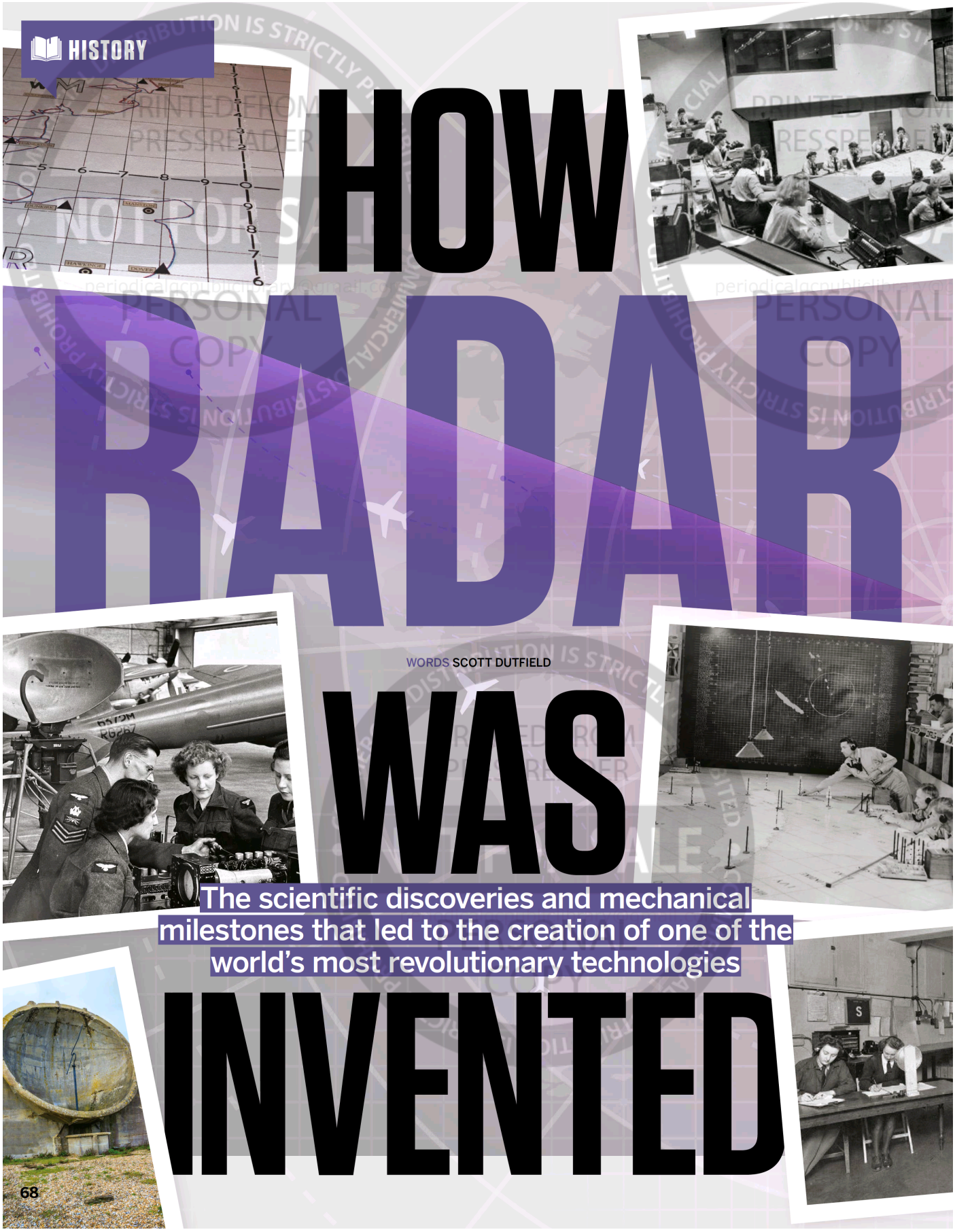
- Radar


HISTORY
HOW
RADAR
WAS
INVENTED
WORDS SCOTT DUTFIELD
The scientific discoveries and mechanical milestones that led to the creation of one of the world's most revolutionary technologies
68



DID YOU KNOW? The cavity magnetron is the same technology used in microwave ovens

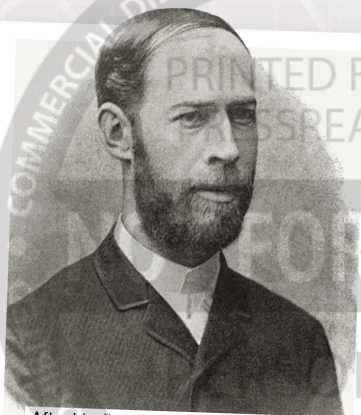
FINDING RADIO WAVES

1865 In the late 1800s, German physicist Heinrich Hertz made a discovery that would change the world forever. Before Hertz' discovery, Scottish physicist James Clerk Maxwell had predicted the existence of electromagnetic radiation in 1865 in his paper *A Dynamical Theory of the Electromagnetic Field*, in which he described electric and magnetic fields moving in waves at equal speeds.

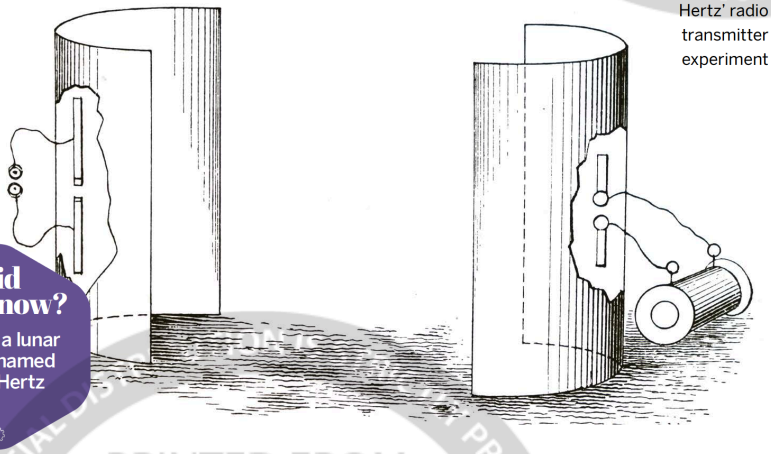
To put Maxwell's theory to the test, Hertz set up a simple home experiment to produce electromagnetic waves. Hertz used an induction coil, a type of electrical transformer, and a Leyden jar as the first capacitor to create an electrical current. The induction coil and Leyden jar were then connected to a pair of copper wires attached to two metal plates. Along each wire and sitting between the metal plates were two metal spheres. A short gap of air, called a spark gap, was left between the two spheres.

When a current was passed through the copper wire, the air in the spark gap became ionised and generated an electrical spark that jumped between the two spheres. Along with the spark, Hertz discovered that the predicted electromagnetic waves had also been released by using a receiver made from a metal loop with a similar spark gap. When the waves reached the loop, another spark was generated in the receiver's spark gap. This signified the existence of electromagnetic waves, which at the time became known as Hertzian waves, later renamed radio waves.

"Hertz discovered that electromagnetic waves had also been released"



After his discovery, Hertz went on to teach as a professor of physics at the University of Bonn, Germany

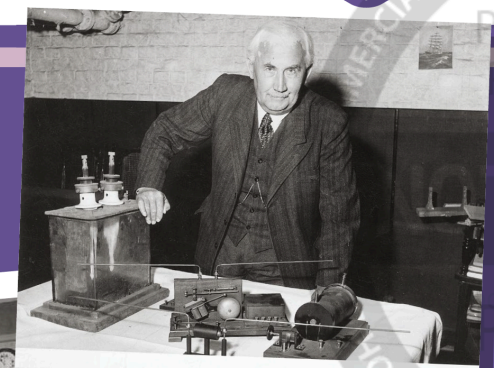


An illustration of Hertz' radio transmitter experiment

Did you know?
There's a lunar crater named after Hertz









THE FIRST 'TELEMOBILOSCOPE'

1903 Armed with the knowledge of radio waves and how to find them, German inventor Christian Hülsmeyer created the first device that used radio waves to detect an object's distance and position.

In 1903, Hülsmeyer patented the 'telemobiloscope', a transmitter-receiver system that could detect the presence of large metallic objects such as ships. The telemobiloscope used two spark gaps and an induction coil to emit a radio frequency. The radio waves were directed using an antenna that could be moved 360 degrees. The returning radio waves were received by a circular antenna that was connected to a device called a 'coherer'. This was a glass tube packed with metal filings. When a current was passed through the tube, these filings clumped together, completing an electrical circuit and ringing an attached bell.

Hülsmeyer intended for the device to be used as a way of preventing ships from colliding with one another. When the telemobiloscope was pointing towards a river, the emitted radio waves would bounce off the metal hulls of passing ships and return to the antenna, causing the bell to ring. But although Hülsmeyer's invention could detect the presence of a ship, it couldn't be used to measure its distance from the transmitter.

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HISTORY



A pair of acoustic mirrors in Kent, UK

ACOUSTIC MIRRORS

1916 While early radar technology was still finding its feet, much of Europe had been catapulted into World War I. The need for a technology that could detect advancing enemy aircraft had never been so crucial. As the precursor to radar, the British Armed Forces invested in 'listening ears' known as acoustic mirrors.

Invented by Major William Sandome Tucker, the director of acoustical research for the Air Force, acoustic mirrors were giant concrete half-spheres used to pick up the sound waves of flying engines, amplify them and bounce them to a microphone. Like electromagnetic waves, sound waves can be reflected and focused to a partial point. The shape of the mirrors caused the sound waves to reflect off the back of the half-sphere and hit the microphone situated in its centre. A vigilant soldier would then sound the alarm when the mirrors tuned in to the sound of enemy threats in the sky.

Acoustic mirrors could give the military a 15-minute head start to prepare for an oncoming attack. However, on the precipice of a second world war, the acoustic mirrors that lined part of England's south coast were abandoned to give way for the very first military radar stations.

THE DAVENTRY EXPERIMENT

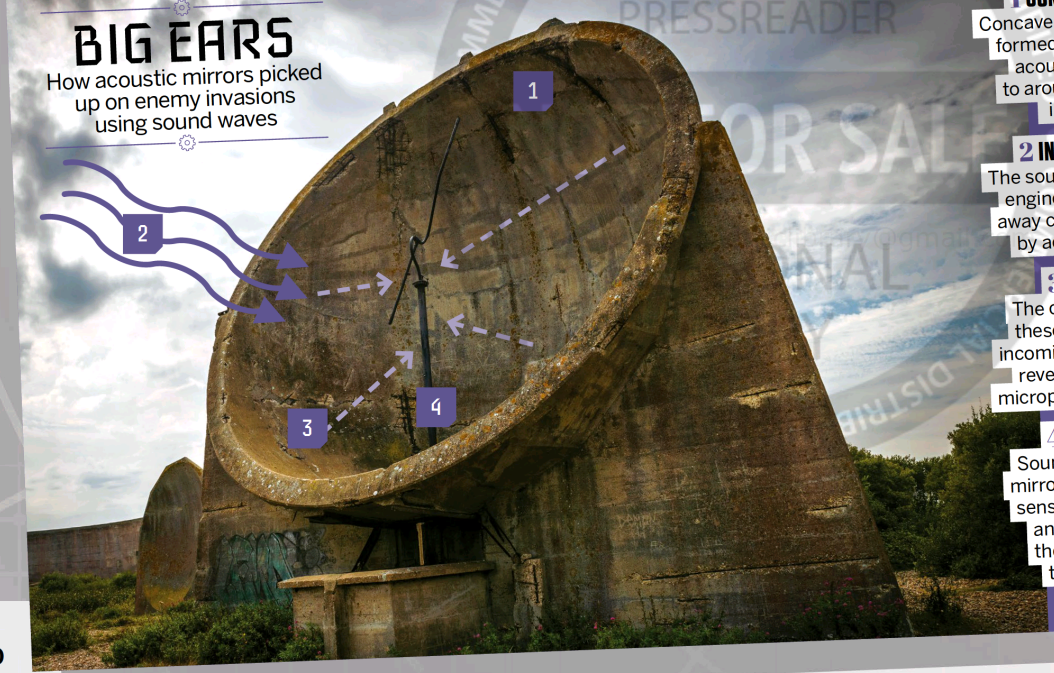
1935 Hülsmeyer had already proven the ability of radio waves to detect ships, but its use in detecting flying objects was yet to be seen – until British inventors Robert Watson-Watt and Arnold Wilkins conducted a pioneering experiment in Daventry, UK. Watson-Watt was head of the Radio Research Station in Slough. During his time at the station, he and Wilkins showcased how radio waves could be used to detect aircraft. In a field experiment, the pair built several posts suspending wires connected to a receiver in the back of a van. The radio waves came from BBC broadcast transmitters near Daventry. When a Handley Page Heyford bomber flew by, the field-bound receiver not only detected its flight, but its eight-mile distance. Watson-Watt and Wilkins' achievement ignited radar research in Britain, and the government approved the construction of new coastal radar stations to detect invading aircraft.



Watson-Watt experimenting with a kite and a wireless radio transmitter

BIG EARS

How acoustic mirrors picked up on enemy invasions using sound waves



1 CONCRETE MIRROR
Concave bowls of concrete formed the shape of an acoustic mirror, up to around four metres in diameter.

2 INCOMING SOUND
The sound of fighter plane engines up to 25 miles away could be picked up by acoustic mirrors.

3 REFLECTION
The concave shape of these mirrors caused incoming sound waves to reverberate and hit a microphone at the centre.

4 MICROPHONE
Sound detected in the mirror was picked up by sensitive microphones and transmitted to the headphones of their operators.

DID YOU KNOW? In 1940 the United States Navy coined the term radio detection and ranging, shortened to radar

CODENAME CHAIN HOME

1935 to 1941

With word that the German military might bring 'death-ray' radio technology aboard their fighter planes to a second world war, Britain quickly constructed coastal radar stations to spot aircraft before they crossed its shores. Known under the codename 'Chain Home', it was a network of transmitter antennae and receiver stations for a giant radar system that could detect incoming aircraft from around 100 miles away. The transmitter antennae sent long pulses out into the English Channel to bounce off any incoming enemy aircraft and return to the receiver station. The encounter would then appear on a radar display, alerting the operator to the presence of the aircraft. This helped give the Royal Air Force enough time – around 20 minutes – to jump into fighter planes and face the enemy before they had the chance to reach land. By 1939 Britain had 18 Chain Home radar stations, and by the end of World War II, 53 had been constructed.

Did you know?

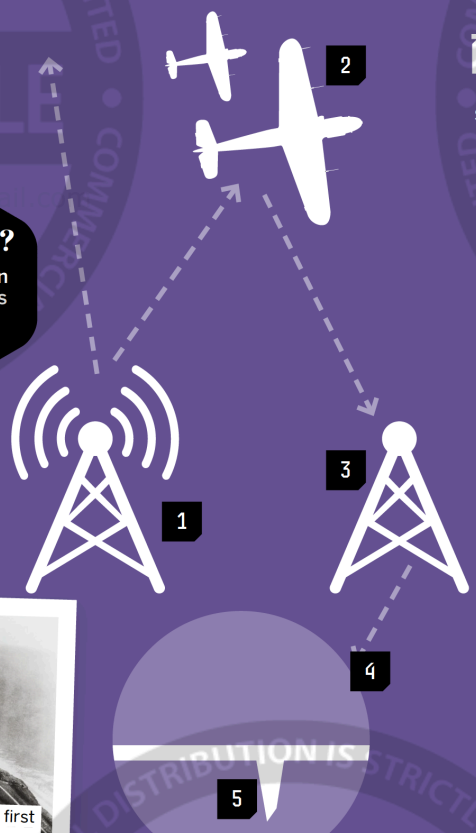
By 1938, Chain Home stations operated 24 hours a day



One of the first Chain Home radar towers to be installed

RADIO BLIPS

How the Chain Home radar system spotted enemy aircraft



1 TRANSMISSION
Pulses emitted from 110-metre transmitter towers flooded large areas of the coast of England towards continental Europe with radio waves.

2 BOUNCED WAVES
When the radio waves hit enemy aircraft, they were reflected and bounced back towards the station.

3 RECEIVER
The radio waves were detected by receiving aerials at the Chain Home stations.

4 BLIP
When an aircraft was detected by radio waves it appeared on a display screen as a spike on a horizontal line, called a 'blip'.

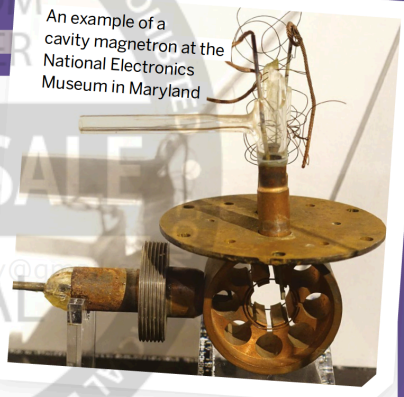
5 POSITION
Operators used the position of the blip on the line, along with its size, to determine its distance and placement in the sky.

MOVE ASIDE FOR THE MAGNETRON

1940 Although revolutionary, Chain Home wasn't without its limits, especially its range of detection. Looking for a way to extend the reach of radar, British physicists John Randall and Henry Boot of the University of Birmingham invented a new type of radar called the cavity magnetron.

The device was made from a piece of cylindrical metal with a negatively charged electrode, or cathode, running through a central hole. Surrounding the cathode was an anode – positively charged electrodes in a series of holes, or 'cavities'. When power was passed through the cathode, a magnetic field emerged around the device and electromagnetic waves radiated from the anodes. These were microwaves, which were much shorter in length than radio waves – just ten centimetres compared to the up to 13-metre wavelength of radio wave radar. For radar, transmitters that use shorter wavelengths are sensitive to detecting targets at longer ranges, and they can be produced in smaller and less expensive devices.

The cavity magnetron was small and mighty. However, Britain's manufacturing industry at the time couldn't sustain mass production of the device. Looking across the pond, Britain turned to America, which had not yet entered the war, for help. Having made the trip on a ship safely across the Atlantic, a Welsh physicist named Edward Bowen revealed the magnetron technology to the Americans. Seeing the potential for the device and its impact on military success, President Franklin D. Roosevelt approved funds to establish the Radiation Laboratory at the Massachusetts Institute of Technology (MIT) to replicate the new microwave radar. These new radars were adapted for compact units installed on aircraft or large truck-mounted devices for long-range detection.



An example of a cavity magnetron at the National Electronics Museum in Maryland

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