a Scotsman with a bicycle lamp and an American farm boy with a better idea, are the next two chapters. But the shape of their race was already fixed: the mechanical television would finally work, and it would work for barely a decade, because even as the first discs spun, the electron was waiting to replace them. Nipkow's spiral of holes is television's ancestor the way the abacus is the computer's: the idea was right, the material was wrong, and the material was about to change.

2

PART I - THE MECHANICAL DREAM

The Televisor Craze

For about five years, mechanical television was not a laboratory curiosity but a consumer product, with kits, magazines, stations and stars. The craze is worth its own chapter because it carries the whole pattern of a technology bubble in miniature: real achievement, wild overclaim, a public that wanted the future on any terms, and a physics ceiling nobody in the industry could afford to mention.

The achievement was real. A mechanical receiver, the "televisor", was a radio set plus a spinning disc, a neon lamp and a synchronising motor, and by 1928 anyone with a

soldering iron could build one; dozens of American stations were transmitting experimental mechanical television, and Baird's company was selling receivers in London.[2] What the owner saw, in a dark room, was a dim orange picture an inch and a half square, forty-eight lines at seven and a half frames a second, about the size and clarity of a stamp held at arm's length, and the owners were entranced, because it moved and it came through the air.[2] The first television stars performed accordingly: a head, lit hard, against black, doing one thing at a time. Studios were built around the physics of the flying-spot scanner, in which the "camera" was a disc projecting a crawling point of light across the performer's face in a darkened room, the reflected light gathered by a bank of phototubes; the performer saw nothing but darkness and heard only the whine of the disc.[2] It was television as séance, and for a few years nobody minded.

The bubble inflated on schedule. Stations multiplied; General Electric's W2XB in Schenectady ran regular schedules from 1928; CBS's experimental W2XAB opened in New York in 1931 with fanfare and a schedule of mechanical broadcasts; Baird staged his firsts like a showman, the 438-mile telephone-line transmission of 1927, the transatlantic signal of 1928, the first shore-to-ship broadcast, the first outdoor remote, the Derby of 1931, and franchised his system into Germany and France.[2][4] In Japan, Kenjiro Takayanagi improved past Baird almost immediately, 40 lines in 1926, 100 lines by 1927, the first half-tone faces in 1928; in Moscow, Léon Theremin's mirror-drum system reached 100 lines the same era.[2] Every year the line count climbed, and every year the industry promised that the home model was just over the horizon.

The ceiling, meanwhile, did not move. Lines per picture are holes per disc, and resolution past a hundred lines or so meant discs spun to speeds where air resistance, vibration and centrifugal stress set hard limits; brightness and size traded against each other through the same holes. The mechanical picture could not grow up because the disc could not spin faster, and everyone in the business knew it by the turn of the 1930s.[2] The ending came fast. W2XAB suspended mechanical operations in February 1933 and returned only in 1939, electronic; the BBC dropped Baird's system in 1937 after the Alexandra Palace trial; the kits gathered dust; the magazines folded.[2] Baird's last serviceable trick told the story in one image: by 1936 his 240-line "mechanical" broadcast no longer scanned the scene at all, it shot the scene on 17.5mm film, developed it in under a minute and scanned the wet film with the disc, a mechanical television that had quietly become an electronic camera with a film broker in the middle.[2] When a technology's flagship achievement is a workaround for its own principle, the principle is finished. The craze left one durable thing behind: an audience. The thousands who had built televisors and chased distant stations through the static were the world's first television viewers, and when the electronic picture finally arrived, they were waiting.

Baird, Jenkins and the Decade of the Disc

The mechanical television, when it finally worked, worked in an attic in Soho, built from a tea chest, a biscuit tin, bicycle lamps and string. Its inventor had been told by every expert he consulted that the thing was impossible. He had the consolation, common among pioneers, of not knowing enough to agree.

John Logie Baird was a Scottish engineer of fragile health and indestructible conviction who had already failed at making jam, at soap, at a glass razor, and at artificial diamonds, when in 1923 he settled in Hastings and turned to television. His equipment list reads like a dare: a Nipkow disc cut from cardboard, a darning needle for a spindle, a tea chest housing, a motor scavenged from a ventilator, bicycle lamp bullseyes for lenses.[4] The experts were, in a sense, right: the selenium cell was too slow, the amplifiers too weak, the maths of illumination brutal. Baird's answer was to make the picture small, just 30 lines, a vertical strip of an image, and to light his subject with ferocious intensity. His first sitters were ventriloquists' dummies, "James" and "Stooky Bill", because no person could endure the lights required for long; the painted faces had to be renewed as they cooked.[4] On 2 October 1925, in his laboratory at 22 Frith Street, the dummy's face appeared on the receiver, grey, wavering, and unmistakably a face: the first television picture with half-tones, the first that looked like the world rather than a diagram of it.[4] A few months later, on 26 January 1926, he demonstrated the apparatus to about fifty members of the Royal Institution in London, the accepted birthday of television as a working fact.[4]

Baird then did what inventors of his stamp do: he ran. In 1927 he sent a television signal down 438 miles of telephone line from London to Glasgow, then the longest demonstration of its kind.[4] In 1928 his company made the first transatlantic television transmission, London to Hartsdale, New York, and that same year he demonstrated the first colour television, red, blue and green filters on the disc, and even a primitive stereoscopic 3D.[4] The BBC, reluctantly at first, let him broadcast: from 1929 the 30-line Baird system used the BBC's transmitters after hours; from 1932 the Corporation produced the programmes itself.[4] The audience was measured in hundreds of "lookers-in" hunched over sets like the Baird Televisor, a walnut cabinet whose neon-lit disc produced an image the size of a cigarette card: orange, flickering, and miraculous. And the content had already begun to find its forms: the first televised drama, *The Man with the Flower in His Mouth*, in 1930; the first live outside broadcast, the Derby, in 1931.[4] Within five years of the attic, the medium had invented its two most durable genres.

Across the Atlantic the same disc spun. Charles Francis Jenkins, an Ohio-born pioneer who had already built one of America's first movie projectors and lost the patent wars around it, publicly demonstrated synchronised silhouette television on 13 June 1925, a toy windmill turning, sent five miles from a naval radio station to his Washington laboratory, and received a foundational patent that month.[2] Jenkins became the

mechanical era's evangelist: he founded America's first television station, W3XK, broadcasting from Maryland to an audience of hobbyists, sold kits and "Radiovisor" sets, and lectured on the coming age. General Electric launched its own experimental station in Schenectady in 1928, the ancestor of today's WRGB, still on air, one of the oldest broadcasting call signs in the world.[2] By 1928 dozens of American stations were transmitting experimental mechanical television. For a brief season the disc was not a curiosity but an industry in embryo, with magazines, kits, stations and stars.

The disc was not the only machine in the race, and its rivals produced the era's most extravagant engineering. The mirror drum, a spinning polygon of mirrors each tilted a fraction differently, could scan more lines than any perforated disc, and it attracted the best minds of the periphery: in the Soviet Union, Léon Theremin, later immortalised by the electronic instrument that bears his name, built a mirror-drum system that by May 1926 was electrically transmitting and projecting near-simultaneous moving images onto a five-foot screen, and reached 100 lines in 1927, a resolution the rest of the world took four more years to pass.[2] In Britain the Scophony company pushed mechanical scanning to its absolute limit: its 1938 receiver drew a 405-line picture two feet wide using a high-speed scanner spinning at over 30,000 rpm, a light valve of a design no one else mastered, thirty-nine valves and a kilowatt of mains power, at twice the price of a cathode-ray set.[2] It was magnificent, and it was the end of the line: no complete Scophony receiver survives. The mechanical era's history is a catalogue of such maximal contraptions, each one solving the last machine's limits by adding speed, mirrors and watts, until the electron made the whole catalogue antique at a stroke.

And yet the ceiling was visible from the start, and everyone honest could see it. Thirty lines cannot carry a face with expression, let alone a football match. More lines meant more holes, a bigger disc, higher speeds, more light, exponentially more of everything, until the mechanics screamed. Baird's own 240-line system of 1936 was already a surrender: an "intermediate film" process in which the scene was shot on cinefilm, developed in seconds, and scanned wet, cameras chained to developer tanks by hoses and cables.[4] The BBC's side-by-side trial at Alexandra Palace, Baird's 240-line alternating weekly with Marconi-EMI's all-electronic 405-line from November 1936, ended in February 1937, after a fire in Baird's Crystal Palace studios and a verdict that had been obvious for months: the mechanical service was dropped.[4] The disc had carried television from impossibility to fact, and the fact then voted for the electron.

Baird deserves the last word on his own era, because he kept inventing past its end: big-screen theatre projection, a wartime 600-line electronic colour system, and, on 16 August 1944, the first demonstration of a practical fully electronic colour television display, the Telechrome, years before the Americans settled the question.[4][7] He died in 1946, too soon to see the postwar boom, and left behind the mechanical decade's one permanent gift beyond the pictures: the idea of a broadcast service, scheduled, public, national, which the electronic age would inherit whole. The disc spun for barely ten years. Everything since has been a refinement of what it proved: that a

moving world could be poured down a wire, and that people would organise their evenings around it.

PART II

The Electronic Eye

The disk was a ceiling. The way through it was a beam of electrons: no holes, no wheels, nothing moving but charge in a vacuum. Between 1927 and 1939, electronic television was invented twice, once by a self-taught farm boy in San Francisco and once by a Russian émigré inside America's largest radio company, and the fight between them decided who would own the century's defining appliance.



4

PART II - THE ELECTRONIC ANSWER

Farnsworth: The Farm Boy Who Saw the Rows

The idea that killed the disc arrived in the mind of a fourteen-year-old ploughing a potato field in Idaho. Philo Taylor Farnsworth looked back at the straight, parallel rows he had just cut, and saw in them a way to paint a picture

with electrons instead of machinery: scan the scene in lines, back and forth, like the field.[3] Every word of that sentence strains credulity, and every word is documented. The age of electronic television begins with a boy who had never seen an indoor toilet explaining an electron camera to his chemistry teacher.

The teacher was Justin Tolman of Rigby High School, and in 1922 Farnsworth covered Tolman's blackboard with the essential drawings: an image dissector, an electron multiplier, a synchronised receiver. Tolman kept his own sketch of the lesson, an act of ordinary tidiness that would, twenty years later, help decide one of the great patent fights of the century.[3] Farnsworth's family moved to Provo, Utah; he went to college for two years, lost his father, went to work, and never took an engineering degree. What he had instead was the idea, held intact through years of odd jobs, and the extraordinary luck, in 1926, of finding backers: two California philanthropists and a group of San Francisco bankers who staked $6,000, then $25,000, then much more, on a twenty-year-old who promised them electronic television.[3] On 7 September 1927, in a second-floor laboratory at 202 Green Street, San Francisco, Farnsworth's camera tube, the image dissector, transmitted its first image: a single straight line, then a line that turned ninety degrees when the slide was rotated, the first all-electronic television picture, no disc, no moving part, nothing but electrons.[3] He was twenty-one. The lab assistant wrote in his notebook: "The received line picture was evident this time." History is made of such sentences.

The image dissector was a strange, beautiful device. Light from the scene fell on a photocathode, which released electrons in proportion to the brightness at each point; magnetic coils then swept the resulting "electron image" bodily across a tiny aperture, so that only one point's worth of electrons at a time passed through into a multiplier that amplified it into a signal.[3] It was genuinely all-electronic, and it worked, but it had a secret weakness that shaped everything after: at any instant, only one aperture's worth of the image's electrons was being used; the rest were thrown away. The dissector was starved for light, demanding ferocious illumination to make a watchable picture. Farnsworth spent the 1930s improving it, and spent them, simultaneously, in the courts, because his claim to have invented electronic television collided with the largest electronics company on Earth.

RCA, and its chief television scientist Vladimir Zworykin, claimed priority through Zworykin's 1923 patent application for the iconoscope. Farnsworth's lawyers had the Rigby blackboard drawing, Tolman's testimony, and the Green Street notebooks, and in a long interference battle before the US Patent Office they won: in 1935, priority on the key claims was awarded to Farnsworth.[3] RCA, which had never paid royalties to an outside inventor, was eventually forced to do exactly that: in September 1939, after losing the appeal, RCA agreed to pay Farnsworth $1 million over ten years plus running royalties, the first royalty licence the company had ever signed with an outside inventor, a humiliation David Sarnoff rarely mentioned afterward.[3] It is one of the only times in the century that the lone inventor beat the industrial laboratory, cleanly, on paper, in its own arena.

The fight's details repay a moment's attention, because they show both men plainly. When Farnsworth's impatient backers demanded to know when they would see dollars from the invention, the first image he put on the screen for the press in 1928 was, pointedly, a dollar sign.[3] When Zworykin, then still at Westinghouse, visited the Green Street laboratory in 1930, he was impressed enough to have his own team build copies of the dissector for experiment; decades later, on videotape, he gave the boy his due in the grudging grammar of a rival: "Farnsworth was closer to this thing you're using now than anybody, because he used the cathode-ray tube for transmission."[3] And when Sarnoff tried simply to buy the problem, offering $100,000 in 1931 for the patents with Farnsworth himself thrown in as an employee, the farm boy refused, and went to Philco instead.[3] Inventors' lives are usually told as eureka followed by glory; Farnsworth's was eureka followed by twenty years of litigation, and the litigation is the truer story of how the industry worked.

And yet the victory was mostly historical. The dissector's light-hunger was fatal at exactly the moment television was going public: Zworykin's iconoscope, which stored each point's charge for the whole frame instead of sampling and discarding, was fundamentally more sensitive, and by 1939 even Farnsworth's own engineers were building storage-type cameras. Farnsworth's company made sets in Fort Wayne from 1938, faltered, and was sold to ITT in 1951; its founder worked on in a basement laboratory the staff called "the cave", producing among other things the PPI radar projector that became the forerunner of modern air-traffic-control displays, and spent his last decades on a small nuclear fusion device, the Fusor, that never powered anything but is still studied.[3] He watched the 1969 Moon landing on television and told his wife, in the only public remark of its kind he is recorded making, that it had made everything worthwhile.[3]

The fair verdict is the one the Patent Office reached: Farnsworth invented the first all-electronic television system, conceived by a farm boy among potato rows, and the television the world actually used was built on the storage principle his rival added to it. The industry that resulted honoured the rival, RCA's machine, and forgot the boy. Only late in the century did the record correct itself: the postage stamp, the statues in Salt Lake City and San Francisco, the plaque on the Green Street laboratory. The rows he saw in the field are in every screen you own: scan lines, one after another, back and forth, an idea so durable it survived the death of the tube itself.

5

PART II - THE ELECTRONIC ANSWER

Zworykin, Sarnoff and the RCA Machine

If Farnsworth's story is the romance of television, Vladimir Zworykin's is its industrial history: the same invention, arriving by way of empire, capital and

organisation. The electron tube did not become the centre of the twentieth-century home because it was invented; it became the centre because the largest radio company in the world decided to put it there, and spent a fortune doing so.

Zworykin was Rosing's student, the young Russian who had watched "very crude images" flicker on a Braun tube in St Petersburg in 1911.[5] The revolution drove him out; by 1919 he was in America, by 1920 at Westinghouse, and in December 1923 he filed his first American patent application for an all-electronic system built on cathode-ray tubes at both ends, camera and receiver.[5] The filing was prescient and the hardware was not: Westinghouse's management, shown a demonstration that worked badly, told him to devote his time to more practical endeavours, and the equipment described in the 1923 application was never successfully demonstrated.[5] The missing piece was storage. Zworykin's eventual camera tube, the iconoscope, aimed its beam at a mosaic of microscopic silver globules on a mica plate, each globule a tiny capacitor; light from the scene charged each one in proportion to its brightness, and the scanning beam then discharged them one by one, reading out a picture in which every point had been accumulating signal for the whole frame. Storage is the difference between listening to an orchestra one instrument at a time and recording the whole ensemble, and it is why the iconoscope could see in ordinary light while the dissector demanded a furnace. But the storage principle arrived in RCA's system by purchase as much as by invention: the key patents, with 1928 priority, belonged to the Hungarian physicist Kálmán Tihanyi, whose work the company approached in July 1930.[5]

The receiving half came first. In November 1929 Zworykin filed for his improved cathode-ray receiver and presented it to the Institute of Radio Engineers days later, naming it the kinescope; within weeks he had been introduced to David Sarnoff, and by the spring of 1930 he was installed at RCA's Camden laboratories, the largest radio company in the world deciding to make his problem its own.[5] At Westinghouse, and then at RCA, Zworykin had found the patron his idea needed. David Sarnoff, the immigrant wireless operator who had built RCA into the sovereign power of American radio, saw in television the next empire and bought it the way empires are bought: laboratories, lawyers, factories, lobbyists, and time. Zworykin demonstrated an improved iconoscope in 1931, and Sarnoff committed the company's fortune to the system around it, cameras, transmitters, studios, and the plants to build the tubes.[5] The kinescope, the receiving tube, and the iconoscope, the camera tube, were the two poles of the RCA system, and around them the company assembled the entire chain: cameras, transmitters, studios, receivers, and, not least, a network to broadcast over, NBC, which RCA owned. Where Baird had a workshop and Farnsworth a laboratory, RCA had an industry before it had a product.

The patent war with Farnsworth ran through the middle of the decade and ended, as the last chapter recorded, with the Patent Office awarding priority on the key electronic claims to the farm boy, and RCA, in September 1939, agreeing to pay Farnsworth one million dollars over ten years, plus licence payments, royalties for

the first time in its history, and to an independent inventor at that.[1][3] The episode is usually told as a curiosity, but it matters to this book for what it reveals: the industrial laboratory does not always win on paper, and it wins anyway. RCA's advantage was never a single patent but the system around the patents, the manufacturing scale, the broadcast licence, the standards seat at the regulator's table, and the sheer capital to out-wait everyone. Farnsworth won the interference; Sarnoff won the industry.

A third figure deserves his paragraph, because he kept the storage idea alive in the years when both giants had half-abandoned it. Kálmán Tihanyi, the Hungarian physicist whose storage patents RCA had approached in 1930, kept the principle alive in print in the years when both giants had half-abandoned it.[5] RCA eventually bought his patents too, the company's customary method of simplifying history. The iconoscope that finally went to market was thus, like most industrial artefacts, a palimpsest: Rosing's receiver, Zworykin's mosaic, Tihanyi's storage, Farnsworth's all-electronic scanning, and a thousand incremental fixes by engineers whose names live only in lab notebooks.

By the late 1930s the RCA machine was ready to perform. It had the cameras, the tubes, the sets, the network, and the regulator's blessing, the standards process that would settle on 525 lines. What it needed was an audience, and in April 1939, at the New York World's Fair, it got one: Sarnoff himself before the cameras, declaring the birth of a new art with the cameras already rolling. The electronic answer had won. The next question was whether anyone was watching, and the answer, as the following chapters record, was interrupted by a war and then answered beyond all expectation.

6

PART II - THE ELECTRONIC ANSWER

Anatomy of a Tube

For eighty years, the television was a cathode-ray tube, and the cathode-ray tube was, in essence, a light cannon in a glass bottle: fire electrons down a vacuum, steer them with magnets, and let them explode into light where they strike. It is worth opening the bottle, because everything the industry later became, the factories, the weights, the sizes, the prices, and eventually the funeral, was written in its anatomy.

The bottle came first. Karl Ferdinand Braun built the ancestor in 1897, a cold-cathode oscilloscope tube for visualising electrical waveforms, and for a generation the "Braun tube" was laboratory glassware, not furniture.[6] The television tube needed two upgrades: a hot cathode, a heated filament giving a copious, controllable electron stream, and acceleration, a charged anode to hurl the stream down the length of the

tube. Around the neck sat the electron gun, cathode, control grid, focusing and accelerating electrodes, a machine for producing a needle of electrons so fine and so fast that its landing point could be a single pixel. The grid, biased by the incoming picture signal, throttled the beam instant by instant: more electrons, brighter point. That is the whole modulator. A television picture, for all its complexity, is a single dot of light, brightened and dimmed by a valve, flown across the screen so quickly that the eye surrenders and sees an image.

The flight path is the raster, Farnsworth's potato rows made of electrons. Two pairs of deflection coils, electromagnets fed with sawtooth currents, bend the beam horizontally and vertically: a fast sawtooth flips it left to right along one line thousands of times a second; a slow one walks the lines down the glass.[6] In the American standard the field rate was locked to the 60-hertz mains, sixty vertical sweeps a second, two interlaced fields of 262.5 lines making each 525-line frame; Europe's 50-hertz mains gave 625-line systems their fifty fields. Interlacing, painting the odd lines then the even, was the era's cleverest economy: it halved the flicker and the bandwidth at once, and its fingerprint, the comb edge on fast motion, survives in archive footage to this day. Even the frame rate was a compromise with the power grid: from the mid-1930s, television ran at the local mains frequency, 50 fields a second in most of the world, 60 in the Americas, because early sets could not filter power-supply ripple out of their own circuits, and an unsynchronised mains hum would crawl visibly through the picture; lock the scanning to the mains and the interference at least stood still, invisible by courtesy of being static.[59] Half a century later, that is why American and European home movies still do not quite look alike: the mains hum of the 1930s is still on the tape.[6] Between the phosphor and the glass, an aquadag coating of graphite formed the final anode and drained the charge. Every part of the bottle worked; nothing was decorative.

Where the beam landed, physics became chemistry. The screen's inside face carried the phosphor, a thin layer of crystals, zinc sulfide doped with silver for blue-white, with copper for green, zinc cadmium sulfide for red, that drink electrons and re-emit the energy as visible light, each with its own colour and its own persistence, the millisecond afterglow that smooths one flash into the next.[6] Phosphor science was a quiet industry of its own, with its own journals and its own supply chains; the rare earths that would later brighten colour phosphors, europium above all, arrived in the 1960s and made reds finally worth watching. Behind the phosphor in later tubes sat a skin of evaporated aluminium, a mirror facing the viewer, doubling the useful light and protecting the phosphor from ion burn.[6]

Colour demanded the tube's one great extravagance: precision. A colour screen carries not one phosphor but three, arranged in triads, dots or stripes, with three guns (or one triple gun) firing through a shadow mask, a sheet of steel perforated with hundreds of thousands of holes, each aligned so that the "red" beam can strike only red phosphor.[6] The mask is a marvel and a tax: it intercepts most of the beam, wasting brightness and heat, and it must hold alignment to a fraction of a millimetre across a metre of glass, through warming and cooling, for years. Sony's Trinitron of

1968 replaced the mask with an aperture grille, vertical wires under tension, and stripe phosphors with a single-lens three-in-line gun: brighter, sharper, cylindrical, and for thirty years the connoisseur's tube.[11] The grille's faint horizontal damper wires, visible if you knew where to look, were the tell of a precision that bordered on obstinacy.

The bottle itself was an industry inside the industry. A tube is three pieces of glass, screen, funnel and neck, each a different formulation: the funnel and neck carried lead, cheap and dense, to stop the X-rays the decelerating electrons throw off; the screen could not use lead, which browns under bombardment, and instead used barium-strontium glass, optically precise and tinted to tune contrast at the cost of beam power.[6] Screens and funnels were made by pouring and pressing glass into moulds fed from furnaces with several taps, so that a single melt could supply tubes of many sizes without the furnace ever stopping, glass furnaces abhor a cold start.[6] The formulations were proprietary, classified by each maker's own codes, and the business belonged to a handful of specialists: Corning, Nippon Electric Glass, AGC, Owens-Illinois, Samsung Corning, with a few set makers like Sony and Thomson running their own glass for strategic sizes.[6] Physics set the size ceiling with brutal simplicity: the anode voltage, and with it the X-ray load and the glass's strength, scaled roughly a kilovolt per inch of screen, which is why monochrome tubes stopped around 21 inches and colour's practical frontier ended not far past 36.[6] The television's dimensions were, for sixty years, a question of glass chemistry.

Now the economics fall out of the anatomy. The bottle must withstand a tonne of atmospheric pressure per face, so it is thick glass, heavy glass; depth must grow with width to keep the beam angles sane, so big tubes are long tubes; the mask and the three-gun geometry make colour a premium; and the whole thing wants to be assembled by people who understand glass. The industry's map followed the bottle: Corning and its joint ventures pressing funnels in Pennsylvania and Shizuoka, the gun and yoke suppliers clustered around them, set factories sized to a product that broke if you dropped it and paid if you didn't. When the flat panel arrived, it did not merely beat the tube's picture. It abolished the bottle, and with the bottle went the weight, the depth, the size ceiling, the factories, and an entire ecology of suppliers. The chapters that follow are about that abolition. But the tube had eighty years, and for most of them it was, as Zworykin predicted it would be, the window through which the century watched itself.

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PART II - THE ELECTRONIC ANSWER

The War and the Restart

Television was switched on in 1939 and then, almost everywhere, switched straight off again. The war did not kill the young industry; it conscripted it, fed it, and handed it back in 1945 with better factories, better physics and a continent of pent-up demand. The boom that followed was not despite the war. In large part, it was because of it.

The conscription was explicit. In the United States, where perhaps ten thousand sets were in homes when Pearl Harbor was attacked, the War Production Board halted the manufacture of television and radio equipment for civilian use from 22 April 1942 until 20 August 1945.[1][8] Britain had gone earlier and harder: Alexandra Palace went dark on 1 September 1939, two days before the declaration of war, on the argument that its transmitter would make a fine beacon for enemy bombers. Germany's service continued in diminished form; France's died with the occupation; Japan's, which had broadcast its own pre-war experiments, was extinguished by defeat, and the research of Kenjiro Takayanagi, who had shown a 40-line Nipkow-disc-and-CRT system in 1926 and reached 100 lines by 1927, years ahead of most of the world, was halted by the occupation authorities after 1945.[1] The first age of television ended, as the age itself might have put it, mid-programme.

But the tube went to war, and the war was good to the tube. The cathode-ray tube was the display of radar, and radar was the decisive electronic technology of the conflict; the same factories that had pressed kinescope bulbs now turned out oscilloscope and radar-indicator tubes in quantities no peacetime market could have justified.[6] The war years industrialised every input television needed: precision glass, phosphors, deflection coils, high-voltage power supplies, wideband amplifiers, microwave plumbing, and the habits of mass-producing all of them to military tolerances. A generation of engineers, the men and women who would staff the post-war set makers, learned electronics on military gear. When the production bans lifted, the industry did not resume where it had stopped; it resumed several years ahead, with tooled lines, trained hands, and components that had been battle-tested in every sense.

The restart was astonishingly quick, and it was global. The BBC's 405-line service, System A in the international catalogue, was reinstated in 1946 and would run until 1985; one of its strangest relics had been made before the war even began, when engineers at an RCA research station on Long Island caught the London signal bouncing off the ionosphere across 5,000 kilometres of Atlantic and recorded a few minutes on film, the only surviving sample of pre-war live British television.[59] American broadcasting, never fully dark, exploded the moment materials were freed; the Soviet Union, which had run a pre-war service, resumed and adopted its own 625-line standard, designed in 1944 and first broadcast from Moscow in 1948, the line count that would become Europe's.[1] France rebuilt on an idiosyncratic high-line system of its own; Japan restarted under occupation, and NHK began regular broadcasting in the early 1950s. The pre-war trio of launches, Berlin, London, New York, became a worldwide roll-out within a decade, each country re-founding the medium in its own institutional image, and each inheriting, without quite choosing it,

the RCA-era technical settlement: the raster, the interlace, the electron gun, the shadow of the tube.

The strangest legacy of the interruption was the standard. Because the war had frozen deployment at the experimental stage, the restart could lock in improved specifications before an installed base made them immovable: the United States had settled on 525 lines in 1941, on the very eve of the freeze; Europe, rebuilding later, adopted 625; the world thereby split into line-count empires that would persist for sixty years, until the digital transition finally erased the distinction.[1] A different war outcome, or a two-year delay, and the map of world television would have been drawn differently. The lesson the industry learned, and never forgot, is that standards are set in windows, and the windows are opened by catastrophe. The next great window, the digital one, would open in the 1990s; Part IV closes with it.

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PART II - THE ELECTRONIC ANSWER

The Camera's Side: Emitrons and Orthicons

The television receiver gets the histories, but the receiver is only half the machine. Somewhere upstream, in a studio lit like an operating theatre, another vacuum tube was doing the harder work: turning light into signal. The camera tube's evolution is a quieter story than the set's, fought among laboratories rather than living rooms, and it decided what the world looked like on the other end of the wire.

The first generation had the dissector's disease: it threw light away. Farnsworth's image dissector read one point of the scene at a time and discarded the rest of the frame's electrons; Zworykin's iconoscope stored the frame's charge but was noisy, its real efficiency, the EMI engineers calculated when they took it apart in the early 1930s, only about five percent of the theoretical maximum.[1] The difference was visible in the studio logistics. Early electronic television was made under ferocious light, presenters wilting, make-up running, because the camera could barely see. The receiving sets of the day were modest by the standards of what came later, but it was the camera that rationed the medium's realism.

The fix came from Britain's EMI, and it came by method. Isaac Shoenberg's team, having measured the iconoscope's inefficiency rather than accepting it, developed and patented in 1934 two new camera tubes, the super-Emitron and the CPS Emitron, between ten and fifteen times more sensitive than the American originals.[1] The gain changed what television could be: on Armistice Day 1937 the BBC used the new tubes for the first true outside broadcast, the King laying a wreath at the Cenotaph, a live street scene taken by cameras on neighbouring rooftops, something neither

Farnsworth nor RCA could manage until the World's Fair two years later.[1] The lesson generalises: the winning laboratory was not the one with the first patent but the one that measured. In Germany the equivalent tube, the Superikonoskop from Telefunken and Heimann, essentially the super-Emitron by licence, carried the 1936 Olympics and remained Europe's standard camera tube until 1960.[1] The patent geography of Part II's chapters had a direct visual consequence: because Dieckmann and Hell had filed their dissector in Germany in 1925, the Farnsworth war simply did not apply in Europe, and the two continents grew different eyes.

America's answer was the image orthicon, RCA's wartime-improved camera tube, sensitive enough for ordinary light and stable enough for the boom years; Europe countered with the vidicon family, compact and simple, and then Philips's Plumbicon of the 1960s, the tube that made colour cameras manageable.[1] Each generation traded the same currencies: sensitivity, size, smear, burn-in, cost. The studios bought them by the rack and babied them like instruments, which they were. And then, at the century's end, the whole tube lineage was ended by the same force that ended the display tube: a chip. Charge-coupled devices, silicon image sensors born in the same Bell Laboratories tradition as the transistor, swept the camera tube out of professional use in the 1990s and then, miniaturised and multiplied, put a camera in every phone.[3] The television camera, for sixty years a crate of vacuum and glass coddled by specialists, became a sliver of silicon manufactured by the billion. The medium's eye had followed the same migration as its screen: from the glassworks to the fab, from the specialist's bench to the commodity line, and with it went the last argument that television production was a scarce craft. Once the camera was a chip, everyone was a broadcaster; the platforms of Part V were built on that fact.

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PART II - THE ELECTRONIC ANSWER

The Hilltop Relays: The Network's Steel Backbone

Before television was a network in the figurative sense it had to become one in the literal sense, and that meant steel. The microwave relay, a chain of unattended towers each within sight of the next, was the physical invention of network television: the apparatus that let one evening be shared by a whole continent at the same moment.

The physics set the architecture. Microwaves travel in straight lines and stop at the horizon, so a coast-to-coast link became a daisy chain of relay stations, thirty to fifty miles apart, perched on mountaintops, grain elevators and the roofs of telephone exchanges, each one catching the beam with a horn-reflector antenna and hurling it onward.[80] AT&T's Long Lines built the prototype, TDX, between New York and Boston

in 1947 with eight relay stations; the improved TD2 spread across the United States through the 1950s until the system carried the majority of the country's long-distance telephone traffic and, riding in the same beams, the networks' television signals.[80] The motive was bandwidth: television needed more of it than any cable then laid could cheaply provide, and the relay could be built fast.[80] The tower on the hill became as much a part of the television landscape as the aerial on the roof; one gathered the signal from the sky, the other handed it across the earth.

The relays reigned for three decades and then vanished with the thoroughness of a displaced technology. Communication satellites took the television market in the 1970s and 1980s, one bird in orbit doing the work of a thousand towers, and fibre optics took the telephone traffic in the 1980s and 1990s; most of the relay networks now stand abandoned, their horns still aimed at neighbours that stopped listening years ago.[80] Yet the idea the relays proved outlives their steel: that a nation's television is a logistics system before it is a culture. The networks of the relay era were called networks because they were one, and every later architecture, satellite footprint, cable headend, streaming server farm, is the same tower chain re-imagined at a new height.

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PART II - THE ELECTRONIC ANSWER

Going Public: Berlin, Alexandra Palace, Flushing Meadows

A technology becomes an industry when strangers can buy it. Between 1935 and 1939, television crossed that line three times, in Berlin, in London, and in New York, three launches with three philosophies, only one of which pointed at the future.

Germany went first, and meant it as theatre. The Reich's broadcasting authority opened a regular service from Berlin in March 1935, 180 lines, electronic cameras for film, mechanical-intermediate film scanners for live events, beamed not to homes, there were almost no private receivers, but to *Fernsehstuben*, public television parlours where citizens could gather to watch the state's new wonder.[1] The 1936 Berlin Olympics gave the system its set piece: cameras built around the Superikonoskop, the German licensee version of Zworykin's iconoscope produced by Telefunken and Heimann, fed the parlours of Berlin and Leipzig, whose audiences over the Games were measured in the hundreds of thousands.[1] It was the first televised Olympics, and almost nobody remembers it, because a service for parlours is a service for nobody in particular. Germany had built television as spectacle for the regime; it never built it as furniture.

Germany's electronic path had its own forgotten pioneers. At the Berlin Radio Show in August 1931, Manfred von Ardenne had given the first public demonstration of a fully electronic television system, a cathode-ray tube at both ends, though without a true camera: the tube served as a flying-spot scanner for slides and film.[1] And in a twist that shaped the European industry for a generation, two German engineers, Dieckmann and Hell, had filed for their own photoelectric dissector tube in 1925, two years before Farnsworth's American filing, which meant the Farnsworth patent war that consumed American television simply did not apply in Europe; the Superikonoskop, produced by Telefunken and Heimann under licence, became the standard European camera tube from 1936 until the vidicon era.[1] The history of television is not one patent map but several, drawn over each other.

Britain went next, and meant it as a service. On 2 November 1936 the BBC opened the world's first regular *high-definition* television service from Alexandra Palace in north London, "Ally Pally", broadcasting first by the alternating Baird and Marconi-EMI systems, then, from early 1937, by Marconi-EMI's 405-line electronic system alone.[1] High-definition then meant 405 lines, against the 30 of the mechanical era and the 180 of Berlin, and the difference was qualitative: faces, sport, variety, the world in motion with expression in it. The audience was tiny, a few thousand sets in London, and expensive, a receiver cost a serious fraction of a working family's annual wage, but the pattern was the true one: scheduled programmes, domestic receivers, a public institution curating the flow. When the service shut down on 1 September 1939, mid-programme, for fear the transmitter's signal would guide German bombers, it closed with a promise to return; it did, in 1946.[59][1] British television's self-understanding, public service, national, decent, was formed in those three pre-war years and the war-long pause that followed.

America went last and biggest, and meant it as a market. The regulator had spent the late 1930s fighting over standards while RCA refined the product; unwilling to wait, Sarnoff forced the moment at the New York World's Fair in April 1939, with his own on-camera dedication, "the birth of a new art", President Franklin Roosevelt televised the same day, the first American president to appear on the medium, and sets in the shops within weeks.[7] The fair's RCA pavilion, with its transparent Lucite television proving the box had no trick inside, made television the fair's sensation.[7] But the standards fight festered: the FCC approved commercial broadcasting on the 525-line NTSC standard only in 1941, and perhaps ten thousand sets were in American homes when Pearl Harbor froze civilian production.[7] The war that silenced Ally Pally conscripted American television too, the tube factories turned to radar, whose oscilloscope was the CRT's first cousin, and the engineers came home with tricks the television would inherit, from better cathodes to the manufacturing discipline of mass electronics.

Three launches, three verdicts. Berlin proved a government could put pictures on the air and built nothing durable; its system died with the regime. London proved a public service could make television a habit, if only for a few thousand households, and created the template half the world would copy. New York proved a market

wanted the product, and then proved nothing for six years while the world burned. When the freeze lifted, it was the American model, commercial, networked, mass-manufactured, that detonated, and its first act was an argument about colour that would take fifteen years to settle. The age of the tube had formally begun; almost nobody, yet, owned one.

PART III

The Appliance of the Century

In 1936 television became a public service; in 1939 it became a product; after the war it became a necessity. Within a single generation the glowing box moved from laboratory curiosity to the centre of the living room, carrying with it a new architecture of networks, advertisers, antennas and habits, and teaching the consumer-electronics industry its first great lesson: the set in the home is the anchor of an economy.



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PART III - THE AGE OF THE TUBE

The Air: Antennas, Towers and the Map in the Sky

For the first fifty years of its life, the television industry rested on a resource nobody could make more of: the air itself. The electromagnetic spectrum assigned to broadcasting was fixed, finite and public, and the whole

architecture of the medium, the networks, the affiliates, the licence fees, the regulators, the rooftop aerials on a hundred million houses, was an answer to one engineering question: how do you share the air without drowning it?

The answer was a map. A television channel is a slice of spectrum six megahertz wide, and a transmitter on it can serve a radius of perhaps a hundred kilometres before physics and the earth's curvature say no; two transmitters on the same slice must be kept far enough apart that their signals never meet. Planning a national television system was therefore a giant tiling problem, and in America it was solved, after four frozen years, by the FCC's Sixth Report and Order of 1952: a national table assigning specific channels to specific towns, 70 new UHF channels added to the twelve VHF ones, with some slices reserved for education.[28] The map in the sky, once drawn, hardened into concrete. Local monopolies and network affiliations flowed from it; so did the decades-long weakness of UHF, the higher band that sets tuned poorly and viewers ignored, and the fortunes of every station that drew a "good" number low on the dial. Property law for a resource that is everywhere and nowhere: this was broadcasting's real constitution.

At the edge of the map stood the most visible machine of the era: the antenna. Every rooftop aerial, the dipole's T, the Yagi's fishbone ladder of directors and reflectors, is a tuned instrument cut to the wavelength it hunts, aimed by the household at a tower it cannot see.[7] The towers themselves became the tallest structures most countries possessed, guyed masts of half a kilometre blinking red over the prairie, each one the visible tip of an invisible estate. Reception drew its own geography: the shadow of a hill, the luck of altitude, the ghost of a distant station skipping in off the ionosphere on a summer night. Television, sold as a picture in the living room, was experienced as a negotiation with terrain. Everyone who grew up with an aerial remembers the household choreography, one person at the window turning the mast, another at the set shouting when the snow cleared.

The air's scarcity was the industry's founding excuse and its founding asset. Scarcity justified licensing, and licensing made the licensees rich; scarcity capped the channel count at three or four, which concentrated audiences in a way advertisers would pay a premium for; scarcity made the spectrum the state's to give, and the state, in every country, kept a hand on what went out over it. When cable and satellite later multiplied the channels, they did not repeal the physics; they bypassed it, which is why the old broadcast settlement, the map, the affiliates, the public-service obligations, persisted long after the technical reason for it had gone. And when the digital transition finally repacked the airwaves at the turn of the 2010s, the freed spectrum, the "digital dividend", was sold to the mobile industry for sums measured in tens of billions, the American converter-box programme itself funded out of the auction proceeds.[49] The last transaction of the broadcast century was the sale of its foundation: the air turned out to be worth more as a medium for telephones than for television. The aerials still rust on the rooftops, a forest of antennae above houses that now receive the world through glass fibre, monuments to the half-century when the most important real estate in the industry was the sky.

The Boom: America Moves Into the Living Room

No consumer technology has ever conquered a country faster. The 1950 census counted just over five million American households with a set, 9 percent of the nation; a decade later the figure was about nine in ten households.[23][24] The telephone had taken decades, the car a generation. Television did it between two presidential elections, and in doing so rearranged the furniture, the evening, the election, the advertisement, and the family.

The explosion was built from war surplus and pent-up demand. The tube factories that had spent the war turning out radar scopes and proximity fuzes turned back to kinescopes with tooled-up lines and trained hands; the returning soldiers had savings, babies, new houses in Levittown and Lakewood, and evenings to fill. RCA, Zenith, Admiral, Philco, DuMont, Motorola and a dozen others fought for the shelf space; prices fell from furniture-grade to merely serious as production scaled, and finance plans carried the rest. The arithmetic of the take-off still startles. In July 1947 the country held perhaps sixty thousand sets altogether; by late 1948 the buyer faced prices from a hundred dollars to $4,100, the average set costing $375, and still the factories could not keep up.[25a] No major household technology, not even radio in its own first decade, had ever spread so fast.[25a] The dealer's antenna installation became a rite of suburban passage, the rooftop aerial the era's flag. Where sets were scarce, the crowd formed anyway: in appliance-store windows, in bars, which bought the first big screens for the fights and the baseball, and in the houses of the one family on the street who had bought first. Neighbourhood children remembered for decades whose living room they grew up in.

The programmes made the hardware necessary rather than merely desirable. Milton Berle's Tuesday nights became the country's first weekly appointment; *I Love Lucy*, the first scripted programme filmed on 35mm before a live audience, because Desi Arnaz insisted on staying in Los Angeles and on film's quality, invented the syndicated rerun as a by-product and remains, seventy years on, the industry's first proof that a television programme could be property forever.[57] The networks, NBC, CBS, ABC, and briefly DuMont, transplanted radio's stars and structures wholesale, then discovered television's own: the anthology drama of the "golden age", the quiz show, the Western, the sitcom. The Army-McCarthy hearings of spring 1954, carried gavel-to-gavel by ABC and DuMont for thirty-six days, introduced politics to the camera and began the long lesson, completed in Dallas in 1963 and Vietnam after, that a nation with one window experiences its crises together; McCarthy's censure followed in December, his power broken in large part by exposure on the medium he had exploited.[58] Advertising, the fuel of the whole machine, found in television a power print had

never had: the demonstration. By the mid-1950s the industry joked that television didn't sell products, it sold everything.

The boom had a shadow, and the shadow was policy. In 1948, with stations multiplying and interference chaos threatening, the FCC froze new licences, a pause meant to last months that lasted four years while the regulator sorted channels, standards and the UHF problem.[28] The numbers at the thaw show both the pent-up demand and the shape of the settlement: when the FCC lifted the freeze on 14 April 1952 it published a national table of 2,053 channel assignments across 1,291 communities, for a country that had spent three and a half years with just 108 VHF stations on the air, and applications flooded in by the thousand within weeks.[28] The freeze entrenched the first-movers, the big-city VHF stations and the networks that fed them, and effectively killed the fourth network, DuMont, which lacked the VHF clearances and the radio profits to survive the pause. The Sixth Report and Order of 1952 thawed the system with a national channel map, 70 new UHF channels, and reserved allocations for education, a decision that eventually produced public television, but the structure it fixed, three networks, local affiliates, federal licence, defined American broadcasting for thirty years.[28] The industry that looks in retrospect like pure market energy was in fact a negotiated settlement, struck once, hard to amend.

Elsewhere the boom came on different terms and different clocks. Britain relit Alexandra Palace in 1946 and rationed its way to the coronation of 1953, the event that sold the nation its first mass generation of sets; France, Germany, Italy and Japan built national systems through the 1950s; the Soviet Union had televised before the war and resumed after it.[1] Everywhere the pattern repeated: the big live event sold the sets, the sets made the audience, the audience made the medium, and the medium quietly became the common room of the country. What made the American boom singular was its speed and its commerce. The rest of the world watched, then built versions filtered through its own institutions: licence fees, state monopolies, party tutelage. The tube was the same everywhere. What flowed through it was a portrait of each country that plugged it in.

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PART III - THE AGE OF THE TUBE

The Colour Wars

Colour television was demonstrated before most people had seen black-and-white, Baird himself showed a working two-gun "Telechrome" colour receiver in 1944, with plans for a three-gun version cut short by his death two years later, and took another two decades to become ordinary.[1] The gap is the story:

not a science problem but a standards war, fought between two companies, two philosophies, and one implacable constraint, the millions of monochrome sets already in the nation's living rooms.

The constraint had a name: compatibility. Any colour system worth adopting had to produce a watchable picture on existing black-and-white sets, and fit inside the channels those sets already tuned. CBS, whose chief engineer Peter Carl Goldmark had built a part-mechanical system, a disc of red, green and blue filters spinning at 1,200 rpm inside the camera, another spinning in sync before the receiver's tube, argued its picture was ready and beautiful, which it was; RCA argued that CBS's spinning disc was incompatible with everything already installed, which it also was.[8] The FCC, after hearings in which one commissioner accused the compatibility camp of "a conspiracy against the public interest", chose CBS in October 1950.[8] The result was a fiasco. The installed base had already decided the war: under a million sets when the FCC began deliberating in 1948, over ten million by the time CBS broadcasts began in June 1951, every one of them blind to the new signal. CBS bought a set manufacturer and shipped its colour model that September; two hundred sets shipped, a hundred sold, and on 20 October 1951 the whole system was suspended, ostensibly at the request of Korean War production authorities, with CBS buying back the sets to placate the customers. Sarnoff could not resist noting the alibi's convenience.[8] The CBS system lived on mainly in legend, and, satisfyingly, in the field-sequential colour cameras that later showed the Apollo Moon walks, where compatibility with home sets was, for once, someone else's problem.[8]

RCA's answer, approved on 17 December 1953, was one of the great engineering settlements: the NTSC colour standard. Its trick was to hide colour in the blind spots of the existing signal, a subcarrier interleaved between harmonics of the monochrome scan, carrying hue and saturation as phase and amplitude at deliberately reduced resolution, while the brightness signal that old sets used stayed exactly where it was; the eye, sharper for brightness than for colour, never notices the cheat.[13] A black-and-white set simply never saw it. A colour set decoded it through the shadow-mask tube RCA had spent, by its own later estimate, $100 million perfecting. The first over-the-air NTSC broadcast was the opera *Carmen* on 31 October 1953.[13] The price of the trick was subtlety: NTSC's hue was hostage to phase errors anywhere along the transmission path, earning the backronym "Never Twice the Same Colour" and a tint control on every American set.[13] Europe, watching this, declined to copy. Germany's PAL added a line-by-line phase alternation that cancelled the hue errors at the cost of a delay line and a more complex set; France's SECAM chose frequency modulation for colour and strategic independence for everything else. The world split into three colour empires, NTSC, PAL, SECAM, and for half a century a videotape was a passport. Britain's road to PAL was the cautionary version of the compatibility story told twice over: the BBC had launched its second channel in 1964 on 625-line UHF, which no existing 405-line VHF set could receive, and for most of a decade the country watched through "dual-standard" receivers, complex, expensive sets carrying two of everything, which became three of everything when

colour arrived on BBC2 in 1967. The old 405-line VHF service lingered as a monochrome simulcast until January 1985, when the last transmitters went dark nearly half a century after Alexandra Palace lit them.[59] Every generational change in television replays the pattern: the new standard is always easy at the transmitter and expensive in the living room, and the installed base always sets the pace.[13]

Standards settled, the market still had to be sold, and here the story belongs to one company's patience. RCA lost money on colour for years: building sets at a loss, seeding colour programming through NBC, the only network whose parent sold sets, while competitors waited for the market to exist. The loneliness of the strategy is hard to overstate: by 1959, RCA was the only remaining major manufacturer of colour sets, its rivals having discontinued their models for poor sales, while CBS and ABC, whose parents made no tubes, saw no reason to spend money programming in colour to sell their competitor's hardware, CBS offered no regularly scheduled colour at all until the autumn of 1965, and even The Lucy Show was filmed in colour and broadcast in black and white.[8] The milestones mark the patience: the first national colour broadcast was the Tournament of Roses Parade on 1 January 1954, and for a decade nearly everything else stayed monochrome; the turn came in 1965, when the networks announced that over half of prime-time would be colour that autumn, with the first all-colour prime-time season in 1966, and the last daytime holdout surrendering only in 1972.[8] The flood followed, and by the early 1970s colour sets outsold black-and-white in North America.[8] By the 1980s the monochrome set was a kitchen appliance, then a memory. The same decade-long choreography, seed, wait, inflect, would repeat for HDTV thirty years later, and for 3D, which never inflected. Picture quality alone never sells the upgrade; content, price and the installed base negotiate the timing.

One more actor in the colour wars matters to this book because it signals the next transition. Japan had no seat in the NTSC-PAL-SECAM argument; it licensed NTSC and then out-built everyone at making the sets. Sony's Trinitron of 1968, aperture grille, stripe phosphors, one gun with three beams in line, made colour brighter and more reliable at once, won an Emmy as an engineering artefact, and announced that the centre of gravity in set-making had moved from New Jersey to Tokyo.[11] The colour war's final irony: the standard was American, the regulators were European, and the winners were Japanese. The transistor had already told anyone listening that this was coming. It is the subject of the next chapter.

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PART III - THE AGE OF THE TUBE

The Transistor Coup, or How Japan Took the Set

The vacuum tube ran hot, burned out, drew power like a heater and filled a third of the cabinet. The transistor killed it quietly, component by component, and the company holding the knife was a thirty-person Tokyo workshop rebuilding from the war. The story of how Sony and Japan took the television set away from America is the template for every industrial migration in this book, so it is worth telling carefully.

Tokyo Tsushin Kogyo, the Tokyo Telecommunications Engineering Corporation, was founded in 1946 by Masaru Ibuka and Akio Morita amid the rubble of a bombed department store. Its first products were rice cookers that cooked badly and tape recorders that worked. In 1952 Ibuka visited the United States to see the transistor, Bell Labs' 1948 invention, which Western Electric was licensing to all comers for $25,000, and did a deal American executives found faintly comic: the Americans imagined the transistor in hearing aids; Ibuka and Morita imagined it in a radio every Japanese teenager could carry. Even Japan's own Ministry of International Trade and Industry was sceptical of licensing American technology; Morita persisted, and the contract was finalised in August 1953.[30] The TR-55 of 1955 was Japan's first transistor radio; the company renamed itself for the product's promise, *sonus*, sound, made pocketable: Sony.[30] What followed is the canonical manoeuvre of postwar Japanese industry: license the American science, then out-engineer the American production. Sony's engineers, including a young physicist named Leo Esaki, whose tunnel diode won a Nobel Prize, improved the transistor faster than its inventors' licensees at home, and the yields, the quality circles and the miniaturisation followed.

Television was the obvious next mountain, and Sony climbed it from the small end. The Philco Safari had reached American shops a year earlier as the first fully transistorised portable, but it was the TV8-301 of 1960 that made the point as a product: the world's first non-projection all-transistor television, an eight-inch screen, every valve gone except the picture tube itself, twenty-three transistors, a carrying handle, and a price that positioned it as a second set, a personal set, an almost frivolous set.[29] It was, characteristically, a product the incumbents could not see as a threat. The TV8-301 was small, expensive for its size, and temperamental enough that Sony's own people nicknamed it the company's "frail little baby"; it lasted on the market barely two years.[29] It also had a battery bay in the back for two six-volt cells, meaning it could leave the house entirely: the first television conceived as a personal appliance rather than a piece of the room. American critics who measured it against a 21-inch console missed the point in the way incumbents always do. The strategy was deliberate. Against the American giants' consoles, furniture for the living room, Japan entered where the giants were not looking: portable, personal, cheap, then steadily better. The pattern repeated across the decade: Sharp, Toshiba, Hitachi, Matsushita, later National Panasonic, each riding the same escalator from transistor radios to small sets to large ones, all of it greased by MITI's coordination, protected home demand, and an export drive priced to clear American shelves.

The American industry, which had invented everything, responded with a grievance rather than a strategy. Zenith stayed superb and stayed domestic; RCA chased

conglomerate dreams; the others sold out or shrank. The fighting word of the era was "dumping", and it was half true: Japanese makers did price exports below home prices, did collude on floors, and were found out in cases that ran for decades.[46] But the other half, the half the Americans underweighted, was that the Japanese sets were simply better built: the failure rates were lower, the pictures brighter, the features newer. The Trinitron of 1968 settled the argument at the high end, and it, too, was born of refusal: Sony's co-founder Masaru Ibuka declined to license RCA's shadow mask, which he considered technically deficient, and his engineers produced instead the aperture grille, one gun, three cathodes, unbroken vertical colour stripes, a set measurably brighter and sharper than anything the mask could make.[11] Sony had entered the television market only eight years earlier, selling a few hundred of the nine million sets bought in Japan that year; the grille made it the aspirational brand of the world's richest market.[11] The 1970s oil shocks, which punished American cars but not small efficient sets, did the rest. By 1976 the United States, which had manufactured nearly all of the world's first fifty million televisions, imported more sets than it made; by 1995 Zenith, the last American-owned major, sold itself to Korea's LG.[46]

What had happened was not primarily about televisions. The transistor had changed what a television *was*: from furniture assembled by craftsmen to electronics assembled by process. In a furniture business, America's brands, dealers and tastes were a moat. In an electronics business, the moat was components, yields and capital, and Japan had organised all three. The next transition, from the tube to the flat panel, would run on the same logic, with Korea and then China playing Japan's part and Japan playing America's. Industries, like pictures on a raster, are redrawn line by line; from inside a line, it is easy to mistake the current row for the whole frame.

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PART III - THE AGE OF THE TUBE

The Clicker: The Smallest Machine in the Room

The most consequential component the television industry ever added was not a better tube or a brighter phosphor but a small object that let the viewer leave. Every economic model in this book, advertising, the bundle, the streamer's autoplay, ultimately rests on how hard or easy it is to change the channel, and that is a question of a few grams of plastic in the couch cushions.

The industry understood early that it had sold a machine with a fatal ergonomic flaw: the controls were on the set, and the set was across the room. Zenith's first answer, the Lazy Bones of 1950, was a remote control connected to the television by a wire, a trip hazard that could change the channel and not much else, but it proved the

demand instantly.[12] Wireless followed in 1955 with Eugene Polley's Flash-Matic, a ray-gun of a device that shone a beam of visible light onto photoelectric cells in the cabinet's corners; it worked, except when the sun did, since the cells could not tell a sunbeam from a command.[12] The durable solution came a year later from Robert Adler's Space Command, a purely mechanical box of aluminium rods: press a button and a hammer struck a rod, which rang at an ultrasonic frequency the set's microphone could hear.[12] It needed no batteries, survived decades of drops, and earned the technology its folk name, the clicker. For twenty years, across millions of American living rooms, changing the channel sounded like a fork hitting a glass, and certain dogs learned to leave the room.

The clicker was the industry's first interface, and like every interface since it redistributed power. Before it, the programme was a destination: you crossed the room, you committed. After it, the programme was a flow you could audit, and the audience acquired its defining modern behaviour, grazing. Advertisers noticed first. As early as 1952 a wired gadget called the Blab-off had let viewers kill the sound during commercials, and the industry spent the next seventy years in an arms race against its own convenience: shorter commercial pods, louder spots, programme sponsorships baked into the content itself, and eventually the streaming model's gambit of removing the button entirely.[12] The remote is where the viewer's counter-technology lives; the history of television economics can be written as the history of attempts to disable it.

The modern many-buttoned remote was invented, improbably, to read the news. When the BBC launched its Ceefax teletext service in 1973, pages were summoned by three-digit numbers, and the era's three-button clickers could not type; engineers at the BBC and the set makers, ITT among them, built prototypes in the late 1970s that added digit keys and function rows, and the infrared protocols they settled on became the furniture of every couch since.[12] Cable converters carried the new remotes to mass adoption in the 1980s: the Viewstar converter, one of the first with an infrared handset, sold its millionth unit in 1985.[12] Infrared won for the usual reason, it was cheap, and for an unusual one, it is visible to machines and invisible to people: point a phone camera at a working remote and you can watch the signal flash, the one part of the television's nervous system the owner can see with borrowed eyes.

Then the object metastasised. Each new box in the stack, VCR, cable box, DVD, game console, soundbar, arrived with its own handset and its own dialect, until the average American home held four remotes and the home-theatre enthusiast juggled six in sequence to make one screen light up.[12] Steve Wozniak's CL 9 tried to unify them in 1987 with a learning remote that could absorb other handsets' codes, too clever and too cumbersome for its moment, but the universal remote it pioneered, and eventually the smartphone with an infrared blaster and an app, completed the thought.[12] The industry's final move was to dissolve the object into the platform: today's television listens for a voice, watches a phone on the same network, or simply starts the next episode by itself. The clicker's lesson survives the clicker. Whoever

owns the two metres between the couch and the screen owns the last decision, and the entire signal economy is a negotiation over whose hand is holding it.

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PART III - THE AGE OF THE TUBE

The Hidden Pages: Teletext and the First Data Broadcast

Twenty years before the web reached the public, the television was already serving pages. Hidden in the spare lines at the top of the broadcast picture, the vertical blanking interval, the dead time while the electron beam ran back to start the next frame, a second, text-only television was broadcast across Europe for three decades: numbered pages of news, weather, football scores, subtitles and holiday offers, summoned by a remote control. It was called teletext, and it was the world's first mass medium made of data rather than pictures.

It began, fittingly, as an accessibility project: John Adams, a Philips video-display designer, created the concept in Britain in the early 1970s to put captions on programmes for deaf viewers.[66] The ITV companies demonstrated the first live broadcast teletext, fifty pages of their ORACLE service beamed from the Crystal Palace transmitter to an invited audience, on 9 April 1973; the BBC's Ceefax, "seeing facts", followed as a proper editorial service on 23 September 1974, run by a newsroom of nine, offering thirty pages, and promising, with perfect seriousness, a "full magazine" of a hundred pages by 1975.[66] The rivals settled on a common 24-by-40 character grid in 1974, and Texas Instruments' British arm committed to the first commercial decoder chips in 1975.[66]

The adoption curve reads like the whole consumer-electronics story in miniature. In 1976 a teletext television cost about a thousand pounds, luxury-car territory for an appliance; by August 1977 perhaps three thousand sets existed; by December 1979, fourteen thousand.[66] Then the decoder chip did what chips do, the price collapsed into the standard feature list, the government's 1981 promotion campaign met sets that already had the circuitry, and within the decade virtually every television sold in Europe carried teletext, standardised as World System Teletext, with Germany and the Netherlands running services from 1980.[66] Elsewhere the idea mostly failed: France's Antiope and America's NABTS limped into the early 1990s and closed, done in, in America, by a market that preferred its data by cable and its captions simple.[66] The page economy lived where public broadcasters could wait for it.

What teletext proved, years early and at national scale, is that the television signal had room inside it for an entire second medium, and that viewers would learn an interface of numbered pages and coloured Fastext keys to get at it. Subtitles on page 888, so standard that broadcasters simply printed "888" in the corner to mean captioned; news, weather, TV schedules: the habit of pulling information out of a screen, rather than merely watching what was pushed, started there, in the dead lines between frames. The engineers who hid data in the blanking interval had found the first free spectrum inside the picture itself. The streaming era, which delivers everything over the top of everything, is that trick generalised: the whole internet, smuggled through the television's own pipe.

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PART III - THE AGE OF THE TUBE

Remote, Cable, Satellite: The Set Escapes the Broadcast

The late tube era transformed the television not by changing what it was but by changing what it was *for*. Three devices did the transforming: the remote control, which put the audience in charge of the moment; the cable, which multiplied the channels; and the satellite dish, which nationalised, then globalised, the signal. Between them they ended the scheduled, shared, three-channel world the boom had built.

The remote began as a gag and became a power shift. Zenith's "Lazy Bones" of 1950 was a box on a wire, and its snaking cable across the carpet was mocked in its own advertisements. Eugene Polley's wireless "Flash-Matic" of 1955 fired a beam of light at photocells in the corners of the screen, and was defeated by sunshine: the cells could not tell the remote's flash from an afternoon.[12] The solution, Robert Adler's "Space Command" of 1956, was gloriously mechanical: aluminium rods struck by tiny hammers, ringing ultrasonically at frequencies the set could hear and the dog mostly could not, four functions, channel up, channel down, mute, power, and the satisfying click that gave a generation of remotes their name.[12] For twenty years the clicker was a luxury; the microprocessor and the infrared LED made it standard by the early 1980s, pushed along, improbably, by the BBC's Ceefax teletext service, whose numbered pages demanded keypads with digits, and with ubiquity came a behaviour no broadcaster had planned for: grazing.[12] The viewer who had once committed to a channel now sampled fifty, skipped the advertisements that paid for everything, and developed the thumb-driven attention span the industry alternately cursed and engineered for. Every later battle, over ad-skipping DVRs, over streaming autoplay,

over the algorithmic feed, is a skirmish in the war the remote control started: the transfer of scheduling power from the broadcaster to the hand on the sofa.

The cable arrived as a humble fix. In the late 1940s, in the mountain towns of Pennsylvania and Oregon, where terrain killed reception, appliance dealers strung "community antennas" on hillsides and ran coaxial wire to the houses below, the better to sell television sets; Ed Parsons of Astoria, Oregon, who had seen a demonstration in Seattle and resolved that his town, and his showroom, would have pictures, is the story's accredited folk hero.[25] For a generation cable meant only better pictures of the same three networks. The conversion began on 8 November 1972, when a service called Home Box Office launched with a hockey game to 365 subscribers in Wilkes-Barre, Pennsylvania, and was completed by the satellite: in September 1975 HBO became the first television channel in the world to distribute by satellite, and suddenly a local operator could offer channels that had never existed as broadcasts at all.[55] Ted Turner understood first what satellite-plus-cable meant: a channel could be national without a single transmitter. ESPN (1979), CNN (1980), MTV (1981) and their hundreds of descendants built the niche era, and the monthly subscriber fee built a second river of money alongside advertising, as the signal-economy chapter describes.

The dish took the same physics and sold it to the individual. The big C-band backyard dishes of the early 1980s, three metres of mesh pulling down the same satellites the cable head-ends used, were a frontier market: rural, enthusiast, legally grey. The encrypted direct-broadcast services of the 1990s, DirecTV in America, Sky in Britain, digital, Ku-band, aimed at dishes small enough for a windowsill, turned the frontier into an industry.[56] In much of the world the dish was never grey at all: it was simply how television arrived. India, the Middle East, and vast rural belts of Asia and Latin America skipped the cable age entirely and went from terrestrial broadcast to satellite, a reminder that the Western sequence was a path, not a law. By the century's end, the channel count had run from three to thirty to three hundred, and the audience's common experience had quietly dissolved: the night the whole country watched the same programme became first a rarity, then a memory kept alive only by sport and disaster, as the next chapter records.

Alongside the pay empires, the dish quietly built a free world too. Germany became the capital of free-to-air satellite, about 250 channels, including the public broadcasters in high definition, receivable in some 18 million homes from the Astra constellation, its analogue satellite broadcasts ceasing only in April 2012; Britain's Astra dish delivered around 160 free channels; India's Doordarshan runs DD Free Dish, dozens of channels from a single satellite, as infill for the terrestrial network.[56] The economics are the inverse of the bundle's: the broadcaster pays the satellite, the viewer pays nothing, and the dish on the roof becomes, in much of the world, the one piece of electronics a household buys before almost any other. The satellite chapter of the story has no single shape; it is Sky's subscription fortress in one country and a free public utility in the next, run off the same physics.

The tube, meanwhile, was being asked to display this new abundance on screens it could barely grow into, and buyers wanted bigger pictures than the bottle could hold. Rear-projection boxes and first-generation plasma panels hung in the shops like a question. The answer, already forty years in the laboratory, was the liquid crystal. Part IV opens with it.

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The Cassette Rebellion: Tape Sets the Viewer Free

The videocassette recorder is the first machine that let the audience talk back to the schedule. For thirty years of broadcasting, a programme existed at its appointed hour and then ceased to exist; the VCR made television a possession, something you could keep, rewind, lend and rent. The industry fought it in court all the way to the Supreme Court, lost, and discovered it had been handed its biggest new market since the set itself.

Recording television was old technology in the studios. Ampex's quadruplex machine of 1956, two-inch tape on open reels, a $50,000 cabinet, had freed the networks from kinescope film and live-only production within a few seasons.[47] The consumer problem was the cassette: nobody would thread two-inch tape in a living room. Sony's U-matic of 1971 solved the packaging, three-quarter-inch tape in a cartridge, and found its home in newsrooms, schools and businesses rather than living rooms; a combination TV/VCR cost $1,395, the price of a small car's down payment.[47] The prize went to whoever could shrink the cassette and the price together, and that produced one of business history's most analysed fights.

Sony's Betamax arrived first, in November 1975, smaller, and by most engineering judgments the better picture. JVC's VHS, Video Home System, followed in 1976 with a longer recording time, two hours against Beta's one, and, decisively, a licensing strategy: JVC spread the format across Matsushita's empire and anyone else who wanted it, while Sony kept Betamax close.[47] The format war that followed was not really won on quality. It was won on tape length, Hollywood movies need two hours, on manufacturing scale, and on the rental shop's shelf: once American video rental stores, the era's accidental kingmakers, stocked more VHS, the buyer's choice made itself. By the late 1980s Betamax was a cautionary tale taught in business schools, and VHS was a utility: Britain's adoption curve shows the shape of it: a tenth of households in 1982, nearly a third by 1985, well over half by the decade's end, with American prices down to a few hundred dollars by 1985.[47]

The studios, meanwhile, sued. Universal and Disney's case against Sony argued that the machine that could copy their broadcasts was itself a burglar's tool; the Supreme

Court's 1984 Betamax decision disagreed, five to four, holding that time-shifting, recording a programme to watch once, later, was fair use, and that a machine with substantial lawful uses could not be banned for its unlawful ones.[47] The sentence that saved the VCR became the foundation of the entire consumer electronics age: every recorder, ripper and stream-ripper since lives in its shelter. And the punchline was financial: the rental and sell-through market the studios had sued to prevent became, within a few years, a major income source in its own right.[47] The cassette did not steal Hollywood's audience; it gave Hollywood a second business larger than its first.

Between the gadget and its exit stood a new retail institution: the video rental shop, one of the great accidental businesses of the century. It had been tried before the market was ready, Cartrivision offered movies on cassette in 1972, with rental cartridges that could not even be rewound at home, and died of its own complications.[47] A decade later the independent rental store was a fixture of every high street and strip mall, a business with no factory, no network and no licence that nonetheless decided what the nation watched on Friday night. The shops made VHS's victory self-reinforcing, shelf space followed the format that rented, and they made the studios rich: prerecorded cassettes, priced first for rental at seventy dollars and then for sell-through at twenty, turned the film catalogue into an annuity. The cassette also taught the industry its modern lesson about windows: cinema, then sell-through, then rental, then pay television, then broadcast, a staircase of prices for the same film that streaming would later collapse into a single door.

The cassette's reign was ended by better circles: the DVD from 1997, monthly player shipments passing VCRs by 2001 and American disc rentals passing tape by 2003, the DVR at the decade's end, which moved recording from tape to hard disk and made pausing live television a party trick, and finally streaming, which abolished the recording problem by making everything always available.[47] The last manufacturer, Funai Electric, ceased production in July 2016, sixty years after Ampex. What the rebellion left behind is permanent: the expectation, now so deep it feels like a right, that television fits the viewer's life rather than the reverse. Every pause button, watchlist and "up next" row on every streaming service is the VCR's descendant. The cassette is dead; the freedom it sued for is the air the industry breathes.

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PART III - THE AGE OF THE TUBE

The Event: When the Whole World Watched

The tube era's deepest product was not any programme but a feeling: the knowledge that everyone else was watching too. Broadcast television made the mass simultaneous audience, an assembly larger than any stadium, square or

church in history, and the high points of that assembly, the events that stopped countries, are worth a chapter of their own, not least because the numbers around them are a minefield of exaggeration that this book should step through carefully.

The canonical event is the Moon. On 20 July 1969, somewhere between 125 and 150 million Americans, the largest audience in the country's history to that point, watched Apollo 11's first steps live, with hundreds of millions more joining around the world by every contemporary estimate, though the honest historian must add that global figures from the era are claims, not measurements.[52] It was the broadcast the century had been building toward: the wireless's war reports, the coronation's procession, the assassination's terrible weekend, all rehearsals for the night the species watched itself step off the planet. What is often forgotten is that the pictures came down on a slow-scan camera incompatible with every home set, converted for broadcast by the improvised method of pointing a standard camera at a special monitor, so the ghostly quality of those images is not the Moon's distance but the conversion's. Even the epochal event arrived through an adapter. In a house in Utah, one viewer wept: Philo Farnsworth, who had drawn the dissector for his teacher in 1922 and been fought, outspent and largely written out of the industry since, turned to his wife as Armstrong stepped down and said, 'Pem, this has made it all worthwhile.'[3] The man who invented electronic television had had to wait for the Moon to be sure it was worth inventing.

Before and after the Moon, the event calendar wrote television's liturgy. The Kennedy assassination of 1963 taught America that the window could hold a nation's grief for four continuous days. The World Cup and the Olympics became, and remain, the only reliably global programmes, with the honest caveat that claimed audiences in the billions are routinely inflated by organisers and that independent analysis suggests few, if any, broadcasts have ever genuinely reached one billion viewers.[52] Royal weddings and funerals drew the Commonwealth; China's Spring Festival Gala claims, and the Guinness record-keepers accept, the title of the world's most-watched programme, with claims of a billion viewers that deserve the same sceptical asterisk.[52] In Brazil, the funeral of the racing driver Ayrton Senna in 1994 was watched by an estimated 75 percent of the country's population, a 100 percent measured share: an entire nation in one room.[52]

The royal calendar supplied the medium's other great set pieces. The 1981 wedding of Prince Charles and Lady Diana was carried simultaneously by networks around the world and claimed an audience in the high hundreds of millions; Diana's funeral in 1997 was bigger still by every contemporary reckoning; Live Aid in 1985, a multi-venue concert linked by satellite across 60 countries, drew an estimated 400 million and invented the global charity broadcast.[52] The honest numbers caveat applies to all of them: global audiences before the internet were estimated, not counted, and the figures that survive are usually the largest anyone claimed. But the inflation cuts both ways. Even halved, these were assemblies without precedent in human history, and they were produced not by states or churches but by an appliance.

The measured record-keeping of the mature medium is more sober, and in its way more impressive. In the United States, where the counting is most rigorous, twenty-two of the most-watched broadcasts in history are Super Bowls; the largest single-network audience ever recorded is Fox's telecast of Super Bowl LIX in February 2025, at 127.7 million average viewers, and Super Bowl LI in 2017 reached 172 million Americans who watched at least some part of it.[52] A century after the attic in Soho, one game still puts more than half of the largest, richest, most distracted country on Earth in front of the same picture at the same moment, several times a decade. No algorithm has ever assembled an audience like that; only the event can.

The event is what the fragmented, on-demand, algorithmic age cannot reproduce, and the industry knows it. Everything else unbundled: drama, comedy, news, the nightly shared schedule dissolved into the library. What remains of the old simultaneity is sport, live competition being the one content that spoils on delay, which is why the rights to football, cricket and the Olympics are the last reliably appreciating asset in television, and why every platform that declared the schedule dead now bids billions for the privilege of owning one again. The tube era's true monopoly was never the channel count. It was the shared moment, and the shared moment, it turns out, was the product all along.

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PART III - THE AGE OF THE TUBE

The Game: How Sport Built the Box

If you want to date every technical threshold in this book, look up what game was on. Sport was the first content of broadcasting because sport solves broadcasting's founding problem: it is compelling live, worthless on delay, and already owns its audience. Each new pipe, radio, television, colour, satellite, high definition, has been christened with a match, a race or a fight, and the industry's history can be read off the fixture list.

The sequence begins before television exists: Marconi himself reported the 1899 America's Cup from New York Harbor by wireless, arguably the first sports broadcast ever; the first boxing commentary on American radio came from Pittsburgh in 1921; and the first live televised sporting event was the Epsom Derby of 3 June 1931, the BBC pointing Baird's cameras at the one spectacle guaranteed to fill any screen.[71] The pattern never broke. The first colour sportscast was a Dodgers-Braves baseball game in 1951; the first programmes on new stations and new satellites were, reliably, games, because the game is the one programme whose value everyone already understands.[71] Even the commentators invented television grammar before television: when the BBC broadcast its first football match in 1927, a second

announcer read out grid squares published in the Radio Times so listeners could follow the ball, the data overlay born as a paper map on the kitchen table.[71]

The incumbents saw the threat instantly, which is the surest sign of sport's power over the medium. In its early decades the BBC was forbidden to broadcast sport before seven in the evening, a rule written to protect newspaper sales, the state itself rationing the new pipe so the old one could finish its dinner.[71] Geography became law in the same spirit: Canada's simultaneous substitution rule lets a Canadian broadcaster black out the American feed of the same game and substitute its own, commercials included, a nation's airwaves redrawn around the advertising rights to a puck.[71] Hockey Night in Canada, on television since October 1952, remains among the country's most-watched programmes seventy years on, the schedule's longest-running proof that nothing rents a nation an evening like a game.[71]

The final chapter of the story is the one this book has already told from the audience side: as every other genre dissolved into the on-demand library, live sport stayed appointment television, the last content that spoils, and its rights became the broadcast economy's last appreciating asset. The Super Bowl, the World Cup, the Olympics, the cricket leagues: the fixture list is now the balance sheet. What the fixture list says, reading it the industrial way, is that sport and television were never two businesses in partnership. They were one business from the start: the manufacture of simultaneity, the scheduled gasp, the shared moment sold by the second. The box was built to show games. Everything else it showed was rehearsal.

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The Programme: What the Hardware Was For

Every chapter of this book so far has been about machines, and every machine in it existed to sell, serve or steal one thing: the programme. The hardware industry's deepest truth is that it is a derived business. Sets are not bought for glass and guns; they are bought for what the glass shows. The tube era's content economics therefore deserve a chapter of their own, because they created the template, programme as property, audience as product, event as monopoly, that the streaming age inherited and merely re-priced.

The first discovery was that a programme could be capital. Radio had treated broadcast as performance: done once, gone. *I Love Lucy*, the first scripted programme filmed on 35mm before a live studio audience, with the cinematographer Karl Freund lighting it, accidentally invented the rerun and its industry. The reason was distribution economics, not art: the networks fed the West Coast fuzzy kinescopes, film recordings of a monitor, of shows broadcast live from New York, and Arnaz,

ordered by the sponsor to produce from New York, instead kept the production in Hollywood and shipped film, which meant every market saw the same first-class picture, and the negative on the shelf could be shown again, sold again, syndicated station by station, forever.[57] The ratings validated the bet beyond argument: the most-watched show in America in four of its six seasons, and the first ever to end its run at number one; as of 2011 it still drew an American audience of forty million a year, and a colorised Christmas episode pulled eight million viewers in 2013, sixty-two years after the premiere.[57] The rerun turned the production budget into an asset with a tail, and the tail became the business model: make once, sell many times, in windows, across decades. Everything since, the network library, the DVD box set, the streaming catalogue, is that insight scaled. Lucille Ball's studio, Desilu, became the template for the producer-as-owner; seventy years later the industry's most bitter fights are still over who owns the tail.

The second discovery was that the programme could go global live. On 23 July 1962 the Telstar satellite relayed the first public transatlantic television, a patched-together exchange of segments between America and Europe watched by over a hundred million people, and the phrase "live via satellite" entered the language as a promise of importance.[56][26][27] Syncom 3 carried the 1964 Tokyo Olympics to the United States; by the decade's end the satellite feed was the machinery of the shared moment, and the events chapter's whole calendar, the Moon, the funerals, the finals, ran on it.[56] The effect on the industry was structural: the satellite made the world's events one market, and the rights to them a global bidding table.

The third discovery was that some programmes could charge admission. The broadcast settlement gave the programme away and sold the audience; Home Box Office, from 1972, sold the programme itself, uncut films and specials behind a monthly subscription, and its 1975 move onto satellite distribution made the premium channel a national business.[55] Between advertising's free stream and HBO's paid one, the industry acquired its permanent two-sidedness: every later service has had to choose, or blend, the two rivers of money. And towering over both was sport, the one content whose value grows with simultaneity, which by the end of the tube era had become the single most expensive programming on Earth, and the load-bearing wall of the entire bundle: take sport out of the American cable package and the package's economics collapse, which is precisely what the streamers later discovered, and precisely why they now pay more for it than cable ever did.[52]

Property, simultaneity, admission: the tube era invented all three logics, and the flat and platform eras have mostly replayed them at higher speed. When a modern streaming service pays billions for a catalogue, engineers an event release, or bolts an advertising tier onto a subscription, it is running programmes written in the 1950s and 1970s on much newer hardware. The content layer is the least technological part of the television industry and the most durable. Glass changes; the sitcom is forever.

The Cabinet: Television as Furniture

For its first forty years in the home, the television was sold as furniture. Not metaphorically: it was designed, priced, retailed and arranged as a cabinet that happened to contain a machine, and the cabinet's rise and fall tracks the industry's whole journey from craft product to commodity panel.

The console was the founding form: a floor-standing wooden cabinet, walnut or mahogany, doors optional, housing a tube that pointed up or straight out, a chassis of hot valves, and a speaker the size of a dinner plate. It was placed like a piano and bought like one, a major household decision, often on instalments, expected to last a decade and to be repaired in the home by a man with a caddy of tubes. The tabletop set was the democratisation, smaller, cheaper, secondary; the early colour sets of the 1950s were sold in both forms, and both were, by any later standard, enormous.[7] The cabinet imposed its own economics: the wood, the joinery and the finishing were a significant share of the set's cost, the furniture factories were regional, and the repair trade was local, which is one reason the industry stayed national so long. You could not efficiently ship a console across an ocean; the value was too bulky.

The transistor began the furniture's long retreat, and the portable was its first casualty of form. Sony's TV8-301 of 1960, handle on top, battery bay in back, announced that a television could be an appliance you carried rather than a fixture you arranged a room around.[29] America answered with its own portables, GE's compact Porta-Color of 1966 with a transistorised UHF tuner, the first fully transistorised colour set, the Quasar, in 1967, and the set began its migration from the corner of the living room to the kitchen counter, the den, the bedroom.[7] The one-set household became the three-set household, and the design grammar changed with it: plastic replaced wood, the chassis shrank behind the tube, the repairman's visit gave way to the warranty and then to the landfill. The set was becoming disposable because it was becoming electronics, and electronics was becoming cheap.

The flat panel finished the argument by abolishing the cabinet entirely. The modern television has no furniture grammar at all: it is a slab of glass with a bezel measured in millimetres, designed to disappear, hung on a wall like a picture or perched on feet so minimal they apologise for existing. The industry's design energy moved into the only surfaces left, the stand, the back cover nobody sees, the remote, and then off the hardware entirely, into the interface: the home screen is the cabinet now. There is a genuine loss recorded in every estate sale and retro shop: the console was often beautiful joinery, an object with presence, and its extinction is why a mid-century television cabinet today sells as antique furniture while a ten-year-old flat panel is e-waste. The object left the furniture business and joined the glass business, and the

living room has been arranged around a black rectangle ever since. What the industry sells now is the window, not the frame; the wall, not the room.

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The Dish: Television from Orbit

The satellite is the only television technology whose selling point was a place: geostationary orbit, 36,000 kilometres above the equator, the one ring of space where a satellite's orbital period matches the earth's rotation and the machine hangs motionless over one spot. Park a transponder there and it can see a third of the planet; aim a dish at it once and never move the dish again. Everything about satellite television, its strengths, its politics, its dishes, follows from that geometry.

The orbit's physics is a club with strict membership rules. Geostationary satellites broadcasting in the original C-band must be spaced two degrees apart to avoid interference, which makes the ring a fixed estate of one hundred and eighty slots, allocated among nations like beachfront; the higher Ku-band permits one-degree spacing and dishes under a metre, which is why the industry's mass-market era waited for Ku.[56] The first tenants were not broadcasters but relays: Syncom 3 carrying the Tokyo Olympics to America in 1964, the first commercial geostationary satellite, Intelsat's Early Bird, in 1965, and, before either, the machine that proved a picture could cross an ocean through space at all.[56] The first country to build television distribution around the orbit was, characteristically, the one with the most geography to defeat: the Soviet Union's Orbita network of 1967, which used Molniya satellites in highly elliptical twelve-hour orbits, inclined so they loitered over the northern hemisphere, to rebroadcast central programming to ground downlink stations across the Union.[56]

Telstar 1 deserves its paragraph, because it was television's first spacecraft and because everything about it was provisional. Built by Bell Telephone Laboratories under John Robinson Pierce, with Rudy Kompfner's travelling-wave tube as its transponder, it was a thirty-four-and-a-half-inch sphere weighing one hundred and seventy pounds, its skin of solar cells making all of fourteen watts, able to relay exactly one television channel on a good pass.[61] It flew too low for the geostationary trick: its elliptical orbit took two hours and thirty-seven minutes, so the Atlantic window opened for barely thirty minutes at a time, and the ground station at Andover, Maine, a horn antenna one hundred and seventy-seven feet long, three hundred and eighty tons of steel steering inside a radome the size of a fourteen-storey building, had to track the little sphere across the sky to within a twentieth of a degree.

[61] The project was also an industrial first: Bell Labs paid NASA for the launch, making Telstar the first privately sponsored object ever sent to orbit, the telephone company buying rocket rides the way it bought cable.[61] On 11 July 1962 the first pictures, an American flag outside Andover, crossed to Pleumeur-Bodou in France; on 23 July came the first public live transatlantic broadcast, Walter Cronkite and Chet Huntley in New York, Richard Dimbleby in Brussels, the Statue of Liberty and the Eiffel Tower traded like postcards. The satellite was acquired before President Kennedy was ready to speak, so the engineers filled the window with a WGN feed of the Phillies and the Cubs at Wrigley Field: the first live television Europe ever received from America was baseball, which is fitting, since filler is what live television is mostly made of.[61] When Kennedy did appear and denied a dollar devaluation, the currency strengthened within minutes, and Cronkite wrote later that the men in the control rooms glimpsed the true power of the instrument they had wrought.[61] The stunt lasted months. Telstar had launched the day after the Starfish Prime high-altitude nuclear test pumped fresh radiation into the Van Allen belt it had to cross, and the belt, topped up by further American and Soviet blasts, slowly killed its transistors: out of service by November 1962, after some four hundred transmissions, revived by a workaround in January, dead for good on 21 February 1963.[61] But the argument was made. The sky could carry the picture, and the only remaining questions were who would own the ring and what the rent would be.

Home reception began, as so much of television began, with hobbyists. Through the late 1970s and 1980s the satellites carried feeds intended for cable head-ends, and anyone with the nerve and the yard could build a television-receive-only terminal: a C-band dish three metres across, the "big ugly dish", a low-noise amplifier at its focus, and a receiver that was, in the early commercial versions, a modified UHF tuner pulling the signal down to an intermediate frequency the household coax could carry.[56] The systems cost thousands of dollars and bought a frontier: every channel the cable companies had, unscrambled, free, plus the raw network feeds and the backhauls never meant for the public. The frontier closed exactly as frontiers do: the programme owners scrambled their feeds and sold descramblers, the small Ku dishes and cheap LNBs, the block downconverter at the dish that let ordinary coax carry the signal indoors, collapsed the cost from hobbyist to appliance, and by the 1990s direct-to-home satellite was a mainstream subscription industry in America, Europe and Asia alike.[56]

The satellite's strangest afterlife is that it outlasted its own obituary in two directions at once. At the bottom end, free-to-air satellite became the poor world's cable: Germany alone broadcasts some 250 free channels from the Astra constellation at 19.2 degrees East, received in about 18 million homes, and India's DD Free Dish serves the subcontinent's off-grid millions from a single slot.[56] At the top end, the analogue era in space ended only on 25 August 2025, when Brazil's last analogue satellite television transmissions ceased, sixty-three years after Telstar.[56] The dish on the roof, like the aerial before it, is becoming archaeology; the streaming packet needs no geometry. But the orbit is still full, the slots are still allocated, and every live event that must reach a continent at once, the World Cup feed, the breaking news backhaul,

still goes up to the ring and comes down everywhere. The television's oldest pipe was the air; its most reliable pipe is the one 36,000 kilometres long.

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The Meter on the Set: Paying for Television

Every television system on earth has had to answer the same rude question: who pays? The answers sort into three great designs, the advertiser's, the state's, and the viewer's, and the third produced the strangest fiscal instrument of the consumer age: a licence, renewed yearly, for the right to own a screen. The licence fee is television's attempt to make the audience a customer without a cashier, and its history is a quiet tour of what different societies thought the box in the corner was for.

The design predates television by two decades. When broadcasting began in the 1920s, a radio set was the only appliance in the house that consumed a public service merely by existing, and governments reached for the tool they knew: the permit. Britain led, funding the BBC from a compulsory wireless licence, the first national experiment in paying for mass media by subscription before the word existed.[60] Canada licensed "private receiving stations" from 1922, a dollar a year to listen, raised to $2.50 as television arrived, until 1953, when the dominion hit on the scheme most satisfying to this book's argument: it abolished the receiver licence and funded the CBC instead with a 15 percent excise tax on television sets, picture tubes and parts.[60] For five years the Canadian broadcaster was financed directly out of the hardware, the object taxed to pay for what passed through it, the cleanest admission ever made that a television is a meter with a screen attached. The excise was phased out in 1958 in favour of ordinary parliamentary appropriation, but the logic never died; it survives every time a levy is proposed on sets, recorders or hard drives to feed some cultural fund.[60]

The television licence proper, a household fee owed for the mere possession of a set capable of receiving broadcasts, spread with the medium itself. At its peak it was the normal arrangement across most of Europe, half of Asia and Africa, and almost nowhere in the Americas, whose systems were built on advertising from the start and never looked back.[60] The fee's quirks accumulated like barnacles, each one a small fossil of the technology's history. Britain still sells a cut-rate black-and-white licence, sixty-odd pounds against the colour licence's hundred and eighty, a discount for a technology almost nobody owns, kept alive by the immortal bureaucratic truth that no tariff line ever truly dies.[60] Japan's NHK fee distinguishes terrestrial from satellite households, charging the dish-owners nearly double, and has spent decades

discovering what every subscription business learns: make payment effectively voluntary and an epidemic of non-payment follows, complete, by 2013, with a single-issue political party whose entire platform is encrypting the signal so that only payers can watch.[60] The enforcement question shaped administration everywhere: Albania folds the fee into the electricity bill, Ireland deputised the post office, Austria fields a small army of household-visiting "customer consultants" against an evasion rate of about two and a half percent.[60]

What the licence bought, at its best, was distance: a broadcaster answerable neither to advertisers' quarterly nerves nor to the governing party's daily moods. What it cost was consent, and consent has been draining away for thirty years under a two-front siege. From one side, channel abundance destroyed the fee's founding fairness argument, everyone watches the public channel, so everyone pays; from the other, the internet dissolved the definitional boundary the whole system rested on, the difference between a television and everything else. The roll-call of abolitions reads like a retreat: the Netherlands in 2000, Sweden in 2019, Norway in 2020, France and Denmark in 2022, Slovakia in 2023, most of the exits converting the fee into an ordinary tax line, which preserves the broadcaster while admitting the appliance can no longer be found.[60] Germany saw the future early: since 2003 its fee has been payable whether or not any television or radio exists in the home, today a flat eighteen euros and change per dwelling per month, the licence quietly admitting it had become a tax.[60]

The licence era leaves one durable insight, which the streaming age has proven from the other direction. Somebody always pays, and the payment method writes the programme. Advertising television optimises for audiences that can be delivered to buyers; licence television optimises, in theory, for citizens; state television for the state; subscription television for the renewal. Britain's hundred and eighty pounds a year and America's advertising load are the same fact in different costumes: the window is never free, only differently metered. The tube era's great institutional invention was the discovery that a meter could be fitted to a broadcast, a signal that everyone with an antenna could take for nothing. The discovery that followed, the one this century is built on, is that the meter works far better on an account than on an appliance, and the appliance is disappearing accordingly.

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The Clock: News Without a Bedtime

Broadcast news was a visit: the anchorman came at six and eleven and left. The idea that news could be a place, on continuously, a river rather than an appointment, required a cable industry to carry it, a satellite economy to feed

it, and one man's stubbornness to pay for it. On 1 June 1980, at six in the evening, the Cable News Network signed on from Atlanta, and the schedule lost its last quiet hours.

The founding was an act of institutional improbability that has become folklore. Ted Turner, a billboard heir turned station owner, and Reese Schonfeld launched the first twenty-four-hour news channel, the first all-news channel in American television, into an industry convinced the demand did not exist: the networks' own news divisions were prestige loss-leaders, and the received wisdom said nobody watched news outside the dinner hour.[67] The first newscast was anchored by the husband-and-wife team of David Walker and Lois Hart; the first two hundred employees included a former ABC correspondent named Bernard Shaw; the whole enterprise ran on a fraction of a network news budget and a conviction that live pictures would find their own audience.[67]

What the twenty-four-hour channel actually changed was the shape of an event. Appointment news compresses: the day's chaos is edited into a tidy half-hour. Continuous news dilates: the event happens on screen in real time, unedited, unended, and the audience watches history at the speed of life. The form invented its own furniture, the anchor who stays for twelve hours, the live reporter on the roof, the split screen, the crawl, and its own economics, since a channel that never stops needs, above all, material: forty-two bureaus and nine hundred affiliated stations feeding the river by the early 2020s.[67] The clock format also inverted the industry's oldest hierarchy. In the schedule era, news was the public-service garnish on an entertainment business. In the clock era, news became a genre, with audiences, ratings and formats like any other, and in due course a segmented market in which the viewer chooses the version of the day that suits them, a development the industry is still digesting.

The numbers trace the arc with unusual clarity. The format Turner invented became a fixture of the cable bundle, carried into some eighty million American households by March 2021; by December 2023 the count was sixty-nine million and falling, as the bundle itself, the delivery system the whole genre was built on, came apart.[67] The river still runs; in June 2024 the channel hosted a presidential debate that it billed as the largest audience in its history, proof that the appointment, declared dead, survives precisely inside the medium that killed it.[67] The clock was cable's answer to the schedule. The stream, which is a clock with no channel at all, is the answer to the clock. Each generation of television has sworn to abolish waiting, and each has rebuilt it in a new form, because waiting, it turns out, was never the burden the industry thought it was. It was the product.

The Wire Up the Valley: How Cable Began

Cable television was not invented by a network, a studio or an electronics giant. It was invented, simultaneously and separately, by shopkeepers in the shadow of mountains, men who sold television sets and had nothing to show on them. The industry that would eventually swallow broadcasting began as an after-sales service: a very good aerial on a hill, and a wire down to the customers.

The founding stories come in competing pairs, and the competition itself is instructive. In Mahanoy City, Pennsylvania, the appliance dealer John Walson strung a mountaintop antenna and ran twin-lead down to the valley, where the terrain strangled reception; Congress and the cable industry later recognised his spring 1948 start, though the documentary record stubbornly suggests late 1950, and the ambiguity has fuelled a small scholarly war.[74] In Astoria, Oregon, Ed Parsons, a radio-station owner who had seen his first television at a broadcasters' convention, learned that a Seattle station 125 miles away was about to sign on; he put a large antenna on the Hotel Astoria's roof, ran coaxial cable across the street to his apartment, and when the station went up in November 1948 he had the only working television in town.[74] Parsons priced the wonder like a utility: $125 to connect, three dollars a month.[74] And in Lansford, Pennsylvania, in 1950, Robert Tarlton organised his fellow set retailers into the first frankly commercial system, selling Philadelphia's signals to the coal country the broadcasters could not reach, a venture written up in the national press and widely copied.[74]

The demand was policy-made. The FCC's freeze on new station licences from 1948 to 1952, the same freeze the boom chapter describes, locked whole regions out of television just as the craze crested, and community antenna television filled the gap exactly the way grey markets always do.[74] The regulators noticed early and did nothing decisive: the FCC's first recorded contact with the industry is a letter of 1 August 1949 asking Ed Parsons to please describe what on earth he was operating, and the Commission's own lawyer's opinion, that cable could be treated as a common carrier, was never acted on, a hesitation that let the wire grow for a generation under no settled rules at all.[74] The numbers measure the result: four and a half million households on the wire by 1970, fifty-three million by 1989, sixty percent of the country by 1992.[74] And the wire changed what it carried: HBO signed on in Wilkes-Barre in November 1972, distributing by microwave, and in 1975 became the first network delivered nationally by satellite, at which point the after-sales service had become the industry, and the broadcasters' days as the sole owners of the audience were numbered.[74][55]

The Toy Aisle: A Short History of Saturday Morning

For fifty years American television reserved one morning a week for its youngest viewers, and the history of that reservation is the whole signal economy in miniature: who the audience is worth, what may be sold to them, and what happens when the programme itself becomes the advertisement.

The block began as a dumping ground. Through the 1950s, with animation fleeing the cinemas after the Paramount Decree broke the studios' block booking, Saturday morning was where old theatrical cartoons went to be rerun; until 1963 the networks' line-ups were hand-me-downs, yesterday's shorts and prime-time repeats.[76] Fred Silverman at CBS saw what the schedule was hiding: an audience with nothing else to do and parents glad of the sitting service. His 1966 restructuring, four and a half solid hours of original cartoons, took CBS to first place and invented the modern block; the superhero wave followed on all three networks.[76] Then came the counter-movement, and it came with unusual force: after the assassinations of 1968, violence on children's screens became a public issue, Action for Children's Television organised the parents, and by 1972 the action heroes were gone; by 1973 advertising inside the block was capped at twelve minutes an hour, and in 1978 the Federal Trade Commission openly weighed banning all advertising to preschoolers, a proposal that would have killed the format and was, in the end, dropped.[76]

What regulation restrained, deregulation perfected. The Fowler FCC of 1981 declared that the market would decide what children watched, swept away the decade's restrictions, and got its answer within a season: the "half-hour toy commercial". He-Man and the Masters of the Universe, the Transformers, the Turtles, programmes built around toy lines, the catalogue and the cartoon merged into one product, were decried by the children's advocates and watched by everyone.[76] When Congress passed a Children's Television Act to rein the practice in, in 1988, President Reagan vetoed it.[76] The 1980s block was, in this book's terms, the purest expression of broadcast's founding trade: the audience was not the customer but the cargo, and the cargo was small, trusting and holding a wish list.

The institution died not of regulation but of plumbing. Cable's cartoon channels, Nickelodeon and Cartoon Network, ran the same product every day, all day, without the broadcasters' advertising restrictions, and by 2004 they took eighty-eight percent of all child advertising impressions while the proudest broadcast block left managed seven.[76] The networks responded by quietly leaving the nursery: from 1992 they swapped cartoons for weekend editions of the morning news, then for cheap educational-tinged documentaries that satisfied the mandates; the last network cartoon blocks closed in 2014 and 2016.[76] Saturday morning, the weekly festival that sold the cereal, the toys and the set itself to three generations, turned out to be a property of the three-channel world. When every morning became Saturday morning, no morning was. The schedule's last children's institution was dissolved by

abundance, the same solvent this book has watched work on everything else the schedule built.

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The Watchdog's Bargain: Fairness and the Licenced Word

The broadcast spectrum's scarcity, the fact at the root of the signal economy, produced American broadcasting's strangest institution: a rule about what could be said. From 1949 to 1987 the FCC's fairness doctrine required every licensee to cover controversial issues of public importance and to do it fairly, airing contrasting views. It was the price of the licence: the airwaves were public, so the microphone could not be wholly private.

The doctrine had an awkward ancestry. Its predecessor, the Mayflower decision of 1941, had forbidden broadcasters to editorialize at all; the 1949 report that replaced it permitted opinion but taxed it with balance.[77] The Supreme Court blessed the arrangement unanimously in Red Lion in 1969, reasoning that scarce frequencies justified what would be unconstitutional for print: the airwaves were not only for those who could pay for airtime; the public had a right to hear both sides.[77] The rule had teeth. The same year, a federal court ordered the FCC to revoke the licence of WLBT in Jackson, Mississippi, a station that had spent years censoring network coverage of the civil rights movement, the starkest demonstration that the licence was a bargain and could be forfeited.[77] And the rule was used, inevitably, as a weapon: the Kennedy, Johnson and Nixon administrations all worked the doctrine's complaint machinery against opponents on the air.[77] A regulation designed to widen debate served, in practiced hands, to police it.

The end came from the same logic that had built the doctrine, run in reverse. Scarcity was the premise, and scarcity was eroding: cable multiplied channels, and the Fowler FCC's 1985 report declared that the doctrine chilled more speech than it protected. On 4 August 1987 the Commission abolished it by a vote of four to nothing; the courts upheld the repeal in 1989; the corpse was formally struck from the Federal Register only in 2011.[77] The equal-time rule for political candidates, a separate creature, survives to this day, which is why the two are so often confused.[77]

What followed the repeal is the live argument of our own moment. Freed of the balance obligation, the airwaves, and then the cable news the Clock chapter describes, discovered the audience economics of the single viewpoint, and the doctrine's abolition is now routinely cited as a contributing cause of American

political polarisation.[77] This book's interest is structural rather than nostalgic. The fairness doctrine was an attempt to write, into the licence, an obligation that the market would not produce on its own: the duty to bore, to balance, to host one's opponents. Its repeal was a bet that abundance made the obligation unnecessary, that a hundred channels would balance themselves. Four decades on, the bet's outcome is visible in every direction the reader cares to look, and the question it posed has not gone away; it has merely moved house, from the licensed station to the unlicensed platform, where no doctrine of any kind yet applies.

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The Standby Image: The Test Card

For most of television's first half-century, the most-seen image on the medium was not a programme at all. It was the test card: the still, geometrical picture a station radiated when nothing else was on, so that engineers, dealers and viewers could adjust their sets. Generations who never saw a studio camera knew the Indian-head intimately.

RCA's Indian-head pattern, a labelled chart of wedges, gratings and grey scales, served North America from the 1940s into the 1970s; each element existed to expose a specific fault in the alignment of a black-and-white receiver.[78] When colour arrived, the card went electronic and acquired the names of its generating machines: Philips' PM5544 across the PAL world, Grundig's VG1000, Telefunken's FuBK, while the industry bodies contributed their own, the SMPTE and EBU colour bars.[78] The card was the industry's handshake with the home: an open standard, broadcast free, by which a television could be tuned without a service call. It was, in the strictest sense, television about televisions.

The card also made culture by accident. In Britain the hours it filled were accompanied by library music, licensed cheaply for heavy rotation, announced in the early years by the three notes B-B-C on a celesta; whole strata of viewers grew up associating easy-listening instrumentals with a picture of a clown.[78] And then the schedule closed in. As broadcasters moved to round-the-clock programming there was no dead air left to fill, and the test card retreated to history, the standby image of an era when television, like its audience, still slept at night.[78] Its descendants survive wherever a screen must declare that it is working without saying anything: the colour bars in the edit suite, the placeholder slate, the buffering wheel. Every one of them is the same quiet device: the machine showing its working.

The Colour That Isn't There: The Green Screen

Television's most important piece of scenery is a colour. Chroma keying, compositing one image over another by hue, is the trick that puts the weather map behind the presenter and the planet behind the starship, and its medium is a shade of green that exists in the studio precisely so that it can be deleted.

The technique came from cinema's optical benches. Blue-screen matting was developed at RKO in the 1930s, where Linwood Dunn's travelling mattes made the wipe transitions of Flying Down to Rio, and Larry Butler's genie escaping the bottle in The Thief of Bagdad won the 1940 effects Oscar; Arthur Widmer refined the process from 1950, and Petro Vlahos's refinements won another Oscar in 1964.[79] Each composite was then a laboratory procedure: high-contrast mattes printed frame by frame through an optical printer, female and male counter-mattes sandwiching the background negative. Television, which could not wait for film to be souped, made the trick electronic and live. In the early 1970s the American and British networks began keying their newscasts, and they chose green over the film industry's blue for gloriously mundane reasons: weather presenters wore blue suits, and the green channel of a broadcast camera carried the strongest signal, giving the cleanest cut.[79]

The green screen thus became a new kind of industrial standard: not a specification published by a committee, but a convention enforced by wardrobe. Its etiquette is exacting, wear the colour and you are keyed out of existence, and its accidents are a genre of their own, the meteorologist whose tie dissolves into the map.[79] When Spider-Man and the Green Goblin share the sky, one must be shot against green and the other against blue, because the screen is a treaty about which colour may exist.[79] From the genie's bottle to the evening forecast, the principle has not changed: television learned to treat a colour as a doorway, and behind the door it built the largest stage in the world, the one that is not there.

The Goodnight: Sign-Off and the Sleeping Signal

Television used to say goodnight. For most of the medium's history the broadcast day ended, and it ended in ceremony: a sermonette or a prayer, a

declaration of the station's good conduct, a film of flags and monuments set to the national anthem, and then the transmitter's carrier cut and the screen collapsing to a point of light. The sign-off was the industry's nightly reminder that the channel was a licence, not a tap.

The ritual was a small constitution read aloud. American stations closed by affirming their subscription to the NAB's Television Code, a practice that lasted until 1983; elsewhere the closedown carried prayers in countries with state churches and anthems everywhere, the station borrowing the state's symbols to bless its own switch-off.[81] Then came the dark: hours in which the frequency, the scarcest asset in the economy of the air, simply rested, guarded by nothing more than the test card of the previous chapter. The empty night was the visible proof that spectrum was rationed: it was too precious to waste, and yet it went to waste every night, because audiences, not airtime, were the true scarcity.

What killed the sign-off was the discovery that the night had a price. As audiences fragmented and 24-hour broadcasting spread, the dead hours filled with whatever cost least: infomercials, reruns, teletext pages simulcast with music, the overnight feed relayed unedited from the network.[81] Some stations kept a ghost of the old ceremony, a formal sign-on in the early morning to open the logging day, the ritual surviving after its reason had gone.[81] The end of the sign-off is a precise marker in this book's larger story: the moment television stopped being an event with edges and became an environment without them. The ambient screen of the chapters ahead begins here, in the night the antenna trade went on duty and never came home. A medium that never sleeps asks its audience never to look away, and the audience economy that followed, measured by the meter, sold by the second, is the subject of the rest of this book.

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PART III - THE AGE OF THE TUBE

The Magnetic Memory: Videotape and the End of Liveness

For its first decade and a half, television had no memory. What went out on the air was gone the instant it arrived, unless a film camera was aimed at a monitor to make a kinescope, grey and ghostly. The machine that gave the medium a past was built not by a network or an electronics giant but by a small Redwood City recorder company, Ampex, and it arrived, with theatrical suddenness, on 14 April 1956, when the quadruplex videotape recorder was unveiled at the broadcasters' convention in Chicago.[84]

The race had been run in the open. Bing Crosby Enterprises gave the first demonstration of video on tape in Los Angeles in November 1951, images "blurred and indistinct" from quarter-inch audio tape running at a frantic 360 inches a second; the BBC chased the same linear approach with its VERA system, and RCA showed colour recording at Princeton in 1953, all of them defeated by the arithmetic of bandwidth: a video signal demanded hundreds of times more tape than sound.[84] Ampex's answer was to stop lengthening the tape path and start widening it: a spinning drum of four heads scanning across two-inch tape, laying the picture down in transverse stripes. Within months CBS was using the VRX-1000 to delay the evening news for the Pacific time zone, and in January 1957 Truth or Consequences became the first programme broadcast to every time zone from tape.[84] The live era was over before most viewers knew it had existed.

The industrial consequences unspooled for half a century. Tape killed the kinescope trade, untied production from the clock and the coast, and created the rerun; Sony's U-matic cassette of 1971 put the technology in a plastic box, Betacam carried it onto every news shoulder in the 1980s, and Sony's D-1 of 1986 began the digital recording era.[84] The consumer branch of the family, the VCR, has its own chapters in this book; its last maker, Funai, closed the line in July 2016.[84] But the deepest change was conceptual. Once television could be stored, it could be edited, sold, repeated, syndicated and archived, and every business described in the parts ahead, from the syndication market to the streaming library, is a business in television's memory. The magnetic stripe was the medium's first hard drive.

PART IV

The Flat World

Between 1995 and 2015 the television lost its depth, its weight and its industry. The cathode-ray tube, for sixty years the unchallenged heart of the set, was displaced by a sandwich of glass, liquid crystal and transistor film that could be made only in fabs costing billions of dollars apiece. The result was the fastest wholesale technology transition in the history of consumer goods, and a new industrial map drawn in cleanrooms.



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PART IV - THE FLAT WORLD

The Liquid Crystal: From Watch Faces to Walls

The technology that dethroned the tube was discovered in 1888, dismissed for eighty years, perfected for calculators, and only then aimed at the wall. The liquid crystal's path from botanical curiosity to the centre of a hundred-billion-

dollar industry is the longest slow fuse in this book, and its story explains, better than any other, why the flat-panel revolution happened where it happened.

Friedrich Reinitzer, an Austrian botanist studying cholesterol in carrots, noticed in 1888 that cholesteryl benzoate had two melting points: it went cloudy at one temperature and clear at a higher one, passing through a state that was neither crystal nor liquid but somehow both.[31] His correspondent Otto Lehmann, with better microscopes, named the state *liquid crystal* and spent a career cataloguing its strange optics: these were fluids whose molecules kept their orientation, fluids you could steer. For seventy years it remained exactly that, a beautiful answer in search of a question. The question arrived in the 1960s at RCA's Princeton laboratories, where a group led by George Heilmeier showed that an electric field could switch a liquid-crystal cell between scattering and clear, a display with no light of its own, no phosphor, no gun, just molecules obeying a voltage.[31] RCA, in the story it told itself afterward, saw no television in it, the cells were slow, the contrast poor, and let the work leak away. Heilmeier's team leaked with it. RCA's headquarters would eventually stand as a cautionary tale in every business school in the world, which is a kind of immortality.

The RCA work stood on a buried foundation, as industrial breakthroughs usually do. The electrically switched light valve itself, the Fréedericksz transition, the essential effect of every LCD ever made, had been devised by the Russian physicist Vsevolod Frederiks in 1927; the Marconi company patented the first practical application, "The Liquid Crystal Light Valve", in 1936, thirty years before anyone could use it.[31] At Princeton the pieces came together in a single decade: Richard Williams found the electro-optic stripe patterns, "Williams domains", in 1962; Paul Weimer developed the thin-film transistor in the same laboratories the same year; George Heilmeier built the first working display on his dynamic scattering mode in 1964; and in 1968 Bernard Lechner conceived the marriage of the two, a TFT at every pixel, and demonstrated the concept with a matrix of 18 by 2.[31] Every liquid-crystal screen on Earth is a descendant of that 36-pixel strip, including the one this sentence may be read on.

The liquid crystal found its first paying customer in the wristwatch and the pocket calculator, where its two decisive virtues, microwatts of power and paper thinness, mattered more than speed or beauty. The twisted-nematic cell, invented at Hoffmann-La Roche in 1970 and promptly entangled in patent wars, became the standard switch; the Japanese electronics industry, Sharp, Casio, Seiko above all, built the volume.[31] This is the hinge of the whole story: the LCD entered mass production not as a television but as a component for gadgets, and Japan, which owned the gadgets, thereby came to own the learning curve. Each calculator bought with a Casio logo was, without knowing it, funding the display industry that would end the Trinitron's reign. The super-twisted nematic improvements of the 1980s made laptop screens possible; the active matrix, a thin-film transistor at every pixel, a silicon chip the size of the screen itself, made them fast.[31] By 1988 Sharp showed a 14-inch colour TFT-

LCD that the trade press recognised, correctly, as the tube's death warrant, and in 1992 it built the first fab meant, from the first sheet of glass, for televisions.[31]

The physics, by then settled, deserves one clear paragraph, because the modern wall is built from it. A liquid-crystal cell is a sandwich: two sheets of glass, each with a transparent electrode and an alignment layer rubbed to set a direction, and between them a few micrometres of rod-shaped molecules twisted into a helix. Light enters through a polariser, follows the twist, and passes the second polariser; apply a voltage and the molecules stand up, the twist unwinds, the light is blocked.[31] The cell emits nothing; it is a shutter, and behind the shutters sits a backlight, cold-cathode fluorescent tubes at first, LEDs after 2005 or so, and in front sit colour filters, red, green, blue, one per subpixel. Everything about the LCD's character follows: its thinness (no bottle), its efficiency (no megavolt electron beam), its size ceiling (none, in principle), its weaknesses (leaky blacks, narrow angles, smeared motion), and its insatiable appetite for manufacturing precision, since a million-pixel panel tolerates no lazy molecule.

The market took its time believing. Through the 1980s the LCD television was a novelty the size of a postcard: Seiko Epson's wristwatch TV of 1982 was the first of the breed, Casio and Citizen followed with pocket sets, and even Sharp's 14-inch colour TFT of 1988, the demonstration that made the industry sit up, was a laboratory flagship, not a product.[14] The mass market arrived on a date one can name: 2001, when Sharp's Aquos line made the flat LCD set a thing ordinary households bought, and the escalator from there was swift, a 65-inch Sharp panel by 2004, a 108-inch monster at CES in 2007, the year LCD sets finally outsold the tube.[14][9] The wristwatch had become the wall in twenty-five years.

The industry that grew from this is the subject of the next two chapters: the fab economy, with its motherglass generations and crystal cycles, and the great geographic migration, Japan to Korea to Taiwan to China, that the fabs drove. The liquid crystal's final indignity is that almost nobody who owns one knows it is there. Ask a hundred people what an LCD television contains and most will say LEDs, which is merely the lamp. The actual working substance, the fluid that obeys, discovered among carrots in Graz in 1888, remains what it has always been: invisible, indispensable, and three micrometres thick.[31]

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PART IV - THE FLAT WORLD

Plasma: The Beautiful Loser

Every technology transition has a ghost, the alternative that was better in some ways and lost anyway. In the flat-panel wars the ghost is plasma, and its story

begins, improbably, in a university computer lab, with a display built to save memory, not to win living rooms.

In 1964, at the University of Illinois, Donald Bitzer and H. Gene Slottow, with graduate student Robert Willson, were building terminals for the PLATO computer-education system and wanted a display with inherent memory, one that would not need expensive refresh circuitry for every point. Their answer: a grid of tiny gas cells between glass plates, each cell a minute neon lamp that, once lit by a firing pulse, stayed lit on a small sustaining voltage. The plasma display panel.[9] The orange Digivue panels that Owens-Illinois built for PLATO terminals in the early 1970s were rugged, flicker-free and a full inch thick, astonishingly slim for their day, and they glowed in teaching labs, lobbies and stock exchanges for years.[9]

Plasma's physics is television's physics in miniature. Each cell holds a mixture of noble gases, neon and xenon in colour panels; a voltage pulse ionises the gas into plasma, and the plasma's ultraviolet light excites phosphors coated on the cell walls, red, green or blue, exactly as a fluorescent lamp works, shrunk to submillimetre scale and multiplied by millions. Unlike a liquid crystal, a plasma cell *emits* its own light. That single property gave plasma sets their deep blacks, their wide viewing angles and their effortless motion, and it won them a devoted following among home-cinema enthusiasts that outlasted the market by years.[9]

Colour plasma was a long time coming. Fujitsu, working with the University of Illinois and NHK, first commercially tested one in 1989. IBM, which had run the world's largest plasma plant in Kingston, New York, making monochrome panels for its own terminals, nearly exited in 1987, selling the plant to a start-up called Plasmaco for $50,000, one of the decade's better bargains.[9] The consumer breakthrough came in 1997: Philips, using Fujitsu panels, put the first big flat television on sale, the 42-inch 42PW9962, at four Sears stores in the United States for $14,999, in-home installation included. Pioneer and Fujitsu followed; by 2000 prices had "dropped" to $10,000.[9] For a brief, shining window around the millennium, plasma *was* the flat television: the only technology that could hang a big, bright, true-colour picture on a wall, and an object of pure desire in every electronics shop in the world.

The object itself was a small masterpiece of awkward manufacturing, which is why it lost. A plasma panel is two sheets of glass sealed around a waffle of glass ribs a fraction of a millimetre high; each cell is lined with phosphor sprayed through a metal mask, addressed by silver-paste electrodes, covered with a dielectric and a layer of magnesium oxide deposited by electron beam, then evacuated and filled with its working gas.[9] The glass alone was a battle: the panels had to be baked to fix the phosphors, which demanded expensive heat-resistant "high strain point" glass until Panasonic worked out how to build them on ordinary window glass.[9] Plasmaco built the first 60-inch panel in 2000; Panasonic showed a 150-inch monster at CES 2008, eleven feet wide, the technology's high-water mark and, in hindsight, its funeral wreath.[9] Every one of those processes was a cost the LCD did not have.

The window stayed open about a decade. Through the mid-2000s plasma, made chiefly by Panasonic, LG and Samsung, fought LCD for the large-screen market and held real advantages in black level and motion; the home-cinema press declared for plasma almost to the end.[9] What killed it was not a better picture but a better factory. LCD panels rode the cost curve of the semiconductor-style fab: every new generation of motherglass cut costs brutally, and the same fabs fed the exploding markets for laptops, monitors and phones, volumes plasma could never touch. Plasma, bound to thicker glass, noble-gas cells and trickier assembly at small pixel sizes, could not chase LCD down into the 32-inch mass market where the volume lived, and it drank power at rates the coming energy rules would not forgive. In the 2007 Christmas season, analysts tallied the numbers twice in disbelief: LCD had outsold not only plasma but CRT.[9] Pioneer, the connoisseur's brand, quit in 2009; manufacturing for the US market ended in 2014; the last Chinese production stopped in 2016.[9]

Plasma's virtues, self-emission, perfect blacks, were eventually inherited by OLED, the technology that finished what plasma started. The industry keeps its ghosts' best ideas. And the plasma decade left one structural lesson that the rest of this Part elaborates: in displays, the manufacturing learning curve is destiny. The panel that fits the biggest, fastest-learning factory wins the living room even when the connoisseurs prefer the loser. It is a lesson the tube's heirs have each learned in turn, and it will be heard again in the chapters on the fabs, on the tube's death, and on OLED's rise.

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PART IV - THE FLAT WORLD

Anatomy of a Panel

The cathode-ray tube was one machine repeated sixty million times a year. The liquid-crystal panel is something stranger: a semiconductor the size of a window, a sheet of printed electronics holding a few milligrams of oil that used to be a vegetable. To understand why the panel industry became a contest of capital and national will, open one.

The trick at the centre is a shutter with no moving parts. Take two polarising filters set at right angles: crossed, they pass nothing, which is why the calculator display with its top film peeled off goes blank or inverts. Between them, sandwich a layer of liquid crystal, rod-shaped molecules that line up with a surface treatment and with each other. With no voltage, the molecules form a helical staircase from one glass plate to the other, and light following the twist is rotated through the crossed polariser and gets through: the pixel glows. Apply a voltage and the molecules stand up straight, the twist collapses, the rotation stops, and the second polariser blocks the

light: the pixel goes black.[31] That is the whole display. Every image on every liquid-crystal television ever sold is millions of copies of that shutter, opening and closing by degrees, sixty or a hundred and twenty times a second. The crystal emits nothing. It is a valve for light made elsewhere, which is why the backlight, fluorescent tubes at first, then white LEDs, is a third of the panel's cost and nearly all of its power budget, and why the industry's deepest irony is that the least efficient display ever mass-produced throws away most of the light it makes.[31]

The shutter had a flaw that took two decades to engineer around: it only worked head-on. The twisted-nematic cell's contrast and colour shifted badly off-axis, fine for a calculator, fatal for a television a family watches from across a sofa. The industry answered with geometry wars. Hitachi's in-plane switching, developed in 1990 and commercialised by 1992, laid the electrodes on one glass plate so the molecules rotate in the plane of the screen, which holds colour and contrast at wide angles at the cost of an extra transistor per pixel and a thirstier backlight; Samsung's 1996 optical patterning enabled multi-domain designs, splitting each pixel into regions that tilt differently, and multi-domain and in-plane switching together remained the dominant LCD designs through the mid-2000s.[31] The mode wars never really ended, IPS descendants and VA descendants still divide the world's television glass between them, and both survive in the phone in your pocket. The point for the industry is the pattern: every weakness of the crystal was retired not by a new material but by a new geometry, printed in the same fabs.

Colour adds printing. Each pixel is three sub-pixels, red, green and blue, made by photolithography directly on the glass: coat the sheet with a photosensitive resin loaded with pigment ground to particles forty nanometres across, bake it, expose it to ultraviolet light through a mask, wash away the unexposed resin, and repeat once per colour.[31] First the black matrix goes down, a grid that frames every sub-pixel to keep their light from bleeding together; in the laptop era the grid was chromium, until environmental rules moved the industry to carbon-loaded photoresist.[31] The result is a colour filter array made by the same family of processes, resist, mask, expose, etch, that makes microprocessors, executed on sheets of glass measured in square metres. A panel fab is what happens when a chip plant and a printing works have a very large child.

Behind the filter sits the part that decided who would rule the industry: the backplane, an array of thin-film transistors, one switch per sub-pixel, laid down as semiconductor layers across the whole sheet. A 4K television carries about twenty-five million of these transistors, printed not in a postage-stamp die but across half a square metre of glass, with the yield arithmetic of chipmaking and the area arithmetic of glazing: a single particle of dust is a dead pixel, and a dead pixel is a rejected panel.[31] Between the plates go spacers a few micrometres tall to hold the cell gap even, and the electrodes themselves are indium tin oxide, the only material that is both a good conductor and transparent, which quietly made television a mining story: indium comes almost entirely as a by-product of zinc refining, with a handful

of countries, led by China, controlling the supply, so every flat screen in every living room carries a few tenths of a gram of a strategic metal nobody has heard of.[43]

Then the whole sandwich, filter glass, crystal, backplane glass, polarisers, is laminated, and several displays are cut from one mother sheet like biscuits from dough.[31] That last sentence is the economics of the next chapter. How many screens one sheet yields, and how big the sheet can be grown, is the entire basis of panel cost: double the mother glass and you can cut a sixty-five-inch television where before only laptops fit, at no new cost per square metre of processing. The industry's generations, Gen 5, Gen 8, Gen 10.5, are simply sheet sizes, and each generation was a bet of billions of dollars that demand would meet the new glass. The panel, in short, is not a component. It is a process, and whoever owns the biggest, newest process owns the price of television itself.

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PART IV - THE FLAT WORLD

Motherglass, Generations and the Crystal Cycle

The most important object in the modern television industry is one the customer never sees: the motherglass. An LCD panel begins life as one rectangle among several on a vast sheet of glass, processed whole through hundreds of steps, deposition, photolithography, etching, colour-filter printing, polariser lamination, cell assembly, and only at the end cut into individual panels, like cookies stamped from dough. Industry people use exactly that analogy: the sheet is the dough, the panel the cutter, and "cut loss" the expensive processed glass thrown away at the edges.[34] Everything about the business, its prices, its geography, its wars, follows from the size of that sheet.

Sheet sizes are measured in "generations", and the generations are the industry's geological strata. Gen 1, around 1990, was roughly a sheet of office paper, 300 by 400 millimetres, good for calculator and watch displays. Each new generation roughly doubled the area: Gen 4 made laptop screens, Gen 6 made monitor panels and small televisions, Gen 8.5, the workhorse of the 2010s at 2,200 by 2,500 millimetres, made the 55-inch living-room standard possible. The fabs grew with the glass, from hundreds of millions of dollars to multi-billion-dollar cleanroom cities, and the economics of the climb are a trap and a goldmine at once: the cost of a fab rises roughly with the square root of the substrate size, while the value it can produce rises with the area.[34] Bigger is better, until defect density, handling robotics and glass sag eat the gain, which is why each generation took years of yield agony to master.

The current summit is Gen 10.5: glass of 2,940 by 3,370 millimetres, a sheet the size of a garage door, on which eight 65-inch panels fit at 94 percent utilisation, or six 75-inch

panels; the older Gen 8.5 lines could only make those sizes with miserable yields or awkward multi-mode cuts.[33][34] The generation race is therefore also a screen-size race: whoever owns the newest glass owns the cheapest big screens, and big screens are where the industry's growth has lived for a decade. The average television diagonal sold has crept upward every year of the flat era, and each step of the creep was set by what the newest fabs could cut without waste.

The geography of the fab tells the story of three industrial eras. Japan built the first generations, Sharp above all, and ruled the 1990s. Korea's Samsung and LG out-invested Japan through the downturns of the late 1990s and 2000s, the famous counter-cyclical bet, building fabs in gluts when equipment was cheap and rivals were paralysed, and took the lead; Taiwan's AUO and Innolux carved out the middle. Then came China, at a scale the pattern had never seen. BOE, once a failing Beijing state electron-tube maker that bought Hyundai's LCD line in 2003 to learn the trade, lit the world's first Gen 10.5 fab at Hefei in December 2017 and began mass production in March 2018, ramping from 40,000 sheets a month toward 90,000 by year-end, with China Star's Shenzhen T6 and others close behind.[32][33] The effect on the market was immediate and brutal: prices for 65-inch panels fell by double-digit percentages within quarters of the new capacity arriving, and the pressure transmitted down through every smaller size.[32] By 2025, mainland Chinese makers held about 69 percent of the world's TV-panel output; BOE alone shipped 26 percent of all units, CSOT 22-23 percent, HKC and Innolux about 15 percent each, and Samsung Display and LG Display, the champions of the previous era, had mostly exited LCD entirely.[18][19] The country that once imported the world's televisions now prints most of their pictures.

This industry has its own heartbeat, known half-jokingly as the "crystal cycle": new capacity floods the market, prices crash below cost, weak players exit or are bought, capacity tightens, prices soar, and the survivors build new fabs at the top, restarting the cycle. Display strategists even play games with it: companies announce enormous fab plans partly to frighten rivals out of building their own, a signalling war in which, historically, only about half of announced capacity has ever actually been built.[34] The cycle's period, roughly three to four years, is set by fab construction time, and it synchronises the industry like a metronome: capex, prices, profits, bankruptcies and mergers all arrive on the same beat. It is a business in which you can make the best panels on Earth and still lose money for years, which is why it has consolidated to a handful of giants, and why governments, Japan's, Korea's, Taiwan's, China's, have always been somewhere in the capital stack. A television fab is closer to an aircraft carrier than to a factory: a national asset with an export schedule.

The set-making layer below the fabs feels all of this as weather. A brand like Samsung or TCL buys panels on a spot-and-contract market whose prices can swing 30 percent in a year; the panel is most of a television's bill of materials; and so the fortunes of the world's largest electronics companies are hostage to the crystal cycle even when, as with Samsung Display and LG Display historically, they own fabs themselves. That tension, panel makers wanting volume, set makers wanting cheap glass, everyone

wanting the premium big-screen segment, is the engine of the industry's last twenty years, and the backdrop to the brand wars of Part V.

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PART IV - THE FLAT WORLD

High Definition: The Standard That Waited for the Screen

High-definition television was broadcasting daily in Japan in 1989, and ordinary in American living rooms in 2009. The twenty-year gap between those dates is the most instructive standards story since colour: an answer that arrived before the question, an analogue masterpiece overtaken by a digital insurgency, and a transition that only completed when the screens were finally flat enough to deserve it.

Japan's NHK had begun the research in 1964, in the afterglow of the Tokyo Olympics, asking what television would need to be to satisfy the eye rather than merely inform it.[48] By the 1970s their laboratories had settled the parameters: 1,125 lines, a wider 5:3 frame, and psychophysical testing to prove the improvement was felt, not just measured. The result, demonstrated in America in 1981, impressed Ronald Reagan into declaring HDTV "a matter of national interest"; the encoding system, MUSE, squeezed the monster signal into a satellite channel by analogue cleverness; on 4 June 1989, daily "Hi-Vision" broadcasts began, the world's first.[48] The system had already been blooded in public: NHK taped the 1984 Los Angeles Olympics with a Hi-Vision camera that weighed forty kilograms, and the engineers marked the format's milestones with a numerologist's pride, regular test broadcasting opened on 25 November 1991, 11/25, chosen for the 1,125 lines.[48] Europe answered with its own analogue system, HD-MAC, proposed by the European Community in 1986 at 1,152 lines and backed by Brussels as industrial policy. For a moment in the late 1980s, the future of television was high-definition, analogue, and split between Japan and Europe. The analogue systems' public life was a string of spectacular demonstrations: Italy's RAI broadcast the 1990 football World Cup in experimental high definition, a chain of satellite and fibre feeding ten cinemas, eight in Italy, two in Spain, because no home could receive it; HD-MAC had its own showcase at the 1992 Barcelona Olympics and was scrapped the following year.[48] The pattern is worth noticing: both analogue HD systems were triumphs of engineering that required a satellite channel and a cinema to be seen. They were standards waiting for a physics that did not yet exist.

Then a San Diego division of General Instrument demonstrated, in 1990, that HDTV could be done *digitally*, compressed, packed, and error-corrected into an ordinary 6-

megahertz channel, and the analogue systems were dead within five years, elegant, expensive, and obsolete, the Concordes of broadcasting.[48] The FCC halted its analogue process, demanded a genuine digital standard, and faced down a queue of competing consortia by the simple device of making them merge: the "Grand Alliance" of 1993 combined General Instrument, MIT, Philips, Thomson, Sarnoff Labs, NBC, Zenith and AT&T into one system, MPEG-2 video, Dolby audio, 8-VSB transmission, that became the ATSC standard.[48] It is one of the few standards in this book that was designed by its rivals' forced marriage, and it worked.

What followed was the slowest fast transition in consumer electronics. American digital broadcasting began at the end of the 1990s; the sets were enormous, expensive, and had almost nothing to receive. The transition limped until three things converged in the mid-2000s: flat panels cheap enough to make HD's promise visible, broadcasters and cable filling the pipe with HD content, and governments setting the date. The digital switchover, the deliberate extinction of analogue broadcasting, rolled around the world by national decree: Germany first in 2003, the United States on 12 June 2009, Japan in 2011, with the spectrum thus freed, the "digital dividend", sold to the mobile industry for sums that paid for the whole exercise several times over.[49] The analogue era ended, fittingly, not with a product launch but with a series of midnight switch-offs, the last stations blinking out to static on a scheduled date, a century's technology turned off like a light.

HDTV's deeper legacy is the shape of the screen itself. The 16:9 frame, a compromise engineered to hold both cinema's widescreen and television's squarer heritage, became the world's rectangle, the shape of phones, laptops and monitors as well as sets.[48] And the high-definition transition taught the industry its modern rhythm: resolution is the escalator that never stops. 4K followed in the mid-2010s, 8K behind it, each waiting on the same three legs, panels, content, bandwidth, that HDTV had needed, and each selling the same promise to the same living rooms. The standard that waited twenty years for its screen now defines the screen's whole market.

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PART IV - THE FLAT WORLD

The Interludes: Rear-Projection and the 3D Fad

Between the tube's reign and the flat panel's, two technologies had their moment in the shop window. One was a bridge, genuinely useful for a decade; the other was a mirage, one of the great collective hallucinations of consumer electronics. They are remembered together because they mark the same truth: the television industry, when its physics is in flux, will try anything, and the buyer decides.

The bridge was rear-projection, and it was older than the big-box decade suggests. At London's Radiolympia show in 1937, Philips and HMV exhibited 25-inch projection televisions, a small, ferociously overdriven tube at 25,000 volts, green phosphor for brightness, its image thrown by mirror and Schmidt lens onto a frosted screen, and the pre-war and immediate post-war console trade kept the scheme alive wherever buyers wanted more picture than a twelve-inch tube could give.[50] Through the 1990s and early 2000s, anyone who wanted a screen beyond the tube's 40-inch ceiling bought a big box that was, in essence, a cinema in a cabinet: three small CRTs, later an LCD or DLP light engine, projected the image onto a mirror and up onto the back of a translucent screen. Early models weighed up to 500 pounds; the picture was dim and soft at close range; and after 2002, when the boxes went digital, the ultra-high-pressure lamps inside them dimmed with use and demanded periodic, expensive replacement, a rare consumer product with a scheduled maintenance bill.[50] And yet until about 2006, rear-projection was how most affordable large screens, up to 100 inches, were made.[50] RCA sold the first wall-mountable model in 2003; Mitsubishi shipped the first 1080p DLP set in 2005; Samsung put LEDs in one in 2006.[50] The technology kept improving desperately as the flat panels closed in: Texas Instruments' DLP chip, a semiconductor whose surface is a matrix of microscopic aluminium mirrors, one per pixel, each tilting on a hinge thousands of times a second to paint brightness by pulse width, gave the boxes digital precision; Mitsubishi's LaserVue of 2008 gave them lasers; Sony's last SXRD models slimmed the cabinet toward wall-mountability. It was not enough. Sony exited at the end of 2007, Samsung in 2008, and Mitsubishi, the last maker standing, stopped in 2012.[50] The rear-projection decade is the proof that "big" was never the customer's final want: the want was big *and* hangable, big and bright, big and cheap, all at once. Only the fab could deliver that.

The mirage was 3D. The idea was old, Baird himself demonstrated a stereoscopic system in 1928, and the industry's physics for it was mature by 2010: active-shutter glasses alternating the lens in sync with the screen, or polarised glasses splitting alternate lines. What ignited the fad was a film: James Cameron's *Avatar* in December 2009, whose 3D cinema success convinced the entire industry that the living room wanted depth.[51] At CES 2010, weeks later, every major manufacturer led with 3D sets; ESPN launched a dedicated 3D channel that June; shipments exploded from 2.26 million sets in 2010 to 41 million in 2012.[51] And then the buyers, having bought, declined to use it. The glasses were uncomfortable, the picture dimmer, the content thin, the novelty one movie deep. Viewership declined from late 2013; ESPN 3D shut that year; by 2016, production of 3D televisions had ended entirely.[51] Forty-one million sets a year to zero in four years is as close as a hardware category comes to a popped bubble.

The post-mortem matters because it disciplines the industry's hype reflex. 3D failed not on technology, the technology worked, but on what this book's earlier chapters keep calling the settlement: content, price, comfort and habit must all move together. A feature that asks the viewer to wear equipment on the sofa, in the dark, for two hours, asks more than a picture improvement is worth. The industry absorbed the lesson so thoroughly that its next great leap, 4K, was marketed with a kind of

chastened minimalism: better picture, no glasses, nothing new to learn. It sold immediately. Sometimes the ghost of a fad is more useful than the fad: 3D's failure is why the modern industry sells improvements to the picture rather than changes to the viewer.

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PART IV - THE FLAT WORLD

The Death of the Tube

For eighty years the television *was* a cathode-ray tube with furniture around it, and then, in roughly a decade, it stopped being one. The end of the CRT is the fastest extinction of a dominant consumer technology on record, and the most instructive, because the tube was not out-invented so much as out-manufactured.

The numbers trace a cliff. Through the 1990s the world made and bought CRT sets at an enormous, steady rate; in 2005 global shipments were still overwhelmingly tubes. Two years later came the crossover in the rich markets: in the 2007 Christmas season, LCD televisions outsold CRT sets, a result analysts reportedly tallied twice before believing it.[9] After that, collapse. The great glassmakers had seen it coming and could not profit from seeing it: the funnel plants of Corning's joint ventures, built to press a million tube-glass envelopes a month, went cold one by one; Samsung SDI, once among the largest CRT producers on Earth, wound down its lines; the yoke and gun and mask suppliers followed. By the early 2010s a technology that had defined the twentieth-century living room was commercially extinct in new sets almost everywhere, surviving only in the second-hand market, in retro-gaming devotion, and in the staggering installed base of the developing world, where the tube's cheapness and repairability gave it a long afterlife.

The tube did not die because its picture was bad. A late Trinitron still has its admirers, and among players of old video games the CRT's instant response and perfect motion remain unreplaced. It died because the physics that made it good also made it heavy, deep and hard to scale. Glass is the binding constraint: a tube's weight and depth grow faster than its screen, so the technology topped out around 36 to 40 inches of viewable diagonal just as flat panels were making 42, 50 and 65 inches ordinary.[6] The last generation of "flat-faced" super tubes, marvellous pieces of stressed glass, only proved the point: they were so heavy that a 34-inch widescreen needed two people and a strong stand, and their makers were building cathedrals at the moment the congregation left. Meanwhile the economics completed the argument. Every dollar of fab investment made panels cheaper; nobody was investing in tubes. Retailers, earning per square foot of shelf, wanted thin boxes that

stacked four high. Regulators added energy rules that a megavolt-per-hour electron gun could not meet. The incumbent was not defeated where it was strong; it was abandoned where the investment was going.

What the tube left behind is still being tallied. The world accumulated on the order of two billion CRT sets and monitors over the technology's lifetime, and each one is a disposal problem: a funnel of leaded glass, several kilograms of lead in a large set, there to shield the X-rays the beam generates, phosphor coatings on the face, and a vacuum that implodes if mishandled.[6] Proper recycling means separating panel glass from funnel glass and smelting or stabilising the lead, work that costs money, which is why so much of the flow moved, legally and otherwise, toward places where labour was cheap and oversight thin. The Basel Convention's assessments follow the trail to scrapyards like Agbogbloshie in Accra, Ghana, where imported electronics are broken apart and burned to recover copper, and the soil and groundwater studies register the cost in lead, cadmium and dioxins.[35][36]

The tube's afterlife is stranger than simple extinction. It survives, first, where replacement is harder than endurance: the flight decks of older airliners, the Boeing 747-400 and Airbus A320 among them, flew for decades on CRT instruments, and some military systems still do, served as of the early 2020s by a single company remanufacturing tubes from donor parts.[6] It survives, second, as connoisseurship: players of old video games prize the tube for its instant response and its timing quirks, some games' light guns cannot work on anything else, and a healthy second-hand market now trades heavy Trinitrons to buyers half the sets' age.[6] And it survives, third, as mass: the billions of tubes already made will be leaving the world, through scrapyards and smelters, for decades yet. Technologies do not die when the factories stop. They die in instalments, one disposal at a time.

The extinction was completed, fittingly, by the signal. The same years that killed the tube retired the analogue broadcast it was built to receive: Germany switched off its terrestrial analogue transmitters first, in August 2003, and country by country the world's broadcasters followed, until the 2006 Geneva frequency agreement fixed 17 June 2015 as the effective international analogue switch-off date for most of the planet.[49] The United States ended full-power analogue broadcasting in June 2009, mailing out government coupons for the converter boxes that kept old sets alive, a programme paid for out of the billions raised by auctioning the freed spectrum to the mobile industry.[49] There is no neater parable of the transition: the airwaves the tube had filled for sixty years were worth more, sold once, to carry telephone calls, and the state paid citizens a bounty to retire the tube's last reason to exist. An analogue-only set after switch-off was an object, not an appliance.

The flat era has not solved this; it has resized it. The replacement cycle shortened, the glue-and-tape construction of modern panels resists disassembly, and the waste stream now runs at tens of millions of tonnes of electronics a year worldwide, with screens a growing share. An industry that taught the world to upgrade its window every few years has never fully owned what happens to the old glass. The television's afterlife is a reminder that a display industry is also a waste industry on a delay, and

that the true bill for the beautiful flat screen arrives years later, in a scrapyard most viewers will never see.

PART V

The Industry Today

Who makes the glass, who makes the set, who pays for the signal - and what the numbers say.



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PART V - THE INDUSTRY TODAY

OLED, Quantum Dots and MicroLED

The LCD won the factory war, but it never stopped being what it is: a shutter. Every LCD picture is a lamp's light, subtracted. The technologies that came for the premium end of the market all share plasma's old virtue instead: each pixel makes its own light. Their contest with the incumbent, still running, is the live display war of the present tense.

OLED's lineage runs through a dying company, which is fitting. The effect had been observed since the 1950s, André Bernanose's group in France ran high voltages

through organic films and saw them glow, and Martin Pope's group at NYU worked out the electrode physics in 1960, but the practical device was built in 1987 at Eastman Kodak by two chemists, Ching Tang and Steven Van Slyke. They stacked separate hole-transporting and electron-transporting organic layers so that charges met in the middle and recombined into light; the two-layer design cut operating voltages from dangerous to useful and made the whole idea manufacturable.[37] Kodak, which had invented the digital camera and then been ruined by it, proved no better at keeping OLED: the first commercial uses were modest, a Pioneer car stereo in 1997, a Kodak digicam screen in 2003, and the patent estate eventually dispersed across the industry, with Universal Display Corporation, spun out of Princeton research, holding key commercialisation rights and taxing the field ever since.[37]

The first OLED television was Sony's XEL-1 in 2007: eleven inches of impossible thinness, three millimetres deep, at a price, about $2,500, that announced a technology rather than a product.[37] What made OLED a mass premium market was LG Display's bet on a different manufacturing route: white OLED emitters with colour filters, deposited by evaporation at television sizes, which sidestepped the fine metal masks that made red-green-blue patterning so hard to scale. LG Electronics put the panels into large sets from 2013; Samsung, after years of dismissing the approach, answered in 2022 with QD-OLED, blue OLED stacks exciting quantum-dot colour converters. An OLED pixel that is off emits nothing at all, so the black is true black, the contrast effectively infinite on paper, and the panel can be millimetres thin, or bent, or rolled. The premium tier of the industry, where the margin lives, now belongs to this chemistry.

Every organic light source carries its mortality in the name: organic. The materials decay with use, and they decay unevenly, blue fastest of all, which is why early OLED engineering was as much gerontology as chemistry. A 2008 teardown put blue-material lifetime around 14,000 hours to half brightness, five years of evening viewing, against 25,000 to 40,000 hours for the incumbent technologies; oxygen and moisture attack the films even when the set is off, which is why the panels are encapsulated like pharmaceuticals.[37] The industry answered with heroic materials science: LG Electronics reported expected lifetimes of 100,000 hours by 2016, up from 36,000 three years earlier.[37] But the phenomenon known as burn-in, the ghost of a channel logo or a news ticker etched into the pixels by unequal wear, remains the technology's honest flaw, and it shapes the business: pixel-shifting firmware, screen savers, warranty fine print, and a quiet industry of compensation algorithms all exist to manage the fact that the best picture in the living room is slowly, permanently, remembering what it has shown.

The incumbent fought back with chemistry of its own. Quantum dots, semiconductor nanocrystals a few nanometres across whose glow colour is set by their size, let LCD makers keep their fabs and their shutters while closing most of the colour and brightness gap: a blue backlight, a film of dots, and the "QLED" television was born. It is an LCD with a better lamp, and it has been commercially formidable, which is its own lesson, the same one plasma taught: in consumer electronics, the technology that

fits the existing factory usually beats the technology that is morally superior. Mini-LED backlights, thousands of tiny lamps behind the LCD, dimmed in zones, closed the black-level gap the same way, by refining the shutter's lamp rather than replacing the shutter.

The third emissive contender is MicroLED: walls of inorganic light-emitting diodes shrunk to tens of micrometres and placed one per subpixel, combining OLED's self-emission with LED brightness and none of the organic decay. Samsung put the idea on sale as "The Wall" in 2018, a modular 146-inch display for commercial spaces, with smaller consumer versions following at prices starting near a house deposit.[38] The physics is solved; the manufacturing is the mountain. Assembling a 4K screen means placing tens of millions of microscopic dies, each one a potential defect, and the mass-transfer and repair economics have so far kept MicroLED a showpiece rather than a market. Perhaps that changes; the history of the display industry is a graveyard of confident predictions, including the ones in this paragraph.

The strangest product of the emissive era was the television that disappeared. At CES 2019, LG showed the Signature OLED TV R, a 65-inch screen that rolled down into its own aluminium plinth like a window shade, and put it on sale in Korea in October 2020 at 100 million won, more than $87,000, and around $100,000 when it later reached the United States.[39] It sold in tiny numbers and was discontinued in 2024, but it made its point: a display that emits its own light need not be a rectangle of glass bolted to a wall. After a century in which the television dictated the furniture, the furniture was starting to win.

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PART V - THE INDUSTRY TODAY

Makers: The League Table and What It Hides

The television industry's league table is one of the longest-running championships in business. Samsung has been the world's best-selling television brand for nineteen consecutive years through 2024, holding about 28.3 percent of global revenue, a streak built on vertical integration, panels, chips, sets, software, marketing, all under one roof, and on never missing a technology transition badly.[15] Below the champion, the table has been rewritten by the same force that rewrote the fabs: in 2024 the Chinese brands, led by TCL, Hisense and Xiaomi, collectively passed the Korean brands in unit shipments for the first time, about 31.3 percent of the world's sets against 28.4 percent.[17] The country that prints most of the world's panels now increasingly sells the sets around them too.

The individual lines behind the shift are worth a beat of attention. Hisense shipped 29.1 million sets in 2024, about 14 percent of the world, and has held the number-two ranking three years running; TCL shipped 29.0 million, 13.9 percent; each is now larger than LG's total set business, and Hisense simultaneously leads the market's most visible trophy category, 100-inch sets.[20][15] In revenue the old order persists, Samsung 28.3 percent, LG 16.1, TCL 12.4, Hisense 10.5, and Sony, the former emperor, at 5.4 percent, a ranking that would have been unthinkable in the Trinitron's reign.[17] The premium corner of the market tells the forward version: premium shipments grew 38 percent across 2024, and in the fourth quarter TCL's unit share of that segment passed LG's for second place behind Samsung.[16] The championship table is being rewritten from the top down and the bottom up at once.

The raw table conceals as much as it shows. Samsung and LG still dominate the revenue and nearly all the profit because they dominate the large and the premium, the 75-inch-plus shelves and the OLED cases where the margin lives; much of the Chinese volume is fought over at prices where a television is nearly a commodity again. TCL and Hisense have answered the only way one can, by climbing: mini-LED flagships, hundred-inch screens, global sport sponsorships, and the slow purchase of premium credibility that Samsung itself bought from Sony's old customers a generation ago.[20] LG, the other Korean giant, has made a different bet: it owns OLED television manufacturing outright, supplying panels even to rivals: LG shipped about 3.18 million OLED sets in 2024, over half of the world's total, and has accepted a smaller unit business in exchange for the premium tier and the panel economics behind it.[15] The direction of travel is the same as it was for Japan in 1970 and Korea in 1995: volume first, then premium, then the championship.

The casualties of each transition tell the story from the other end. The American brands, RCA, Zenith, Magnavox, Admiral, were bought, hollowed or licensed into nameplates; the last, Zenith, sold to LG in 1995.[46] The great Japanese houses that ruled the tube era mostly retreated: Toshiba exited, Hitachi exited, Panasonic shrank to niches, and Sharp, the company that bet everything on the LCD and built the industry's first true TV fab, burned so much money in the crystal cycle's troughs that in 2016 it was sold to Foxconn, the Taiwanese contract assembler best known for making other companies' phones.[18] Sony survives as a premium brand without a panel fab, buying its screens from former rivals. Europe's Philips licenses its name to TPV. What remains of the old West is mostly the badge: an American "RCA" television today is a Chinese-made set wearing a rented memory.

And beneath the brands sits the industry's invisible tier: the original design manufacturers, TPV, MTC, KTC, Foxconn and others, who assemble a large share of the world's sets, including many under famous names, in plants the buyer will never hear of. A modern television brand is increasingly a design studio, a software platform, a retail relationship and a sourcing operation; the thing itself is made by specialists at margins the brand owners would not accept. It is the pattern the shipping container imposed on trade, applied to the product that displays the result:

the brand owns the customer, someone else owns the factory, and the customer sees only the box.

The league table's deepest secret is that everyone on it loses money on the hardware, sometimes, some years, and stays in anyway, because the set is the beachhead for everything else in this Part: the platform, the advertising, the data. The chapters that follow count that hidden business. But never mistake the visible table for the business: the championship of sets is real, and it is also the loss leader for a larger game.

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PART V - THE INDUSTRY TODAY

The Invisible Makers: Who Actually Builds the Set

The league table of brands is the visible industry. Beneath it sits a second industry that most viewers have never heard of and have certainly watched: the contract makers, companies that design and build televisions which leave the factory wearing someone else's badge. A surprising share of the world's sets, and a majority of its cheaper ones, come from factories whose names appear nowhere in the shop.

The pattern is old and the epitaphs are instructive. Consider Funai, for decades the most invisible important company in American television. From its Osaka base it built the sets that American shops sold as Philips, Magnavox, Emerson and Sanyo, famous names licensing themselves onto another firm's engineering, and it became the main electronics supplier to Walmart and Sam's Club, turning out more than two million flat panels a year for the Black Friday ritual alone.[64] Funai's deeper fame is as a finisher of eras: it was the last company on Earth still manufacturing videocassette recorders, continuing under the Emerson and Magnavox badges until July 2016, when the last VCR line in the world finally stopped.[64] The end, when it came for Funai itself, was pure crystal-cycle arithmetic: the budget end of the market it owned collapsed under Chinese panel economics, and in October 2024 the company entered a court-approved quasi-bankruptcy with liabilities of some eighty-two billion yen against assets of barely one and a half billion.[64] Within a year, the Philips badge on American televisions had passed to China's Skyworth, and the circle closed: the licensed brand, invented so that a European giant could leave the industry without leaving the shelf, had migrated to the next maker down the cost curve.[64]

The giants of the invisible industry are larger than most visible ones. Hong Kong's TPV Technology is the world's largest maker of computer monitors, roughly a third of the global market, and builds televisions under its own AOC badge, under Philips licence, acquired with Philips' monitor and entry-level television business in 2005,

and as an original design manufacturer for other companies' brands, with a capacity measured, by 2010, at over six million monitors a month across factories in China, Brazil, Poland and Russia.[64] Turkey's Vestel plays the same role for Europe from "Vestel City", a 1.3-million-square-metre complex in Manisa: by 2006 it was the largest television producer in Europe with a quarter of the market, almost none of it under its own name, prompting Businessweek to call it "the unknown TV giant", and by 2021 its lines could turn out ten million sets a year.[64] Walk a European hypermarket's budget wall and count the badges: a dozen defunct-sounding national brands, supermarket labels, mail-order names, and behind most of them one Turkish factory, one licensing department, one bill of materials.

The badge market is the logical end of the learning-curve industry. Once panels are commodities bought by the square metre, a television is a panel, a power supply, a tuner board and a logo, and the logo is the only part that differentiates. The old brands, unable to make money manufacturing, discovered they could make money not manufacturing: licensing the name, collecting the royalty, letting Funai or TPV or Vestel carry the factories, the inventory and the crystal cycle's losses. The arrangement hollows out gracefully until it doesn't: the licensee lives on margin slivers a bad panel-price year can erase, as Funai's balance sheet proved. What the invisible makers reveal, better than any league table, is where the industry's remaining value sits: not in assembling the set, and not, any longer, in the famous name on its chin, but upstream in the panel fabs and downstream in the interface. The middle of the television, the box itself, became a service performed for logos.

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PART V - THE INDUSTRY TODAY

The Bazaar: The Industry's January

Every January, in a convention hall in the desert, the television industry holds its annual general meeting with itself. CES, the consumer electronics trade show in Las Vegas, is where the year's screens are unveiled, the year's buzzwords minted and the year's hype written off in advance, and its history is a compressed history of the industry: what was shown at the winter show, and what was never shown again, tells you everything.

The bazaar began, appropriately, as a spin-off. The first Consumer Electronics Show opened in New York in June 1967, hived off from the Chicago Music Show that had housed the gadget trade until then, with some seventeen and a half thousand attendees, a couple of hundred exhibitors and Motorola's chairman Bob Galvin as kickoff speaker; among the exhibits were pocket radios and the first televisions built with integrated circuits.[72] From 1978 the show ran twice a year, winter in Las Vegas,

summer in Chicago, until the summer edition faded and, from 1998, CES settled into its modern form: one show, January, Vegas, grown by 2025 to a hundred and forty-one thousand attendees and a build that takes the better part of three weeks to erect and demolish.[72]

The show's real function is dating. The industry's milestones arrive with a CES stamp: Philips unveiled the first home videocassette recorder at the 1970 show, a nine-hundred-dollar box replacing fifty-thousand-dollar studio machines; the plasma wall, the 108-inch LCD, the 150-inch plasma monster of 2008, the 3D wave of 2010, the 8K escalator and the transparent-panel stunts all had their first outings under the same roof.[72] The pattern to notice is the gap between the unveil and the uptake. Some January stars, the VCR, the flat panel, walked out of the hall and ate the world; others, 3D most lavishly, were launched at CES for years running and died there just as regularly. The show is the industry's memory and its amnesia at once: every January the same claims, bigger, thinner, brighter, smarter, are true just often enough to keep the pilgrimage rational.

For this book's purposes the bazaar matters as a calendar. The crystal cycle may run on fab time, but the industry's public rhythm runs on CES time: panels ramped in autumn become sets announced in January, which become doorbusters the following November, which become the shipment numbers that close the year and set up the next January's claims. The trade show is where the manufacturing curve meets the marketing curve, where a panel maker's capex decision of three years ago is dressed in black cloth and spotlights and sold to the world as the future. Watch the January hall long enough and you can read the whole industry in it: what the fabs could make, what the brands could not resist announcing, and what the public, in the end, actually bought.

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THE THIRD INDUSTRY

The Signal Economy: What the Set Sells After It Is Sold

A television is unusual among machines in that selling it is only the beginning of the business. The car sells petrol; the razor sells blades; the television sells attention, and it sells it continuously, for a decade, to whoever can assemble an audience in front of the screen. The industry that lives off this flow is larger than the industry that makes the sets, and it has reinvented itself at least four times: broadcast advertising, the cable bundle, the satellite and pay era, and now streaming and the operating system. The hardware chapters of this book are about glass; this chapter is about money.

The first signal economy was the simplest. American commercial television was built on a single proposition: the programme is free because you are the product. Advertisers bought the audience that broadcasters assembled, and the numbers grew with the sets. By the mid-1950s television had overtaken radio and print as the main stage of American advertising; the quiz shows, the soap operas named for their detergent sponsors, the single-sponsor dramas of the "golden age" were all artefacts of a market in which three networks could deliver most of a nation's living rooms at eight in the evening. Britain and much of Europe built a parallel public model, the licence fee, in which the household pays the broadcaster directly and the advertiser is kept out, a fork in the road that still marks the world's broadcasting map: the BBC and its imitators on one side, the American commercial web on the other, most countries some hybrid of both.

What changed the economics was not a better picture but a better pipe. Cable television, which began in the late 1940s as community antennas pulling distant signals into mountain valleys, became in the 1970s and 1980s a second revenue stream nobody had planned for: the subscriber fee. A household now paid for television itself, monthly, forever, and the bundle of channels that fee supported, CNN, ESPN, MTV, HBO, invented the idea of the channel as a brand and the niche as a business. Satellite distribution carried the same logic across continents: Rupert Murdoch's Sky, India's Star, Latin America's DirecTV. The economics of the bundle were extraordinary because they were opaque: every subscriber paid for every channel, whether watched or not, and the carriage negotiations between channels and distributors became some of the hardest-fought contracts in business. At its peak, the American cable bundle reached around a hundred million households; the carriage fees for the big sports channels, extracted from every subscriber including those who never watched sport, became the textbook example of bundle power.[25]

Advertising, meanwhile, remained the deep layer. Global television advertising revenue has been measured for decades in the hundreds of billions of dollars; Statista's long series puts worldwide TV ad spending on a plateau through the 2010s and into slow decline in the 2020s, with the broader "TV and video" advertising market, traditional plus digital video together, projected at about $339 billion for 2024, and digital video, at about $191 billion, now the larger half.[40] The direction of the crossover is the story: the money is leaving the scheduled channel for the addressable screen. An advertiser in 1985 bought a programme and hoped; an advertiser in 2025 buys a household, or a person, and checks.

Which brings the story back to the set itself, and to the strangest development in the industry's recent history: the television as a software platform. The "smart TV", a set with an operating system and an internet connection, turned the one-time hardware sale into a continuing relationship. Samsung's Tizen, LG's webOS, Roku, Amazon's Fire TV, Google's TV, each fights to own the home screen, because the home screen is where the new money is: placement fees from streaming services, a cut of subscriptions sold through the platform, and, above all, advertising. Automatic content recognition, software that identifies what is on the screen, tells the platform

(and its ad partners) what the household actually watches. The set makers discovered what the phone makers already knew: in a market where hardware margins are thin, the services layered on top are where the profit can live. Roku, which sells hardware as a lure, earns all of its gross profit from its platform and then some, the devices segment booked negative gross profit through 2024 while the platform grossed about two billion dollars; the television set, which spent eighty years as a dumb terminal for someone else's signal, has become a tollbooth with a screen attached.[41]

The streaming wars are this economy's current battle, and they rhyme with every earlier one. Netflix, which began posting DVDs in 1997 and started streaming in 2007, did to the bundle what the bundle did to the networks: it unbundled attention from the schedule. The incumbents answered with their own services, Disney+, Max, Paramount+, Peacock, and the result, by the mid-2020s, was a market in which streaming had overtaken the combined total of broadcast and cable viewing in the United States, the industry's home market and its largest pool of ad money: in May 2025, by Nielsen's Gauge, streaming took 44.8 percent of American television usage against broadcast's 20.1 and cable's 24.1, the first month the new pipe beat the two old ones together.[42] The economics remain unsettled: streaming loses the bundle's opacity and gains the customer's monthly freedom to cancel, and the industry's answer, predictable in retrospect, has been to reintroduce advertising and re-bundle the bundles. Plus ça change. The signal economy keeps inventing new pipes, and the pipes keep refilling with the same two liquids: subscriber money and advertiser money.

One more participant deserves naming, because it is the least visible: measurement. The entire advertising economy rests on knowing, or pretending to know, who watched. Nielsen's ratings, a sample of households standing in for a nation, decided the fate of programmes and the price of ads for seventy years; the shift to streaming and to automatic content recognition has shattered that monopoly and set off a fight over what counts as a viewer that is, at bottom, a fight over billions of dollars. The television measures us back. That sentence, which would have sounded sinister in 1965, is in 2026 merely a description of the billing system.

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PART V - THE INDUSTRY TODAY

The Set Becomes a Platform

The most consequential change to the television in the last fifteen years is invisible from the sofa: the set stopped being a terminal and became a computer with an agenda. The "smart TV", a set with an operating system, a network connection and an app store, went from a differentiator on middle

and high-end models in the early 2010s, only about 12 million American households had actually connected a web-capable set in 2012, to the dominant form of television by the end of the decade, when the installed base of connected sets worldwide reached 1.26 billion.[53] The chapter on the signal economy described the money; this one is about the machine that collects it.

The smart set's business logic was forced on the manufacturers by arithmetic. Hardware margins had been crushed by the panel wars; a 55-inch television sold for less real money every year. The software layer offered what the glass could not: recurring revenue. The home screen became property, and a quiet war for it broke out among Samsung's Tizen, LG's webOS, Roku, Amazon's Fire TV and Google's Android/Google TV, each of which could charge streaming services for placement, take a cut of subscriptions sold through the platform, and sell advertising against the audience it could now measure directly.[53] The set maker, for eighty years a hardware company paid once, became a landlord paid forever.

The measurement is the sensitive part, and it deserves plain language. Modern smart sets and streaming devices run automatic content recognition, software that identifies what is on the screen, whether it arrives by broadcast, cable, console or app, and reports viewing data back to the platform and its advertising partners. A 2019 Princeton and University of Chicago study, "Watching You Watch", found that a majority of tested streaming devices covertly transmitted user data, in some cases captured screen images, to a wide network of advertising and analytics companies.[53] Regulators noticed: in 2017 Vizio paid $2.2 million to settle charges by the US Federal Trade Commission and the New Jersey Attorney General that it had captured second-by-second viewing data from 11 million sets, appended demographic profiles, and sold the result to advertisers, all without consent.[54] The industry line, that this powers "recommendations", is true; the critic's line, that the television now watches back, is also true. Both fit in one sentence, which is the sentence that matters: the set became a two-way device, and the household was not always told.

The road to that duopoly-plus-challengers is littered with dead platforms, a graveyard worth naming because it shows how quickly the television absorbed the software industry's rules. The catalogue of discontinued or absorbed smart-TV systems includes Samsung's Orsay, Yahoo! Smart TV, the first Google TV, Boxee, Ubuntu TV, MeeGo, Vewd, the Smart TV Alliance, and a dozen more.[53] Each arrived with an app store and a developer pitch; each discovered that a television platform lives or dies on two things only, the volume of sets it ships on and the completeness of its streaming catalogue, and that nobody writes apps for a screen that sells a million units a year. The survivors are the ones attached to a distribution engine: Samsung's own production lines, LG's, Amazon's retail channel, Google's licensing machine, and Roku's deliberate neutrality, the Switzerland strategy of selling to every brand too small to build its own system. Software, it turned out, followed exactly the same learning curve as glass: scale first, profit after.

What the platform era means for the industry is a power shift as deep as any in this book. The broadcaster once owned the schedule; the set maker once owned the glass; the platform now owns the interface, and the interface owns the audience. A streaming service that is not on the home screen barely exists; a set maker that controls the home screen can charge everyone else rent; and the viewer, offered endless choice, in practice chooses from what the interface puts forward. The television's century has been a sequence of these shifts, from the inventor, to the network, to the cable bundle, to the platform. Each time, the layer closest to the audience won. There is no closer layer left, unless the screen disappears entirely, which is exactly what Part VI considers.

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PART V - THE INDUSTRY TODAY

The Watchers: Measuring the Audience

The signal economy sells attention, and attention, unlike sets, cannot be weighed on a factory scale. Every era of television has therefore needed a meter, a trusted way to say how many people watched what, and the meter has quietly decided what got made. The story of measurement is the signal economy's shadow history: whoever counts the audience sets the price of the programme.

For most of the broadcast age the meter was a sample: a few thousand households, a box on the set or a diary on the arm of the sofa, extrapolated into "the ratings". The arrangement's absurdities were famous inside the industry and invisible outside it, a handful of families standing in for a continent, sweeps weeks when the measured months got the best programming, programmes living and dying on the viewing habits of a statistical village. But the system's virtues were real: the sample was independent of the seller, the method was public enough to argue about, and everyone, network, advertiser, affiliate, paid for the same numbers. Television's hundred-billion-dollar advertising market rested, for sixty years, on the honour system of a few thousand diaries. It is one of the stranger load-bearing walls in modern commerce.

The streaming era broke the sample and then rebuilt measurement inside the set itself. A smart television can, in principle, report every second of its own use, and most now do: automatic content recognition, ACR, samples the pixels on the screen, whatever their source, broadcast, disc, game console, streaming app, matches them against a reference library, and phones home. When researchers from Princeton and the University of Chicago instrumented smart TVs for their 2019 "Watching You Watch" study, they found tracking of this kind endemic across platforms.[53] The

industry's own milestone tells the same story from the other side: in May 2025, by Nielsen's Gauge, streaming passed broadcast and cable combined in American viewing, 44.8 percent against 44.2, and the company doing the measuring was no longer extrapolating from diaries but ingesting telemetry by the billion.[42] The meter had moved into the merchandise.

The dangers of that move have a documented case. In 2017 the US Federal Trade Commission and the state of New Jersey settled with Vizio for $2.2 million over exactly this practice: from February 2014, the company had collected second-by-second viewing data from some eleven million smart TVs, appended demographic data, and sold the lot to third parties for advertising, without meaningful consent.[54] The episode matters less as scandal than as blueprint. It showed that the set had become a sensor, that the sensor's product was the audience, and that the line between measuring viewing and monetising the household had already been crossed by one of the industry's largest brands before anyone thought to ask. Every smart-set privacy policy since is a footnote to it.

Where this ends is an industry with perfect meters and fragmented truth. The broadcast age had one flawed, shared, independent count; the platform age has a dozen precise, private, self-interested ones, each platform grading its own homework, each advertiser buying its own version of the audience. The irony is worth recording: television can now count every pixel it shows to every set on Earth, and it has never been harder to say, in a way all parties trust, how many people watched the programme. The ratings were a fiction everyone agreed to believe. Telemetry is a fact nobody is obliged to share. The audience, measured more precisely than ever, has become a trade secret.

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PART V - THE INDUSTRY TODAY

The Listings: The Paper Schedule

Before the schedule lived in the set, it lived in the shop. For half a century the essential accessory of American television was not a component at all but a small digest-sized magazine sold at supermarket checkouts, and its rise and fall trace the whole arc of the scheduled age with an almost suspicious neatness.

TV Guide was assembled, like the networks themselves, from regional pieces: a New York listings sheet founded in 1948, its rivals in Chicago and Philadelphia, bought up and welded by Walter Annenberg's Triangle Publications into a national magazine with local insides, launched on 3 April 1953 with Lucille Ball's newborn son on the cover, fifteen cents a copy, one and a half million copies in ten cities.[65] The formula

was industrial publishing of a high order: one national colour section of features and criticism, wrapped around listings compiled city by city, until the magazine ran a hundred and forty separate local editions and was, by the 1960s, the most-read magazine in the United States, peaking near twenty million weekly copies in 1970.[65] No programme was ever watched by that many people at once. The schedule was the medium's largest shared text, and it was printed on paper, weekly, forever.

The magazine's economics rested on a monopoly so ordinary nobody noticed it: the list itself. Knowing what was on required either the newspaper's incomplete courtesy grid or TV Guide's authoritative one, and the authority was worth, in 1988, three billion dollars, the price Rupert Murdoch's News Corporation paid for Triangle, at the time the most expensive publication transaction in history.[65] The listings even adapted to the VCR: from 1990 the magazine printed PlusCodes beside each programme, short numbers that told a suitably equipped recorder what to tape, the paper schedule learning to talk to the machine.[65] But the list's value was an artefact of scarcity, and scarcity was ending. In 1998 the magazine passed to United Video Satellite Group, owner of the Prevue listings channel, for eight hundred million dollars plus stock, print and electronic schedules merging under one roof.[65]

The endgame came fast once the guide moved into the set. Why buy next week's grid on paper when the set-top box drew it live, searchable, free? In October 2005 the magazine surrendered: the digest format of fifty-two years abandoned, the hundred and forty local editions collapsed into two timezone versions, listings thinned to grids, the institution admitting that its reason to exist had migrated on-screen.[65] Circulation, twenty million at the peak, fell under three million by 2007.[65] And then the detail this book exists to record: in October 2008 the owner, Macrovision, sold TV Guide, the magazine that had organised the evenings of the most televised nation on earth for fifty-five years, to an equity fund for one dollar, plus a loan to keep it running, while the listings website, severed from the magazine, fetched three hundred million.[65] The paper schedule was worth a dollar; the data was worth three hundred million. Between those two prices lies the entire economics of television's digital transition, and the fate of every medium that ever sold attention by the week.

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PART V - THE INDUSTRY TODAY

The Grid: The Schedule Made Visible

For most of television's first half-century, the schedule was invisible, printed in a newspaper or a magazine and memorised by the faithful. The electronic programme guide turned the schedule into something the set itself could show, a grid of channels and hours drawn on the screen, and in doing so it quietly

became the most-used piece of software in television history and the first battlefield of the interface wars that this Part describes.

The first guide was a channel. In 1981 a company called United Video Satellite Group began feeding a scrolling listings service to American cable systems by satellite: a dedicated channel that showed what was on, up to ninety minutes ahead, assembled by a computer at each cable headend from raw data beamed down to it.[63] Renamed Prevue Guide, and later the TV Guide Channel, it was the de facto guide of North American cable for three decades, and anyone who watched it remembers its strange rhythm: the listings scrolled at their own sweet pace, half the screen devoted to a video window showing whatever the guide's owners were promoting, the viewer reduced to waiting for the scroll to come around, a captive of the most boring loop on the dial. It was television about television, and it drew audiences large enough to advertise against.

The interactive guide, the grid you steer, arrived from the satellite hobbyist fringe. In 1986 a print-listings publisher showed SuperGuide, an on-screen guide for home dish owners that stored a week of listings in the receiver itself; by 1990, integrated into the Uniden 4800 satellite receiver, it could tune a chosen programme at a button-press and fire an infrared emitter to start the VCR recording, the guide and the recorder fused into one gesture.[63] Cable followed: Scientific Atlanta's 8600X set-top of 1993 carried an interactive guide, downloadable software and two-way communication; TV Guide On Screen, a joint venture between the listings magazine and Liberty Media, reached the market in General Instrument's CFT2200 box in late 1995.[63] Behind the product race ran a property race: a 1988 patent on the searchable electronic guide established early that even a list of times and titles, the least ownable thing imaginable, could be fenced, a reminder that in television the interface is where the rents hide.[63]

The grid's raw material became an industry of its own. Listings data, the start times, titles and synopses of every programme on every channel, is gathered by metadata aggregators whose names never reach the screen: Gracenote, now part of Nielsen, and TiVo Corporation among them, sold to box makers and broadcasters worldwide.[63] The delivery plumbing layers tell the story of the medium's digitisation in miniature: analogue guides rode the vertical blanking interval, the spare lines between frames; digital guides travel as tables inside the broadcast stream itself, Europe's ETS 300 707, North America's PSIP tables, so that even a set with no network connection knows what it is showing.[63] By the end of 2008, fifty-nine million Western European households used electronic guides, and in Britain, the most developed market, ninety-six percent of viewers used one by 2010.[63]

The grid's fate is the schedule's fate. The old scrolling guide channel died of its own success: the TV Guide Network, finding its listings redundant in the interactive age, rebranded as an entertainment channel, Pop, in 2015, a guide that stopped guiding.[63] What replaced the grid is the recommendation row, the streamer's algorithmic shelf, which answers the same question, what is on, with a different grammar: not a table of times but a ranked guess about you. Something was lost in the translation that this

book wants to mark. The grid showed the whole schedule, every channel at once, the commons made visible; the recommendation row shows only your own reflection. The schedule was public. The guess is private. Between those two interfaces lies most of the difference between the century's television and the present one's.

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PART V - THE INDUSTRY TODAY

The Thirty Seconds: Advertising, the Industry's Fuel

The first paid television advertisement in history was a clock. On 1 July 1941, before a Dodgers-Phillies game on New York's WNBT, the Bulova watch company bought a minute of airtime, for somewhere between four and nine dollars, and filled it with the station's test pattern dressed as a watch face, the second hand sweeping while an announcer intoned the time.[68] The whole economics of commercial television are present in embryo in that minute: the audience assembled by someone else's content, the sponsor's name bolted on, the price trivial because nobody yet knew what the audience was worth.

The pattern repeated at every system's birth: the first British commercial, for Gibbs SR toothpaste, opened ITV on 22 September 1955; the first Asian one, on Nippon Television in August 1953, was, again, a clock, Seiko showing the time.[68] Then the form grew up. The thirty-second spot became the industry's standard ingot, minted by agencies, cleared by gatekeepers, Britain's Clearcast still vets every script, and sold against programmes whose only economic function was to deliver the interruptions.[68] The culture absorbed the form so deeply that its fragments outlived the campaigns: jingles and catchphrases passing into the language, and from 1985 onward, when Burger King put Aretha Franklin's "Freeway of Love" under a burger and Nike put the Beatles' "Revolution" under a shoe two years later, the pop catalogue itself became raw material, licensed by the second.[68]

The audience's counter-technology, met in the chapter on the clicker, reached its logical end with the recorder. The industry began studying fast-forwarding through commercials as soon as the VCR spread in the 1980s; the digital recorder, TiVo and its kin, made skipping automatic, and the arms race escalated through product placement inside the programme, sponsorship baked into formats, and, in 2018, Fox and NBC's experiment with one-minute "prime pods", fewer, dearer breaks intended to keep the live viewer from reaching for the remote.[68] Note the direction of travel: every defence works by dissolving the boundary between the programme and the pitch, which is to say by conceding that the audience will not voluntarily cross the boundary itself.

The spot's final migration is into the auction. Broadcast advertising was sold on the gross rating point, a blunt estimate of eyeballs by age and sex, the currency the measurement chapter describes; streaming replaced the estimate with the impression, individually served, individually counted, individually priced, and the thirty-second ingot dissolved into a programmatic market that runs behind the home screen. What has not changed since Bulova's nine dollars is the underlying trade, which this book keeps returning to because the whole signal economy is built on it: somebody pays to borrow the audience's evening, and the audience, given any technology at all, spends the evening trying to leave.

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PART V - THE INDUSTRY TODAY

The Aftermarket: The Rerun as Property

A television programme, properly understood, is not a broadcast but a building: an asset constructed episode by episode, expensively, and then rented out for decades. The industry that rents it out is syndication, the aftermarket where the schedule's used programmes are sold market by market, and it is the reason the economics of the whole medium have always been, at bottom, property economics.

The aftermarket was invented early, by people who understood film libraries better than networks. Ziv Television Programs, already a major radio syndicator, became the first major first-run television syndicator in the 1950s, making series expressly to sell station by station to regional sponsors: The Cisco Kid, Highway Patrol, Sea Hunt.[69] Ziv's defining act of foresight was to shoot The Cisco Kid in colour in the black-and-white era, an extravagance that made no sense on first broadcast and every sense in the aftermarket, where the episodes are still being rented.[69] The networks initially looked down on the trade, then noticed the margins and began syndicating their own reruns in the late 1950s, whereupon first-run syndication shrank for a decade.[69] The pattern holds throughout this book: the incumbent always arrives late to the aftermarket and then owns it.

The rules of the trade hardened into a discipline every producer knew by heart. A series becomes rentable property at about four seasons, the famous threshold of eighty to a hundred episodes, low enough for a station to strip the show five days a week for months without repeating; until that threshold the show is a cost centre, after it an annuity.[69] Hence the industry's defining financial manoeuvre, deficit financing: the production company sells the first run to a network for less than the episodes cost to make, deliberately, because the profit lives in the aftermarket.[69] A cancelled show that dies before the threshold is a write-off; a show that limps across

it is an asset. The deals themselves come in three denominations: cash, the station pays; barter, the syndicator keeps some of the advertising minutes; or both.[69] Until about 1980 the physical trade ran on sixteen-millimetre film prints bicycled between stations, the programme as a can of celluloid with freight charges; videotape and then satellite delivery dematerialised it.[69]

Two quiet consequences deserve marking. First, the aftermarket edits: a network sitcom runs twenty-two minutes, but in syndication it is trimmed to twenty to clear another commercial minute, so the version of a beloved show most people know is a slightly shaved one, cut for rent.[69] Second, the aftermarket proved that repetition builds value rather than burning it. The industry long feared that selling reruns while a show was still in production would kill the original; the experience of Law & Order and its kind showed the opposite, the rerun advertising the first run.[69] That discovery is the seed of the streaming library: the platform era's entire business model, a subscription to the aftermarket with no first-run network in front of it, was latent in syndication all along. Netflix did not invent the idea that old episodes are worth money. It invented charging the viewer directly for what the local station used to sell to the advertiser, one market at a time.

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PART V - THE INDUSTRY TODAY

The Format: Selling the Recipe

The strangest commodity in the television trade weighs nothing at all. A format is a programme stripped to its recipe: the rules, the beats, the set's geometry, the catchphrases, the lighting cues, bound in a production bible and licensed to a broadcaster in another country, who then cooks the dish again with local contestants, local hosts, local commercials. The recipe is copyright; the cooking is local; and the result is the closest thing the industry has to a global factory system.

The economics explain themselves in a single word: risk. A commissioned programme is a bet; a licensed format is a bet that has already won somewhere else. Broadcasters pay for the de-risking, and audiences reward the localisation, preferring, with remarkable consistency, the same show with their own accents in it.[70] The genres that travel are the ones built on procedure rather than dialogue: game shows and reality competitions, where the rules are the programme. Who Wants to Be a Millionaire? has been recreated in 108 territories; the Idol singing-competition format has run to more than 129 series in 42 territories, accumulating, by the format owners' count, some three billion viewer votes.[70] A handful of firms, Warner Bros. International Television Production, ITV Studios, Talpa, Endemol Shine, Fremantle,

industrialised the trade, maintaining catalogues of recipes the way patent pools maintain inventions.[70]

The format is the final dematerialisation of the product this book has tracked from the beginning. The tube-era trade shipped film cans; the satellite era beamed finished programmes; the format era ships nothing but instructions. What crosses borders now is not a recording but a method, quality-controlled, brand-managed, engineered to be rebuilt anywhere there is a studio, a host and a phone vote. And it carries one lesson straight back to the manufacturing chapters: in every layer of this industry, value migrates to whatever is hardest to copy. The set became a commodity and the value went to the fab; the programme became a commodity and the value went to the schedule's owners; the finished show became a commodity and the value went to the recipe. The television business keeps turning its products into processes, and the format, television as a repeatable industrial design, is the purest case of all.

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PART V - THE INDUSTRY TODAY

The Second Voice: The Dubbing Trade

A television programme crossing a border meets a decision that splits the viewing world in two: subtitles or a new voice. The countries that chose the new voice built an invisible industry inside the visible one, studios of anonymous actors who spend their careers being other people, and its history shows better than any other trade in this book that what looks like a technical choice is usually a political one.

The dub was born of dictatorship as much as of craft. In Fascist Italy and Francoist Spain, re-voicing foreign film was a censorship instrument and a language policy: the imported picture could be scrubbed of inconvenient references and made to speak the standard national tongue over the heads of the dialects.[73] Post-war Germany inherited the machinery and used it, among other things, to edit the recent past: Hitchcock's Notorious reached German screens with its Nazi plot converted into a drug-smuggling ring.[73] The technology of the trade was brutal hand-work: actors performing against short loops of film, cut and spliced scene by scene, until videotape and then digital workstations turned "looping" into automated dialogue replacement.[73] The artists stayed famously invisible, uncredited or pseudonymous, a whole profession of ghosts; Iran's "golden age of dubbing" in the 1960s and 1970s, when American, European and Indian films poured in and the voice actors became national figures in all but name, showed how high the craft could rise when a market lived on imports.[73]

The economics were always volume economics: dubbing pays when the audience is large enough and allergic enough to subtitles, which is why the dubbing map tracks market size and habit more than geography, and why children's television is dubbed everywhere, the one audience that cannot be asked to read. The streaming platforms, needing every catalogue title to play in every territory, turned the trickle into a flood, and then, inevitably, reached for the machine: Amazon tested AI-generated dubs in March 2025, to criticism of their quality and their threat to the profession, and YouTube opened automatic multi-language dubbing to creators in September 2025.[73] The newest frontier is not the voice but the face: "visual dubbing" systems adjust the actor's lip movements on screen to fit the new language, a practice the 2023 SAG-AFTRA contract already contemplates, provided a human still performs the voice.[73] The second voice, in other words, is becoming a second face. The industry that began by hiding its ghosts is ending by automating them, and the programme that crosses a border in 2030 may arrive speaking the local language with the local mouth shapes and no human in the chain at all, the final dematerialisation of a trade built, from the start, on pretending to be somebody else.

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PART V - THE INDUSTRY TODAY

The Rulebook's Teeth: Fin-Syn and the Unbundled Networks

For two decades the American networks were forbidden, by regulation, from owning the programmes they broadcast. The Financial Interest and Syndication Rules, imposed by the FCC in 1970, are the great forgotten fork in television's industrial history: they created the modern independent studio system by fiat, and their repeal, in 1993, set the industry on the road that ends at the vertically integrated streamer.

The rules' logic was antitrust in its purest form. Three networks controlled what America watched in prime time; left alone, the Commission reasoned, they would come to own what they aired, and the programme market would shrink to three buyers selling to themselves. Fin-syn barred the networks from holding financial interests in prime-time programming and from the syndication aftermarket outright.[75] The surgery was immediate and, in hindsight, historic: the networks' syndication arms were amputated and set loose. CBS's became Viacom in 1971, a divestiture that grew into a media empire larger than the parent that shed it; ABC's was sold to its own executives in 1973 and renamed Worldvision; NBC's went to National Telefilm Associates the same year for seven and a half million dollars, a price that tells you how little the sellers understood what they were giving up.[75]

The numbers record the experiment with unusual cleanliness. In the 1987-88 season, of sixty-six prime-time shows on the three networks, not one was network-produced; by 1992-93 the figure had crept to six of sixty-seven. The rules were repealed in 1993, and the very next season the count jumped to eleven; by 2001-02 it stood at twenty.[75] The vertical integration the rule had banned returned in a decade, and this time nobody stopped it: studios bought networks, networks became studios, and the logic ran to its conclusion in the streaming era, where the platform, the studio, the network and the syndication library are one company with one balance sheet. Netflix owning its originals outright is not a break with television history. It is fin-syn's repeal arriving at its final address.

The lesson the rules leave behind is the one this book keeps meeting at every layer: structure is destiny. An industry's output is set by who is allowed to own what, and the twenty-three-year experiment in forced separation produced the most competitive programme market American television ever had, a golden age of independent production that ended, as the rules did, by a regulator's vote. The repeal's defenders argued the networks needed to own content to survive cable; the consequence they did not advertise is that ownership, once permitted, becomes compulsory, and the independent producer, the creature fin-syn had made, began the long slide toward today's arrangement, where the buyer, the seller, the pipe and the shelf are the same entity wearing different hats.

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PART V - THE INDUSTRY TODAY

The Webbing: Chain Broadcasting and the Affiliate Compact

The American network was a machine for sharing one evening among two hundred stations that it did not own. Its core institution was the affiliate compact: an independently owned local station signed a franchise contract to carry the network's feed, and in return received the programmes it could never have afforded to make. The network got national reach; the station got prime time; and the arrangement, not any tower, was the real meaning of the word network.

The compact was assembled in stages. In the 1940s they called it chain broadcasting, because the stations were literally linked in chains along the East Coast; in January 1949 DuMont's WDTV in Pittsburgh joined the Midwestern and Eastern chains by coaxial cable, and by 1951 the four networks reached coast to coast on the Long Lines microwave relays of an earlier chapter.[83] In those years the network supplied only a few hours a week, mostly between eight and eleven in the Eastern evening, and the

local station produced nearly everything else itself. As the networks' hours grew, the FCC grew anxious that local television would disappear, and answered with the Prime Time Access Rule, which capped the network evening; the stations, unwilling to bear the cost of making their own programmes, bought them instead from independent producers, and so the regulator's defence of localism became one of the foundations of the syndication market described earlier in this part.[83]

The bargain was policed at both ends. FCC ownership limits kept most stations independent of the networks they carried, with owned-and-operated stations only in the largest cities; in the earliest days, when a market had only one or two stations, a single station might affiliate with several networks and pick the best of each schedule, a promiscuity that ended as more licences were granted and exclusive affiliation became the norm.[83] The station kept its own voice at the edges: local commercials inserted into network breaks, the station identification flashed in the first seconds back from a break, the right to break away entirely for local emergency or news.[83] The result was a genuinely hybrid creature, a national culture delivered through local businesses, and the tensions inside it, over money, over hours, over who owned the audience, structure the rest of television's industrial history, from the rise of the fourth network to the day the feed began to bypass the station altogether.

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PART V - THE INDUSTRY TODAY

The Fourth Leg: Fox and the New Networks

For thirty years the lesson of American television was that three networks were a law of nature. DuMont, the fourth leg of the first table, shut down in 1956, and every attempt to replace it failed for three decades.[83] Then, in a single decade, the table gained a fourth leg and very nearly a fifth and sixth, and the way it happened explains both the strength of the network system and the conditions of its decline.

Fox broke the duopoly's successors by buying its way into the furniture. Launched on 9 October 1986 on the foundation of the Metromedia station group, it began with a sliver of programming and grew, by 1994, into the recognized fourth major network.[83] Its method was the affiliate compact run in reverse: where the first networks had built programmes and then found stations, Fox's parent started with stations and built programmes to fill them. The pattern repeated, faster and thinner. In one week of January 1995 two more networks launched, Time Warner and Tribune's WB and the Chris-Craft-Paramount alliance UPN; eleven years later, in September 2006, the two were consolidated into a single schedule as The CW, while the orphaned affiliates regrouped as MyNetworkTV.[83]

Each new network, though, supplied less than the last. The old Big Three had filled prime time, daytime, news and sport; The CW provides just fifteen hours of prime time a week, MyNetworkTV ten, and their affiliates paper over the rest with syndication.[82] The trajectory is the point. A network is, at bottom, a wholesaling arrangement for programmes, and the thinner the wholesale supply grows, the more the system comes to resemble what cable and then streaming would make of it: a brand and a feed, with the stations as optional retailers. The fourth leg held. It was the table itself that was being replaced.

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THE HIDDEN WIRING

Bottlenecks: Indium, Cycles and Standards

Every industry has a public story and a supply story. The public story of television is brands and screen sizes; the supply story is a handful of obscure materials and structures on which the whole edifice stands. Three of them deserve a chapter of their own, because each is a different kind of bottleneck: a metal, a rhythm, and a rulebook.

The metal is indium. Every LCD and every OLED panel conducts electricity to its pixels through a transparent electrode, and for forty years that electrode has been indium tin oxide, ITO, because almost nothing else combines transparency and conductivity as well. Indium is not mined for itself; it falls out of zinc refining as a by-product, a few tens of grams per tonne of ore, which means its supply cannot respond to its demand: when the display industry wants more indium, the world does not get more indium unless it also gets more zinc. A price spike in the mid-2000s, when LCD fabs were multiplying, sent indium from under a hundred dollars a kilogram toward a thousand and briefly made the thin film on the glass one of the most anxiously watched commodities in electronics. The industry answered the way industries do: with thrifting (ITO targets are now mostly recycled in the fab), with recycling of panel scrap, and with research into substitutes, silver nanowires, graphene, conducting polymers, none of which has yet displaced the incumbent. China refines most of the world's indium, as it does for a long list of minor metals, which gives the display map and the metals map the same awkward centre of gravity.[43] The television, emblem of the immaterial age, hangs on a zinc by-product.

The rhythm is the crystal cycle, met earlier in the fab chapter, but worth standing under from the buyer's side. Because a fab costs billions and takes years, the industry's capacity arrives in lumps; because demand grows smoothly, the lumps guarantee alternating glut and shortage. In glut years the panel price falls toward cash cost, set makers enjoy a buyer's market, consumers get bigger screens for less, and panel makers post losses that would bankrupt any normal company; in shortage

years the same panel maker is a prince. Strategists have learned to read, and to game, the cycle: capacity announcements are partly theatre aimed at rivals' boardrooms, and display economists note that historically only about half of announced capacity ever gets built.[34] The cycle's period, roughly three to four years, is set by fab construction time, and it synchronises the whole industry like a heartbeat: capex, prices, profits, bankruptcies and mergers all arrive on the same beat. No other consumer product is made inside a machine this cyclic except memory chips, which is not a coincidence: DRAM and displays are sibling industries, born of the same semiconductor capital logic, and in Korea the same chaebol have run both.

The rulebook is the least material bottleneck and the most consequential. Television is a standardised art. NTSC, PAL and SECAM divided the analogue world into three incompatible colour empires, each with its own frame rates and line counts, so that for half a century a French cassette would not play on an American set; the absurdity was deliberate, at least in part, since each standard carried industrial policy inside it, protecting domestic set makers and national champions.[13] The digital era repeated the pattern with ATSC in North America, DVB in Europe and beyond, ISDB in Japan and Brazil, DTMB in China: four more empires, same logic. Standards decide who collects patent royalties, whose chips ship, whose broadcasters can reach whose screens. HDMI, the connector on the back of every modern set, is a private standard with a per-device royalty; the HEVC video codec that carries much of today's streaming is licensed through patent pools whose disputes have occupied courts on three continents. The battles over 8K, over HDR formats, HDR10, Dolby Vision, HDR10+, over the ATSC 3.0 broadcast upgrade in the United States, are the modern front of the same war: whoever writes the rulebook taxes everyone who plays.[44]

What ties metal, rhythm and rulebook together is that none of them appears in an advertisement. The buyer compares screens; the industry compares indium contracts, fab ramp schedules and patent pools. The visible television business, the league table of brands, is the foam on top of these deeper currents, and the companies that have survived longest, Samsung above all, are the ones that learned to swim in all three at once: commanding materials through vertical integration, riding the crystal cycle with counter-cyclical investment, and sitting at every standards table that matters. The television looks like the simplest object in the house. It is built on some of the most contended ground in the world economy.

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PART V - THE INDUSTRY TODAY

The Ledger: An Industry Counted

Before the future, the ledger. The television industry is one of the most counted in the world, tracked quarterly by Omdia, Counterpoint, AVC Revo, TrendForce

and others, and its numbers repay a close look, because the trackers do not always agree, and the disagreements are themselves information.

Start with the basic quantity: how many televisions the world buys in a year. Two reputable counts of the same year, 2024, differ by tens of millions of sets. Omdia tallied 208.8 million shipments, its first reading above 200 million in years, driven by replacement demand and the big-screen upgrade; Counterpoint's methodology counted about 230 million, up 2 percent on the year.[15][16] The gap comes from definitions, what counts as a television, which sales channels are captured, how commercial displays are treated, and any honest account carries both numbers rather than splitting the difference. The same caution applies to value: market-size estimates for the television business cluster around $90-100 billion a year for the sets themselves, with the forecasters projecting steady growth toward $104 billion by 2028 and beyond, projections to be read as projections.[21][22]

THE INDUSTRY IN FIGURES, MID-2020S

Measure	Figure	Source
Global TV shipments, 2024	208.8M units (Omdia); ~230M (Counterpoint)	[15][16]
Samsung revenue share, 2024	28.3%, 19th consecutive year at #1	[15]
China brands' unit share, 2024	~31.3% vs Korea's ~28.4%	[17]
TV display panel shipments, 2025	~257.8M units (+2.9%)	[18]
Panel share, 2025	BOE ~26%, CSOT ~22%, HKC and Innolux ~15% each; mainland China ~69%	[18][19]
Global TV/video advertising, 2024	~$339bn total; digital video ~$191bn	[40]
Set market value	~$91bn (2024), forecasts to ~$104bn by 2028	[21][22]
Households with a TV, world, 2013	~79% of all households	[7]

Three patterns stand out from the table. The first is saturation at the top and churn beneath: in the rich world nearly every household has had a television for generations, the United States passed nine in ten households by 1960, so the market there is replacement and upgrade, bigger screens, better panels, which is why the industry's growth metrics are inches and resolution rather than units.[24] The second is the geographic handover: unit leadership has moved from America to Japan to Korea to China in fifty years, each transition following the underlying display technology, and the revenue leadership is following more slowly behind, Samsung's 28.3 percent and LG's 16.1 percent of 2024 revenue still tower over TCL's 12.4 and Hisense's 10.5.[17] The third is the divergence of volume and value: the brand that sells the most sets and the company that earns the most money are no longer

automatically the same, because the profit has migrated to premium panels and to the platform layer the last chapter described.

The premium shelf tells the sharpest story of the mid-2020s. Counterpoint reckoned the premium segment of the market, the large, bright, expensively engineered sets, grew 51 percent year on year in the fourth quarter of 2024, even as the overall market crept forward by 2 percent; the industry's growth is concentrated exactly where the margin is.[16] That is why every brand war in this Part is fought at 65 inches and above, why Samsung's two decades at the top of the table rest on never missing a transition, and why the Chinese challengers' route to the championship runs through mini-LED flagships and hundred-inch screens rather than another percentage point of cheap volume. The ledger, read carefully, is the strategy section of this book with the nouns changed to numbers.

And one number stands apart from the trackers' quarterly precision, because it is the industry's true denominator: by 2013, about 79 percent of the world's households had a television.[7] No machine for communication has ever spread so thoroughly, not the telephone, not the radio it displaced, and only the mobile phone, which spread faster still, rivals it. The remaining fifth of humanity is mostly poor, rural or off-grid, which is to say the television's expansion problem is now the same as electricity's. When this book began, the television was a laboratory curiosity that its own inventors' associates struggled to explain. It became the most common window on Earth.

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PART V - THE INDUSTRY TODAY

The Set in the World

The league tables of Part V are written from the rich world's vantage, but most of the world's televisions, and nearly all of its remaining growth, live elsewhere. The industry the trackers count is the industry of replacement: bigger, brighter, smarter. The other industry, of first sets, second-hand sets and shared sets, is larger in human terms and almost invisible in the data. Both are the television.

The map of the last unconnected fifth of humanity is, to a close approximation, the map of electricity. By 2013, 79 percent of the world's households had a set; the remainder are mostly rural, poor or off-grid, which is why the television's expansion problem and the grid's expansion problem are the same problem.[7] Where the grid is weak, the set adapts: small, efficient panels run off batteries and solar controllers, and the broadcast infrastructure adapts with it. India's Doordarshan runs DD Free Dish, dozens of free channels from a single satellite, as deliberate infill for the places terrestrial towers do not reach; across much of Africa and South Asia, the dish and

the shared set in a public room remain how the medium arrives.[56] The world's digital transition, when it came, was negotiated as a treaty rather than launched as a product: the 2006 Geneva agreement set 17 June 2015 as the effective international analogue switch-off date, and the world sorted itself into four digital empires, DVB across Europe, Africa and Oceania, ATSC in North America and Korea, DTMB in China, ISDB in Japan and most of South America.[49] Digital's quiet gift to the poor country was power: digital signals need less transmission power for the same coverage, and a small set with a decoder sips where the tube drank.[49]

Between the rich industry's front door and its back gate runs a grey river: the trade in used sets. The rich world replaces a working television on the upgrade escalator; the set, too cheap to recycle properly and too valuable to scrap, is exported, officially as "second-hand goods", and flows toward the markets where a ten-year-old flat screen is still a family's first. The Basel Convention's assessors traced the river to Ghana in 2011 and found the delta at places like Agbogbloshie in Accra, where imported electronics, the world's discarded windows, are broken and burned for copper, and where the soil studies read like a table of contents of the industry's material history: lead, cadmium, dioxins.[35][36] The set in the world ends where this book's material story began, in elements and energy, except that the furnace at the end of the chain is an open fire.

The two industries are converging, from opposite directions. The rich world's market is a replacement treadmill whose growth is measured in inches; the poor world's is an adoption curve still working through its steep section, served by Chinese brands and Chinese panels at prices the old champions cannot touch, the same volume-first strategy that built Japan's and Korea's champions now running one rung further down the income ladder.[17] And above both, the phone: for the next billion viewers, the first television is already a handset, the set a second purchase, maybe. Whether the box in the corner survives the century as furniture is a question the next Part takes up; but as a window, the television's colonisation of the world is effectively complete. The industry that began with a handful of "lookers-in" at 30 lines now touches nearly every household on Earth, and its frontier is no longer a technology but a wall socket.

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PART V - THE INDUSTRY TODAY

The Price of a Window

There is no better single series in consumer electronics than the price of a television over time. It is the industry's whole argument in one curve: every generation of the window arrives as a luxury object priced like a car, and is

ground down by the learning curve into an appliance priced like a chair. The modern market, two hundred million sets a year, is what the bottom of that curve looks like.

Start at the top of the curve, where every new display begins. When the first NTSC colour sets reached American dealers in the spring of 1954, Admiral's prototype was priced at $1,175 and Westinghouse's first model at $1,295, roughly $14,000 and $15,500 in today's money; the Westinghouse sold thirty sets in its first month. A decade later, in 1964, only 3.1 percent of American television households had colour.[8] The first commercially available flat-panel television, the 42-inch Fujitsu-panel Philips plasma of 1997, went on sale at four Sears stores for $14,999, installation included; by 2000 the price had "fallen" to $10,000.[9] The pattern repeats so faithfully it might be a law: the first unit of any new window costs as much as a new car, because it nearly costs its maker that much to build.

The grind down is the fab doing its work. Panel prices fall not smoothly but in steps, each step a new factory generation coming online: when BOE's first Gen 10.5 fab ramped in the spring of 2018, 65-inch panel prices fell 14 to 16 percent in a single quarter and small sizes fell harder, and the floor under 65-inch sets has been collapsing ever since.[32] The result, by the mid-2020s, is the strangest price structure the appliance business has ever produced: a 55-inch 4K television, an object of eight million addressable shutters on metre-class glass, retails for less than the cabinet a 1955 console came in; the industry ships about 209 million sets a year and the volume tier of the market earns margins a grocer would recognise.[15] Money in television was never really in the glass; it was in being early to the glass. Which is why the premium segment, OLED, mini-LED, giant screens, the top of the curve where the next window is being born, grew 38 percent in a year the commodity tier barely grew at all: the industry's profit pools migrate up the curve exactly as fast as the fabs push the bottom of it down.[16]

The bottom of the curve has its own ritual, and it is the loudest day in American retail. The doorbuster television, a big set priced below cost to open the Black Friday flood, became the appliance industry's annual theatre of deflation: contract makers like Funai turned out more than two million flat panels a year expressly for Walmart's and Sam's Club's Black Friday events, sets built to a price point announced months in advance, the learning curve packaged as a queue in a car park.[64] A technology that began the century's retail history as a dealer-installed luxury, sold from a showroom by a man who climbed on your roof, ends it as bait: the cheapest thing in the shop that can still fill a trolley, the anchor tenant of the discount season.

Two footnotes keep the story honest. First, the curve was not always left to itself: in 2012 the European Commission fined Samsung SDI and several other majors for fixing the prices of cathode-ray tubes, with similar cases later in the US and Canada, a reminder that even the learning curve has been nudged by cartels at the margin.[6] Second, the buyer's total price was never the sticker: the American colour adopter of 1954 paid $1,295 for the set and then waited a decade for enough colour programming to fill it; the plasma pioneer of 1997 paid $14,999 for a panel whose

tuner, mounting and power draw cost extra. The industry's true product is the watched hour, and the watched hour has never stopped getting cheaper. That is the deepest reason the window won: no other hour of manufactured experience, cinema, concert, sport, print, has been deflated anything like as hard. The television did not out-argue its rivals for the evening. It out-manufactured them.

The Box on the Box: The Set-Top as Tollbooth

The most fought-over object in the television economy is a small appliance that most owners never chose: the set-top box. Its job description is translation, taking a signal the set cannot use, a scrambled premium channel, a digital stream, a satellite feed, and turning it into a picture. But because it sits between the distributor and the viewer, everyone in the industry has wanted to own it. The box is a tollbooth, and the history of television's plumbing is a history of quarrels over who collects.

The species is older than cable. Before the All-Channel Receiver Act of 1962 obliged American sets to tune UHF, a converter box did it for them; when cable systems outgrew the VHF dial, the cable converter arrived, and with premium channels came the descrambler, the box as gatekeeper of what a household had paid for.[85] Each new layer of distribution added its own translator: the digital-terrestrial box that kept analogue sets alive through the American switch-off of 2009, the satellite receiver, the IPTV box, the streaming stick.[85] In the professional wing the same device is rack-mounted and renamed the integrated receiver-decoder, the IRD.[85]

The tollbooth's economics explain the regulation. Renting the box monthly, operators turned a ten-dollar appliance into one of the great annuity streams in consumer electronics, and in July 2007 the American regulator ruled that subscribers must be able to buy their box from a third party rather than rent the operator's.[85] The quarrel never ended; it migrated. Today's hybrid boxes merge broadcast, broadband and apps under standards like HbbTV, and the tollbooth function is dissolving into software, the smart-TV platform and the streaming stick.[85] What remains constant is the strategic value of the last socket before the glass. The screen chapters of this book describe who makes the window; the set-top story is about who owns the sill.

The Time Shifter: The DVR and the Unscheduled Audience

The videocassette let viewers keep programmes; the digital video recorder let them ignore the schedule entirely. By recording to a hard disk what the aerial or cable delivered, the DVR made pausing live television, chasing a recording still being made, and skipping the advertisements that paid for everything into living-room reflexes, and in doing so it attacked the two pillars of the broadcast economy: the schedule and the spot.

The device descended from professional iron. Sony's DVR-1000 of 1987 was a digital tape machine for studios; Tektronix's Profile PDR100 of 1995 replaced the tape with a hard disk, won an engineering Emmy, and worked the 1996 Atlanta Olympics for NBC; a Stanford prototype in 1998 sketched the consumer version.[87] The market opened at the Consumer Electronics Show in January 1999, where two boxes debuted at once: ReplayTV, which took the best-of-show award with Netscape's Marc Andreessen on its board, and TiVo, which shipped its first units that March and whose name became the verb.[87] Take-up was slow at first, fewer than a hundred thousand American homes by the end of 1999, but the direction was set.[87]

The industry answered in court and then by absorption. Suits from the networks stripped ReplayTV of its automatic commercial-skip and sharing features, and as late as 2012 Fox was suing Dish over the ad-skipping Hopper.[87] Meanwhile the cable and satellite operators simply built recording into their own set-top boxes, and the standalone DVR faded into a feature.[87] That absorption is the chapter's lesson. Time-shifting did not destroy the television business; it forced the business to swallow the technology and grow around it, first as the operator DVR, then as the catch-up service, finally as the streaming library, where nothing is scheduled because everything is stored. The viewer who once programmed a VCR clock now presumes the whole archive is on call. The schedule, the skeleton of the broadcast century, became a suggestion, and the audience economy of the meter chapters had to learn to count viewers who no longer watch when they are told.

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PART V - THE INDUSTRY TODAY

The Jukebox Channel: MTV and the Formatting of Youth

At one minute past midnight on 1 August 1981, a Warner-Amex cable channel opened with footage of the moon landing and a three-minute film clip by a one-hit band: "Video Killed the Radio Star" by the Buggles. MTV's wager was that the promotional clips record companies gave away free could themselves be the programming, and that a channel aimed at teenagers could be sold to advertisers as a demographic machine.[89]

The business model was a swap no broadcaster had tried at scale: the labels supplied the product, the channel supplied the shelf, and both sides sold records and attention respectively. When cable operators balked at carrying it, George Lois's 1982 "I Want My MTV!" campaign had rock stars demanding the channel by name, an early demonstration that a brand could be marketed over the head of the distributor to the customer.[89] The channel's rock-format gatekeeping, which refused videos like Rick James's "Super Freak" as outside the format, broke open under the commercial force of Michael Jackson's clips, and the jukebox learned to cross formats.[89] Imitators multiplied, HBO's Video Jukebox, WTBS's Night Tracks, NBC's Friday Night Videos, and Ted Turner's Cable Music Channel, which lasted a money-losing month in 1984 before Turner sold it to MTV itself.[89]

MTV's deeper legacy is what it taught the industry. It proved that programming could be built from material its subjects paid to have aired, that a channel could be a lifestyle rather than a schedule, Spring Break broadcasts from 1986 turned the network into an event brand, and that youth was a sellable inventory in itself.[89] When the music video later migrated to the internet, the channel became a reality and scripted programmer, which is why the next chapter's genre grew up in this one's house. The jukebox channel was the template for every niche network that followed: find an audience the broadcasters treat as a by-product, and make it the product.

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PART V - THE INDUSTRY TODAY

The Unscripted Turn: Reality and the Price of People

The cheapest hour of television ever devised turned out to be other people's lives. Reality television is an industrial solution disguised as a genre: when writers and actors cost too much, cast the audience itself, point the cameras, and let the editing suite manufacture the drama.

The raw material is as old as the medium. Candid Camera was staging encounters for hidden lenses from 1948; Granada's Seven Up! in 1964 began filming fourteen children every seven years, a documentary experiment, still running under Michael Apted's succession, that turned ordinary people into lifelong public figures; and in

1973 PBS's twelve-part An American Family let cameras record the Loud household until the marriage collapsed on film, the moment the genre's bargain, access in exchange for exposure, first showed its teeth.[90] The modern format was assembled in the Netherlands in 1991, where Nummer 28 put strangers in a house, gave them soundtrack music and after-the-fact confessionals, and invented the grammar every successor uses; a year later MTV's The Real World carried the formula to cable.[90] The critic Charlie Brooker has argued the enabler was technological: computer-based non-linear editing, arriving with Avid in 1989, made it cheap to cut hundreds of hours of footage into a story, where film had been ruinously expensive.[90]

Then came the globalization of the format trade described earlier in this part. Big Brother has been produced in around fifty national versions; Survivor turned the elimination ritual into prime-time infrastructure; and by the mid-2010s even the flow of ideas had reversed, with Korean reality formats such as Grandpas Over Flowers adapted by NBC.[90] The unscripted turn is the audience economy's logical endpoint: after the meter chapters taught the industry to count viewers and the advertising chapters taught it to sell them, reality taught it to cast them. The viewer had always been the product; now the viewer was the programme as well.

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PART V - THE INDUSTRY TODAY

The Store in the Screen: Home Shopping and the Transactional Channel

Every channel in this book sells something, but only one kind sells directly through the glass. The shopping channel abolished the distinction between programme and advertisement: the show is the pitch, the pitch is live, and the telephone number on the screen is the business model, a television station that is also a department store.

The format was popularized in the United States in the 1980s, when Lowell "Bud" Paxson and Roy Speer turned a local cable operation, the Home Shopping Club, into a national service, and it acquired its durable rival in QVC; decades later the two merged, QVC agreeing to buy the Home Shopping Network in 2017.[91] The mechanics inverted broadcasting economics. A conventional channel sells its audience to advertisers; a shopping channel keeps the whole transaction, presentation, demonstration, order desk and margin, under one roof, with the telephone initially doing the closing and, later, the website.[91] The form travelled: QVC UK in Europe, Momo in Taiwan, TSC in Canada, teleshopping blocks on channels across the world.[91]

The shopping channel matters to this book's argument because it was a preview. It showed that a television stream could carry a complete commercial loop inside itself, attention to transaction without an intermediary, decades before the internet made that loop the default ambition of every platform. The smart-TV storefronts and shoppable streams of the final chapters are its heirs, and its live demonstrator, talking to the camera as the clock counts down, is the direct ancestor of the livestream seller. Television began as a window; the shopping channel made it a till.

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PART V - THE INDUSTRY TODAY

The Brand in the Story: Product Placement and the Unskippable Ad

There is one advertisement the DVR cannot skip, because it is inside the programme. Product placement, the compensated weaving of a brand into a story itself, is the advertising industry's answer to every technology in this book that taught viewers to avoid the commercial break, and it is older than the break it replaces.

The trade predates television by half a century. By 1873 shipping and transport companies were lobbying to be mentioned in Jules Verne's Around the World in Eighty Days; by 1896, on the research of Jean-Marc Lehu, the Lumière brothers were making films at the request of a Lever Brothers representative, with Sunlight soap in the frame, product placement is nearly as old as the moving picture itself.[92] The categories settled early: automobiles and consumer electronics, expensive objects that stories use and audiences covet, and the vertically integrated studios eventually joined in, a conglomerate's films pointedly using its own electronics division's gadgets.[92]

Television made the practice an industry and then a necessity. As the previous chapters' machines arrived, the remote, the VCR, above all the DVR, each one weakened the spot break, and each time, the money moved into the programme: the twenty-first century saw placement on television grow precisely to counter ad-skipping recorders.[92] The logic completes this part's arc. The meter chapters counted the audience; the spot chapters priced it; the time-shifter chapters let it escape; and placement followed it into the story, the last place attention could be sold without asking permission to interrupt. The streaming services that closed the loop with ad-free subscriptions merely restarted the cycle: the brand in the story is the form of advertising that survives every escape technology, because leaving it would mean leaving the programme itself.

PART VI

What Comes Next

The screen after the screen.



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The Future of the Television

Forecasting is the cheapest commodity in the technology business, and the television has buried more confident predictions than most, 3D television, curved screens, and the annual declaration that broadcast is dead among them. So this chapter deals in directions, not dates. Four of them seem solidly grounded in the physics and the factories, and the fifth is the honest admission that the most important change may not be in the set at all.

The first direction is resolution and size, the industry's oldest escalator. 8K sets exist and remain a niche, starved less by panel capability than by content and by the eye's

diminishing returns at normal viewing distances; the meaningful mass-market shift of the mid-2020s is not 8K but the collapse of the 65-inch and 75-inch price floor as Gen 10.5 glass floods the market, with 98- and 100-inch panels, exotic in 2020, reaching about 1.9 million units in 2025, up 47 percent in a single year.[19] Bigger remains the industry's most reliable verb, and the escalator's motor is the fab generation, exactly as Chapter 13 described.

The second is form. The rollable OLED proved a screen can vanish into furniture, even if the market declined to pay $100,000 for the trick.[39] Transparent displays, projection and ambient modes all push the same way: the television stops being a black rectangle dominating a wall and becomes a surface that appears when wanted. MicroLED, if its assembly economics are ever tamed, would accelerate this, since a modular emissive wall can be any size or shape at all.[38] The endgame of a century of display physics may be a television that is, when off, not visibly there.

The third is the signal. In the United States, the broadcast standard itself is being rebuilt: ATSC 3.0, "NextGen TV", an IP-based, addressable, 4K-capable over-the-air system, reached about 76 percent of American television households by late 2024, won a permissive-use order from the FCC in late 2025, and was adopted by Brazil in 2025 as the basis of its DTV+ system, with Jamaica and Trinidad and Tobago also on air.[44] Broadcast, the original pipe, is merging with the internet rather than dying. The set-top war and the spectrum war have quietly become the same war.

The fourth is intelligence, and it is the one where humility is most required. Sets now ship with processors marketed as AI: they upscale, they recognise scenes, they adjust picture and sound by content, and the remote microphone listens. The plausible near future is not a smarter screen but a more mediated one, an agent between the household and the flood of content, choosing, summarising, even generating. Whether that is still a television is a fair question, and a good place to stop.

What seems certain is the shape of the industry's gravity. Display manufacturing will keep migrating to whoever builds the biggest fabs, and that is currently China; premium differentiation will keep migrating to whoever owns new device physics, and that is currently Korea, with China's fabs closing; and the money will keep migrating to whoever owns the relationship with the viewer, which is increasingly the platform, not the broadcaster and not the brand. The television has been declared finished many times, by radio's defenders, by cable, by the internet, by the phone. Each time it absorbed the challenger and grew a new business around the absorption. A century after Baird's mannequin, the box in the corner is still there, thinner, brighter, and listening. It would be a brave forecaster who bet against its next century.

The Second Screen

The strangest thing to happen to the television in the 2010s was not a new display technology but a rival in the same room: the phone. The industry discovered, sometime around the middle of that decade, that the family gathered around the set was each also holding a smaller window, and that the second screen was not complementary. It was competitive.

The set's industry responded the way it always does, by absorbing the challenger. Smart televisions added second-screen companion features, apps that put programme guides, remote control and social chatter onto the phone in the viewer's hand, and the platforms built casting protocols so the small screen could throw its picture onto the big one.[53] The logic was the VCR's logic and cable's logic: if the audience is going somewhere, meet it there. And the audience was unmistakably going somewhere. By the time streaming passed the combined total of broadcast and cable viewing in the United States in May 2025, 44.8 percent against 44.2, a large and growing share of that streaming never touched a television set at all: it went to phones, tablets and laptops, devices this book has deliberately not counted as televisions, though their owners use them for exactly the hours the television used to own.[42]

The honest way to frame the rivalry is by job, not by device. The television set remains unbeatable at the shared, leaned-back, big-picture job: the match, the movie night, the ceremony, the game on the big wall. It has lost the solitary, distracted, kill-ten-minutes job almost completely. Between those poles lies the contested middle, the evening drama, the news, the long video, and there the screens split the household by age and habit more than by technology. The industry's numbers reflect the split: the set is in 79 percent of the world's households and effectively saturated in the rich ones, so its unit market is replacement, and the industry's growth segments, premium sets and giant screens on one side, services and platforms on the other, both assume the phone is in the room.[7][16]

What the second screen really changed is the direction of attention's price. The tube era sold one audience watching one thing; the platform era sells each viewer separately, and the phone, logged-in, personal and always present, is a far better meter and cash register than the family set ever was. That is why every serious television platform is now also a phone app and every serious phone video service also ships a television app: the two screens have stopped competing for the industry and started jointly enclosing the viewer. The set's future, on the evidence, is not replacement but specialisation. It becomes the household's ceremonial screen, the biggest and best window, reserved for the hours worth watching together, while the phone absorbs the rest of the waking day. Whether that is a dignified retirement or a slow demotion depends on how many hours remain worth watching together. The events chapter's answer, the Super Bowl's 127.7 million, suggests the ceremonial screen is not done yet.[52]

The Ambient Screen: Television Leaves the House

The fastest-growing television audience of the twenty-first century never sits down. It passes through airports, waits in checkout lines, pumps fuel, rides lifts, and glances, for seconds at a time, at the screens that have colonised every surface where strangers wait. The industry calls the business digital signage, and its advertising arm digital out-of-home, and together they are what happened when the panel got cheap enough to wallpaper the world.

The economics are the panel's economics, read outdoors. A display that costs what a television costs and draws what a light fitting draws can be justified anywhere a poster used to be, and so the poster died, replaced by a networked screen that can change its mind. The systems come in two breeds: standalone players fed from a USB stick, the electronic version of the billboard crew, and networked estates run from cloud content-management systems that schedule, update and monitor thousands of screens from one desk.[62] The hardware will be familiar to every reader of this book: the same LCD, LED and OLED panels, the same system-on-chip players, increasingly running the same operating systems as the living-room set, Android, Tizen, webOS, Roku OS, because a sign is, electronically, a television with the tuner removed and the brightness turned up.[62]

Out-of-home screens learned the streaming era's trick faster than the living room did. Because the audience cannot be logged in, the sign watches back: cameras in the bezels count viewers, estimate age and gender, measure dwell time and attention, and feed the numbers to the same advertising economy that pays for everything else in this book, with the industry promising, as industries do, that the data is anonymised.[62] Context-awareness is the sales pitch: the screen that shows umbrellas when it rains, dinner menus at dusk, evacuation routes when it matters, the display as a civic utility one firmware update away from an advertisement.[62] The cleverest screens in the world are not in homes. They are in the places where a captive audience of strangers can be measured without being asked.

The signage business matters to the television industry for a structural reason: it is the display's second engine. Every advance in this book, brightness, thinness, efficiency, pixel density, arrived first or fastest where a screen earns money per hour rather than per household, and the commercial panel lines, video walls, stadium boards, kiosks, menu displays, soak up fab capacity that cushions the crystal cycle when living rooms stop upgrading.[62] The great public screens are the visible tip: Times Square's canyons of animated glass, the stadium halo boards, the departure hall walls, each one a direct descendant of the tube era's dream of the wall-sized window, achieved at last and sold by the second. The television began as a piece of

furniture and then became an appliance, a platform and a pane of glass. Its final form may be the environment itself: the screen as wallpaper, everywhere, always on, watched by nobody in particular and counted by everything.

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PART VI - WHAT COMES NEXT

The Emissive Pixel: OLED and the Screen That Is the Lamp

Every display this book has described so far is, in one way or another, a valve: the tube paints light, the liquid crystal shutters someone else's backlight. OLED closes the century's loop by abolishing the distinction. In an organic light-emitting diode the pixel is the lamp: a film of organic compound between two electrodes that emits light where current passes, no backlight, no shutter, the picture and the light source at last the same object.[37]

The device was born, fittingly, in a photography company that was running out of photography. In 1987 two Kodak chemists, Ching Wan Tang and Steven Van Slyke, built the first practical OLED, a two-layer sandwich whose separated charge-transport layers cut the operating voltage and made efficiency respectable; the first polymer devices followed at Cambridge with Burroughes' poly(p-phenylene vinylene).[10][37] Commercial life began humbly: a Pioneer car stereo in 1997, small monochrome panels for dashboards and portables, a Kodak digital camera screen in 2003, a Kodak-Sanyo fifteen-inch television prototype shown at CEATEC in 2002.[10] Manufacturing followed the by-now-familiar itinerary of this book: Pioneer first, then TDK, then the Samsung venture that became Samsung Display, with the technology's mass adoption arriving only in the late 2010s, in watches, phones and the top shelf of the television aisle.[10]

The industrial lesson is the same one the plasma and LCD chapters taught, with a new twist. Each generation of display won not by being best but by being manufacturable at scale, and OLED's decades of small-screen apprenticeship are exactly the learning-curve climb that the tube and the liquid crystal made before it. What is new is the philosophical completion: the television set began, in the mechanical era, as a lamp whose light was modulated by a scanning disc, and it has ended, for now, as a sheet of glass in which every point of the picture is its own tiny lamp, individually lit, individually extinguished. The display industry spent a hundred years separating the light from the picture and then perfecting the machinery that joined them again. The emissive pixel is where the tube's ghost finally re-enters the glass.

The Squeeze: How the Codec Remade the Pipe

Television's final industrial revolution did not look like one, because its product is invisible. The video codec, the standardized mathematics that compresses a picture stream to a fraction of its size, decided how much television fits down a wire. Every service of the last thirty years, the DVD, digital broadcasting, satellite HD, YouTube, the streamers, the video call, is an application of one idea: throw away what the eye will not miss.

The lineage is a genealogy of standards committees. The first digital video standard, the CCITT's H.120 of 1984, was too crude to use; H.261 in 1988 made videoconferencing possible; MPEG-1 in 1991 squeezed VHS-quality video onto a CD; MPEG-2 in the mid-1990s carried the DVD and the world's digital broadcast switch.[86] The practical trick beneath them all, motion-compensated discrete cosine transform coding, encodes only what changes between frames, block by block.[86] Then came the two giants: H.264 in 2003, which by the end of the 2010s was the most-used video format on Earth, and HEVC in 2013, built for the ultra-high-definition era.[86] Each generation roughly halves the bits for the same picture, which is to say each generation doubles the television that fits through the same pipe.

The codec is also an industry, and a litigious one. The standards are thickets of patents, pooled and licensed per device, and the fear of submarine patents has repeatedly driven the open internet to commission royalty-free rivals.[86] The politics matter because the mathematics is load-bearing: the streaming economy of this book's later chapters exists only because compression outran bandwidth. The tube got a chapter as the engine of the first television age; the codec is the engine of the last one, a standard with no moving parts that moves more pictures than every transmitter ever built.

The Watching Set: Television as Surveillance

There is a second television industry that this book has deliberately kept at the edge of the frame: the one in which the camera points at us. Closed-circuit television, the transmission of pictures to a limited set of monitors rather than

to the public, is broadcast's dark twin, built from the same tubes, cameras and screens, aimed the other way.

The system's first documented use was military and precise: in 1942 Siemens installed cameras at Test Stand VII in Peenemünde so that engineers could watch V-2 rocket launches from safety, television as a remote eye where a human could not stand.[88] For its first decades the technology had a crippling limit, there was nothing to record with, so surveillance meant a guard watching a wall of monitors in real time; the arrival of the videocassette recorder in the 1970s let the eye remember, and digital multiplexing in the 1990s let one screen hold many cameras.[88] Civic adoption followed: Olean, New York, became the first American city to mount crime-fighting cameras along its main business street in September 1968.[88]

From there the closed circuit became an environment. The same manufacturing learning curves that cheapened the home screen cheapened the watching one, and the deployment of camera networks has driven a documented global growth in state surveillance and social monitoring.[88] The lineage now runs from the Peenemünde test stand to the body-worn police camera.[88] This book has told television's story as a sequence of industries that brought the world into the living room; the watching set is the reminder that every component of that apparatus, the lens, the tube, the panel, the codec, is reversible. The window in the corner of the room looks both ways, and which way it looks is a choice made not by the technology but by the institutions that buy it.

EPILOGUE

The Box in the Corner, Once More

This book opened with an object so ordinary that nobody photographs it: the box in the corner of the room. It closes with the same object, now legible. Behind the evening's viewing stand a century of specific people and specific machines: Nipkow's spinning disc of 1884, Baird's ventilator motor and bicycle lamps, Farnsworth's rows of light in a San Francisco loft, Zworykin's iconoscope and the RCA empire that grew around it; the electron gun and the shadow mask, Trinitron's grille and the transistor's quiet coup; the calculator screen that became the wall, the fabs of Hefei printing glass the size of garage doors; the advertisers, the bundles, the streamers, the platforms. The television is not one invention. It is a stack of them, each layer an industry, each industry a migration of power from one country's factories to another's, and the stack is still growing.

The stack's next layers are already visible, if not yet legible. At one extreme the set is dissolving: the phone in the pocket is now the first screen for much of the world, and the industry that once sold a box per household increasingly sells a window per person. At the other extreme the set is becoming architecture: 98- and 100-inch panels, a niche a few years ago, grew nearly half again in 2025 to almost two million

units,[19] and emissive technologies from OLED to microLED are pushing the screen toward the size of the wall itself. Between the dissolving box and the growing wall, the three stacked industries of this book, the device, the brands, the signal, will keep trading power exactly as they always have: to whoever commands the display technology of the era, and whoever owns the attention it displays. The box in the corner may not survive the century as furniture. The industry that built it is not going anywhere.

That is the pattern this series exists to record. Take one thing the modern world runs on; follow it from the materials up; watch the industries form, fight, migrate and settle. The television's version of the story happens to be unusually complete: it has a birthday, an inventor's quarrel, an eighty-year reign of one technology, a dethroning, a global relay of champions, and an afterlife in the scrapyards of Accra. Few objects summarise the industrial twentieth century so neatly, or preview the twenty-first so clearly. The next time the screen lights up in the corner of the room, it is worth remembering what is actually being switched on: not a gadget, but a geography, a history, and an economy, compressed into a sheet of glass.