Our last episode brought us to the start of the 20th century, where early, special-purpose computing devices, like tabulating machines, were a huge boon to governments and business — aiding, and sometimes replacing, rote manual tasks.
上集讲到 20 世纪初，当时的早期计算设备都针对特定用途，比如制表机大大推进了政府和企业——它们帮助甚至代替了人工。 解析

But the scale of human systems continued to increase at an unprecedented rate.
然而人类社会的规模在以前所未有的速度增长。 解析

The first half of the 20th century saw the world's population almost double.
20 世纪上半叶，世界人口几乎翻倍。 解析

World War I mobilized 70 million people, and World War II involved more than 100 million.
一战动员 7 千万人，二战 1 亿多人。 解析

Global trade and transit networks became interconnected like never before, and the sophistication of our engineering and scientific endeavors reached new heights — we even started to seriously consider visiting other planets.
全球贸易和运输更加紧密，工程和科学的复杂度也达到新高——我们甚至开始考虑登陆其他行星。 解析

And it was this explosion of complexity, bureaucracy, and ultimately data, that drove an increasing need for automation and computation.
复杂度的增高导致数据量暴增，人们需要更多自动化，和更强的计算能力。 解析

Soon those cabinet-sized electro-mechanical computers grew into room-sized behemoths that were expensive to maintain and prone to errors.
很快，柜子大小的计算机变成房间大小，维护费用高，而且容易出错。 解析

And it was these machines that would set the stage for future innovation.
然而，正是这些机器，为未来的创新打下了基础。 解析

One of the largest electro-mechanical computers built was the Harvard Mark I, completed in 1944 by IBM for the Allies during World War 2. It contained 765,000 components, three million connections, and five hundred miles of wire.
最大的机电计算机之一是哈佛马克一号，IBM 在 1944 完成建造，给二战同盟国建造的。它有 76 万 5 千个组件，300 万个连接点和 500 英里长的导线。 解析

To keep its internal mechanics synchronized, it used a 50-foot shaft running right through the machine driven by a five horsepower motor.

为了保持内部机械装置同步，它有一个 50 英尺的传动轴，由一个 5 马力的电机驱动。 解析

One of the earliest uses for this technology was running simulations for the Manhattan Project.
这台机器最早的用途之一是给 “曼哈顿计划” 跑模拟。 解析

The brains of these huge electro-mechanical beasts were relays: electrically-controlled mechanical switches.
这台机器的大脑是继电器，继电器是用电控制的机械开关。 解析

In a relay, there is a control wire that determines whether a circuit is opened or closed.
继电器里，有根控制线路，控制着电路是开还是关。 解析

The control wire connects to a coil of wire inside the relay.
控制线路连着一个线圈。 解析

When current flows through the coil, an electromagnetic field is created, which in turn, attracts a metal arm inside the relay, snapping it shut and completing the circuit.
当电流流过线圈，线圈产生电磁场吸引金属臂，从而闭合电路。 解析

You can think of a relay like a water faucet.
你可以把继电器想成水龙头。 解析

The control wire is like the faucet handle.
把控制线路想成水龙头把。 解析

Open the faucet, and water flows through the pipe.
打开水龙头，水会流出来。 解析

Close the faucet, and the flow of water stops.
关闭水龙头，水就没有了。 解析

Relays are doing the same thing, just with electrons instead of water.
继电器是一样的，只不过控制的是电子，而不是水。 解析

The controlled circuit can then connect to other circuits, or to something like a motor, which might increment a count on a gear, like in Hollerith's tabulating machine we talked about last episode.
这个控制电路可以连到其他电路，比如马达，马达让计数齿轮 +1，就像上集中 Hollerith 的制表机一样。 解析

Unfortunately, the mechanical arm inside of a relay "has mass", and therefore can't move instantly between opened and closed states.
不幸的是，继电器内的机械臂 “有质量”，因此无法快速开关。 解析

A good relay in the 1940s might be able to flick back and forth fifty times in a second.
1940 年代，一个好的继电器 1 秒能翻转 50 次。 解析

That might seem pretty fast, but it's not fast enough to be useful at solving large, complex problems.
看起来好像很快，但还不够快，不足以解决复杂的大问题。 解析

The Harvard Mark I could do 3 additions or subtractions per second; multiplications took 6 seconds, and divisions took 15. And more complex operations, like a trigonometric function, could take over a minute.
哈佛马克一号，1 秒能做 3 次加法或减法运算，一次乘法要花 6 秒，除法要花 15 秒。更复杂的操作，比如三角函数，可能要一分钟以上。 解析

In addition to slow switching speed, another limitation was wear and tear.
除了速度慢，另一个限制是齿轮磨损。 解析

Anything mechanical that moves will wear over time.
任何会动的机械都会随时间磨损。 解析

Some things break entirely, and other things start getting sticky, slow, and just plain unreliable.
有些部件会完全损坏，有些则是变黏，变慢，变得不可靠。 解析

And as the number of relays increases, the probability of a failure increases too.
并且随着继电器数量增加，故障概率也会增加。 解析

The Harvard Mark I had roughly 3500 relays.
哈佛马克一号有大约 3500 个继电器。 解析

Even if you assume a relay has an operational life of 10 years, this would mean you'd have to replace, on average, one faulty relay every day!
哪怕假设继电器的使用寿命是 10 年，也意味着平均每天得换一个故障继电器！ 解析

That's a big problem when you are in the middle of running some important, multi-day calculation.
这个问题很严重，因为有些重要运算要运行好几天。 解析

And that's not all engineers had to contend with.
而且还有更多其他问题要考虑。 解析

These huge, dark, and warm machines also attracted insects.
这些巨大、黑色、温暖的机器也会吸引昆虫。 解析

In September 1947, operators on the Harvard Mark II pulled a dead moth from a malfunctioning relay.
1947 年 9 月，哈佛马克二号的操作员从故障继电器中拔出了一只死虫。 解析

Grace Hopper who we'll talk more about in a later episode noted, "From then on, when anything went wrong with a computer, we said it had bugs in it." And that's where we get the term computer bug.
Grace Hopper（这位我们以后还会提到）曾说从那时起，每当电脑出了问题，我们就说它出了 bug（虫子）。这就是术语 "bug" 的来源。 解析

It was clear that a faster, more reliable alternative to electro-mechanical relays was needed if computing was going to advance further, and fortunately, that alternative already existed!
显然，如果想进一步提高计算能力，我们需要更快更可靠的东西来替代继电器，幸运的是，替代品已经存在了！ 解析

In 1904, English physicist John Ambrose Fleming developed a new electrical component called a thermionic valve, which housed two electrodes inside an airtight glass bulb — this was the first vacuum tube.
在 1904 年，英国物理学家约翰·安布罗斯·弗莱明开发了一种新的电子组件，叫热电子管，把两个电极装在一个气密的玻璃灯泡里——这是世上第一个真空管。 解析

One of the electrodes could be heated, which would cause it to emit electrons — a process called thermionic emission.
其中一个电极可以加热，从而发射电子——这叫热电子发射。 解析

The other electrode could then attract these electrons to create the flow of our electric faucet, but only if it was positively charged — if it had a negative or neutral charge, the electrons would no longer be attracted across the vacuum so no current would flow.
另一个电极会吸引电子，形成 "电龙头" 的电流，但只有带正电才行——如果带负电荷或中性电荷，电子就没办法被吸引越过真空区域，因此没有电流。 解析

An electronic component that permits the one-way flow of current is called a diode, but what was really needed was a switch to help turn this flow on and off.

电流只能单向流动的电子部件叫二极管，但我们需要的是一个能开关电流的东西。 解析

Luckily, shortly after, in 1906, American inventor Lee de Forest added a third "control" electrode that sits between the two electrodes in Fleming's design.

幸运的是，不久之后，在 1906 年，美国发明家李·德富雷斯特在弗莱明设计的两个电极之间，加入了第三个 “控制” 电极。 解析

By applying a positive charge to the control electrode, it would permit the flow of electrons as before.

向控制电极施加正电荷，它会允许电子流动。 解析

But if the control electrode was given a negative charge, it would prevent the flow of electrons.

但如果施加负电荷，它会阻止电子流动。 解析

So by manipulating the control wire, one could open or close the circuit.

因此通过控制线路，可以断开或闭合电路。 解析

It's pretty much the same thing as a relay, but importantly, vacuum tubes have no moving parts.

和继电器的功能一样，但重要的是，真空管内没有会动的组件。 解析

This meant there was less wear, and they could switch thousands of times per second.

这意味着更少的磨损，而且每秒可以开闭数千次。 解析

These triode vacuum tubes would become the basis of radio, long-distance telephone, and many other electronic devices for nearly a half-century.

因此这些三极真空管成为了无线电、长途电话以及其他电子设备的基础，持续了接近半个世纪。 解析

I should note here that vacuum tubes weren't perfect, they're kind of fragile, and can burn out like light bulbs, they were a big improvement over mechanical relays.

我应该提到，真空管不是完美的，它们有点脆弱，并且像灯泡一样会烧坏，但比起机械继电器，是一次巨大进步。 解析

Also, initially, vacuum tubes were expensive — a radio set often used just one, but a computer might require hundreds or thousands of electrical switches.

起初，真空管非常昂贵，收音机一般只用一个，但计算机可能要上百甚至上千个电气开关。 解析

But by the 1940s, their cost and reliability had improved to the point where they became feasible for use in computers...at least by people with deep pockets, like governments.

但到了 1940 年代，它的成本和可靠性得到改进，可以用在计算机里，至少有钱人负担得起，比如政府。 解析

This marked the shift from electro-mechanical computing to electronic computing.

这标志着计算机已从机电转向电子。 解析

Let's go to the Thought Bubble.

我们进入思想泡泡。 解析

The first large-scale use of vacuum tubes for computing was the Colossus MK 1, designed by engineer Tommy Flowers and completed in December of 1943. The Colossus was installed at Bletchley Park, in the UK, and helped to decrypt Nazi communications.

第一个大规模使用真空管的计算机是 “巨人1号”，由工程师 Tommy Flowers 设计，完工于 1943 年 12 月。“巨人” 安装在英国的布莱切利园，用于破解纳粹通信。 解析

This may sound familiar because two years prior, Alan Turing, often called the father of computer science, had created an electromechanical device, also at Bletchley Park, called the Bombe.

听起来可能有点熟，因为 2 年前，阿兰·图灵（经常被称为 “计算机科学之父”）也在布莱切利园做了台机电装置，叫 “Bombe”。 解析

It was an electromechanical machine designed to break Nazi Enigma codes, but the Bombe wasn't technically a computer, and we'll get to Alan Turing's contributions later.

这台机器的设计目的是破解纳粹 “英格码” 通讯加密设备，但 Bombe 严格来说不算计算机，我们之后会讨论阿兰·图灵的贡献。 解析

Anyway, the first version of Colossus contained 1,600 vacuum tubes, and in total, ten Colossi were built to help with code-breaking.

总之，巨人1号有 1600 个真空管，总共造了 10 台巨人计算机，来帮助破解密码。 解析

Colossus is regarded as the first programmable, electronic computer.

“巨人” 被认为是第一个可编程的电子计算机。 解析

Programming was done by plugging hundreds of wires into plugboards, sort of like old school telephone switchboards, in order to set up the computer to perform the right operations.

编程的方法是把几百根电线插入插板，有点像老电话交换机，这是为了让计算机执行正确操作。解析

So while "programmable", it still had to be configured to perform a specific computation.

虽然“可编程”，但还是要配置它。解析

Enter The Electronic Numerical Integrator and Calculator, or ENIAC — completed a few years later in 1946 at the University of Pennsylvania.

几年后，电子数值积分计算机 ENIAC 于 1946 年，在宾夕法尼亚大学完成建造。解析

Designed by John Mauchly and J. Presper Eckert, this was the world's first truly general-purpose, programmable, electronic computer.

设计者是 John Mauchly 和 J. Presper Eckert，这是世上第一个真正的通用可编程电子计算机。解析

ENIAC could perform 5000 ten-digit additions or subtractions per second, many, many times faster than any machine that came before it.

ENIAC 每秒可执行 5000 次十位数加减法，比前辈快了很多倍。解析

It was operational for ten years and is estimated to have done more arithmetic than the entire human race up to that point.

它运作了十年，据估计，它完成的运算比全人类加起来还多。解析

But with that many vacuum tubes failures were common, and ENIAC was generally only operational for about half a day at a time before breaking down.

因为真空管很多，所以故障很常见，ENIAC 运行半天左右就会出一次故障。解析

Thanks, Thought Bubble.

谢了，思想泡泡。

By the 1950s, even vacuum-tube-based computing was reaching its limits.

到 1950 年代，真空管计算机都达到了极限。解析

The US Air Force's AN/FSQ-7 computer, which was completed in 1955, was part of the "SAGE" air defense computer system, which we'll talk more about in a later episode.

美国空军的 AN/FSQ-7 计算机于 1955 年完成，是 SAGE 防空计算机系统的一部分，之后的视频还会提到。解析

To reduce cost and size, as well as improve reliability and speed, a radical new electronic switch would be needed.

为了降低成本和大小，同时提高可靠性和速度，我们需要一种新的电子开关。 解析

In 1947, Bell Laboratory scientists John Bardeen, Walter Brattain, and William Shockley invented the transistor, and with it, a whole new era of computing was born!

1947 年，贝尔实验室科学家 N John Bardeen，Walter Brattain 和 William Shockley 发明了晶体管——一个全新的计算机时代诞生了！ 解析

The physics behind transistors is pretty complex, relying on quantum mechanics, so we're going to stick to the basics.

晶体管的物理学相当复杂，牵扯到量子力学，所以我们只讲基础。 解析

A transistor is just like a relay or vacuum tube — it's a switch that can be opened or closed by applying electrical power via a control wire.

晶体管，就像之前提过的继电器或真空管——它是一个开关，可以用控制线路来控制开或关。 解析

Typically, transistors have two electrodes separated by a material that sometimes can conduct electricity, and other times resist it — a semiconductor.

晶体管有两个电极，电极之间有一种材料隔开它们，这种材料有时候导电有时候不导电——这叫半导体。 解析

In this case, the control wire attaches to a "gate" electrode.

控制线连到一个 “门” 电极。 解析

By changing the electrical charge of the gate, the conductivity of the semiconducting material can be manipulated, allowing current to flow or be stopped — like the water faucet analogy we discussed earlier.

通过改变 “门” 的电荷，我们可以控制半导体材料的导电性，来允许或不允许电流流动，就像之前的水龙头比喻。 解析

Even the very first transistor at Bell Labs showed tremendous promise, it could switch between on and off states 10,000 times per second.

贝尔实验室的第一个晶体管就展示了巨大的潜力，每秒可以开关 10000 次。 解析

Further, unlike vacuum tubes made of glass and with carefully suspended, fragile components, transistors were solid material known as a solid-state component.

而且，比起玻璃制成、小心易碎的真空管，晶体管是固态的。 解析

Almost immediately, transistors could be made smaller than the smallest possible relays or vacuum tubes.

晶体管可以远远小于继电器或真空管。 解析

This led to dramatically smaller and cheaper computers, like the IBM 608, released in 1957 — the first fully transistor-powered, commercially-available computer.

这带来了更小更便宜的计算机，比如 1957 年发布的 IBM 608—— 第一个完全用晶体管，而且消费者也可以买到的计算机。 解析

It contained 3000 transistors and could perform 4,500 additions, or roughly 80 multiplications or divisions, every second.

它有 3000 个晶体管，每秒执行 4500 次加法，每秒能执行 80 次左右的乘除法。 解析

IBM soon transitioned all of its computing products to transistors, bringing transistor-based computers into offices, and eventually, homes.

IBM 很快把所有产品都转向了晶体管，把晶体管计算机带入办公室，最终引入家庭。 解析

Today, computers use transistors that are smaller than 50 nanometers in size, for reference, a sheet of paper is roughly 100,000 nanometers thick.

如今，计算机里的晶体管小于 50 纳米——而一张纸的厚度大概是 10 万纳米。 解析

And they're not only incredibly small, they're super fast, they can switch states millions of times per second, and can run for decades.

晶体管不仅小，还超级快，每秒可以切换上百万次，并且能工作几十年。 解析

A lot of this transistor and semiconductor development happened in the Santa Clara Valley, between San Francisco and San Jose, California.

很多晶体管和半导体的开发在加州克拉拉谷，位于旧金山和圣荷西之间。 解析

Since the most common material used to create semiconductors is silicon, this region soon became known as Silicon Valley.

而生产半导体最常见的材料是硅，所以这个地区被称为硅谷。 解析

Even William Shockley moved there, founding Shockley Semiconductor, whose employees later founded Fairchild Semiconductors, whose employees later founded Intel — the world's largest computer chip maker today.

甚至 William Shockley 都搬了过去，创立了 “肖克利半导体”，里面的员工后来成立了 “仙童半导体”，这里面的员工后来创立了英特尔——当今世界上最大的计算机芯片制造商。 解析

Ok, so we've gone from relays to vacuum tubes to transistors.

好了，我们从继电器讲到了真空管，又讲到了晶体管。 解析

We can turn electricity on and off really, really, really fast.
我们可以让电路开闭得非常非常快。 解析

But how do we get from transistors to actually computing something, especially if we don't have motors and gears?
但我们是如何用晶体管做计算的？我们没有马达和齿轮啊？ 解析

That's what we're going to cover over the next few episodes.
我们接下来几集会讲。 解析

Thanks for watching. See you next week.
感谢观看，下周见。 解析

我的笔记