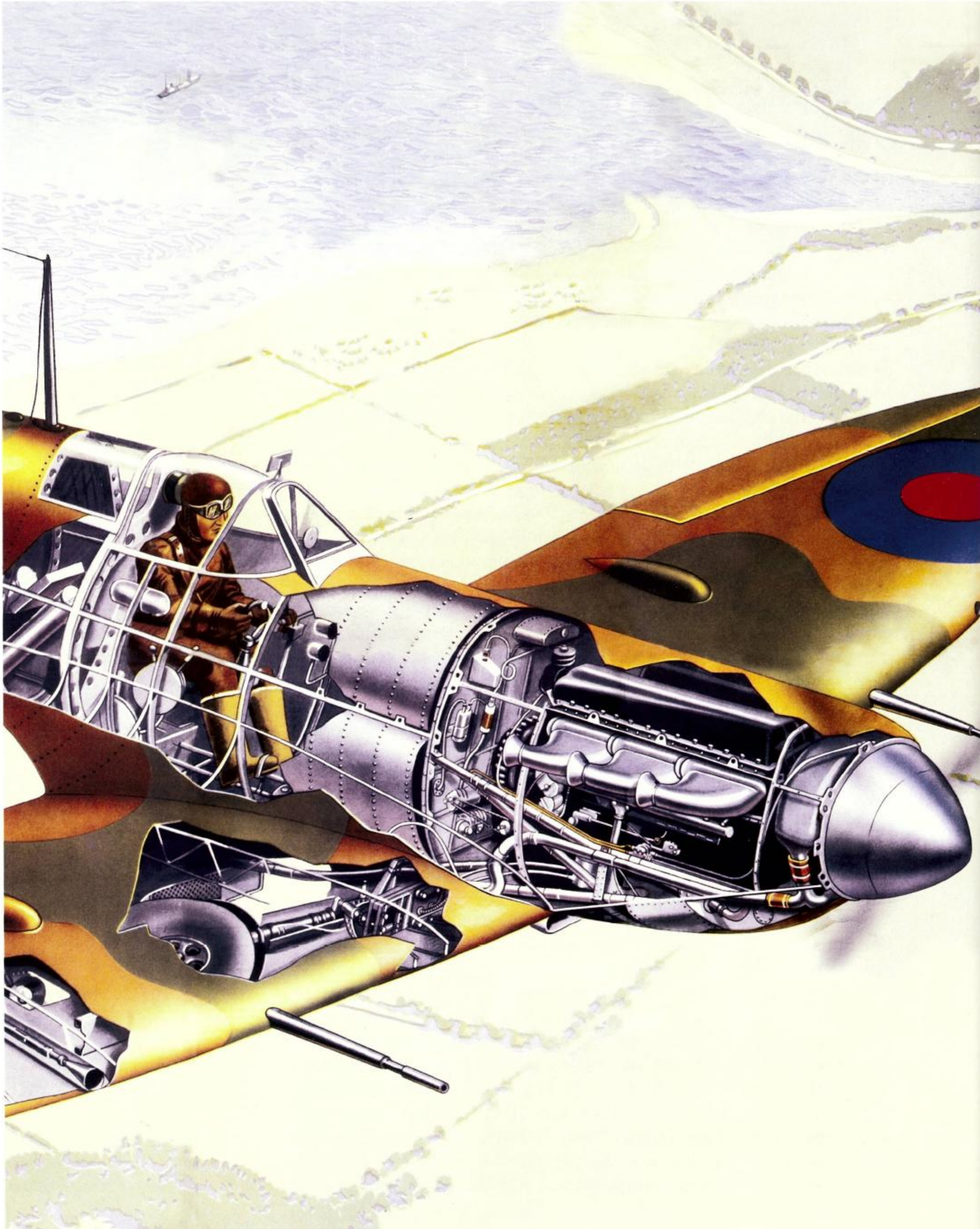


Case Construction and Protection against Magnetic Fields

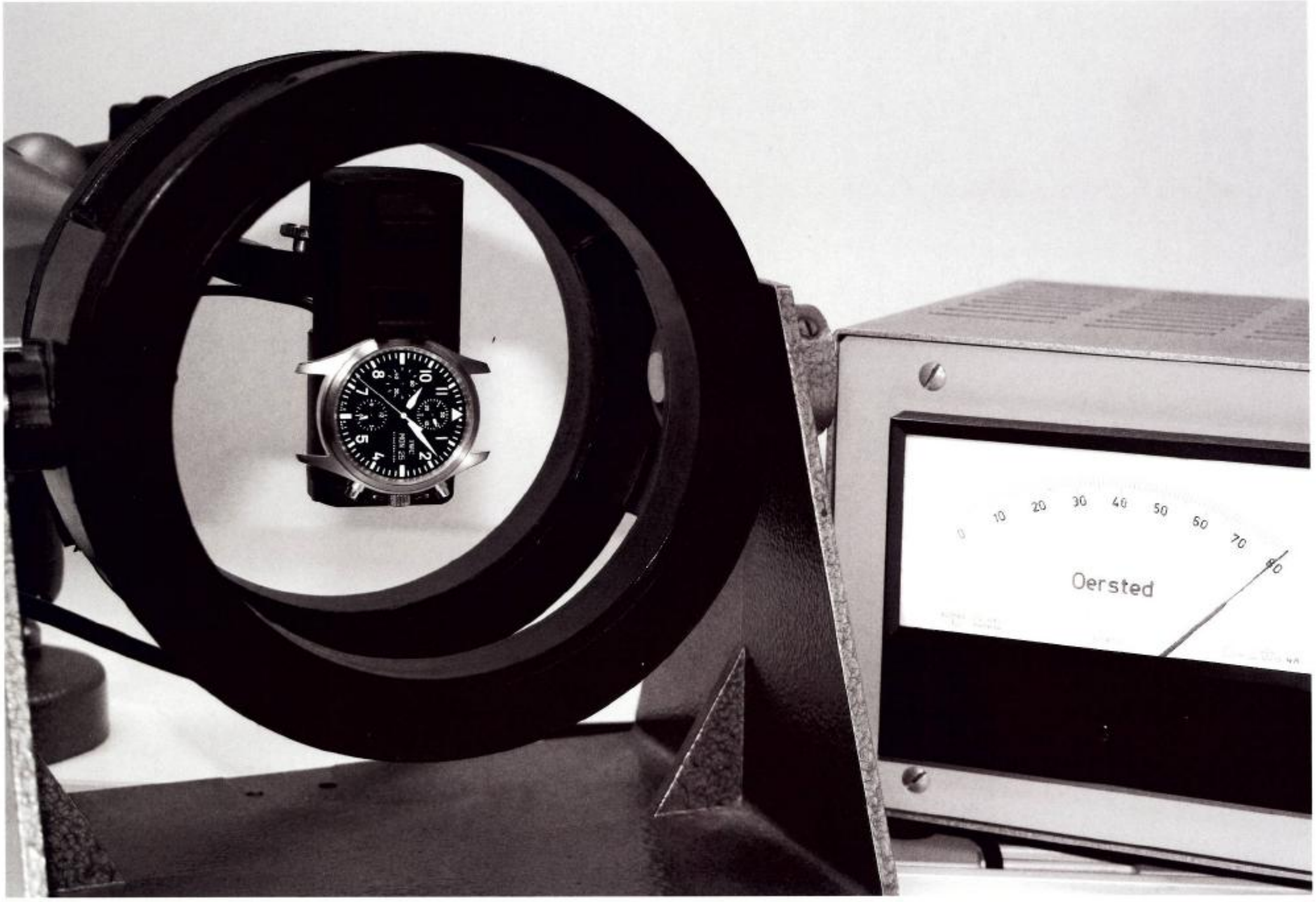
Immune to All Adversaries

by Gisbert L. Brunner

Specialists sometimes describe mechanical watch movements as marathon runners, because their gear-trains run and run and run. Even without lubrication they continue to perform their timekeeping labor until they've abraded away an essential component. On the other hand, external influences can cause even the most lovingly cared for mechanical movement to grind to a halt or to lastingly lose its hard-won precision.

Magnetism is one of such culprit. Every schoolchild learns about the Earth's magnetism and its effects. Mariners put magnetism's positive aspects to good use many centuries ago with the aid of the compass. The scientific background for the Earth's magnetism involves our globe's liquid core, which begins at a depth of 2,900 kilometers and consists of hot, molten metal. The first proof of the existence of this core was furnished by the Darmstadt scientist Benno Gutenberg in 1914. The core consists of an inner and an outer part. In simpler terms, one could say that their interaction creates a gigantic dynamo, which generates an enormous magnetic field. This charged field is useful for navigation, but it also shields the Earth from solar wind, which contains such highly charged particles that it would destroy all life on Earth were it not for the protection provided by our planet's magnetic field.

This natural effect is fairly strong, but manmade magnetic fields can be considerably stronger, for example, those produced by powerful permanent magnets or the flow of electrical current. The magnetic behavior of a material depends upon its atomic structure. Many metals, all nonmetals, and noble gases exhibit a diamagnetic behavior. Familiar, frequently used metals such as iron, cobalt and nickel, are ferromagnetic. Gases, alkali metals and all



The self-winding pilot's chronograph undergoes a magnetic-field test

substances above the Curie temperature at which their ferromagnetic order disappears (1,121°C for cobalt, 766°C for iron and 360°C for nickel) are known as "paramagnetic." Diamagnetic elements are nearly unaffected by magnetic fields; paramagnetic substances displace them; only ferromagnetic materials are attracted to them, and this attraction can interfere with the steady rhythm of even an antimagnetic watch.

Ferromagnetism occurs through the orientation of many elementary magnets in large crystalline areas – so-called "Weiss regions." An external magnetic field causes a ferromagnetic material to itself become a magnet.

The elements iron, nickel and cobalt all have ferromagnetic properties at room temperature. In practice, ferromagnetic alloys, such as NiFe ("permalloy" or "mu-metal"), are often used. Unlike paramagnetic and diamagnetic substances, their elementary magnets remain subordinated to a magnetic field; the material is nearly neutral towards the outside.

Beneficial Effects

The attractive effect of permanent magnetism has fascinated and been used by mankind for thousands of years. But magnetic fields don't only surround magnetic materials; they're also induced by the flow of electrical current.

The Danish researcher Hans Christian Oersted discovered in 1820 that a compass needle can be diverted by a conductive material through which electrical current passes. His discovery revealed the previously unknown connection between magnetism and electricity. Magnetism continued to play an important role in the subsequent evolution of electrical engineering. The best examples are the copper coils through which electrical current flows in electrical motors or generators. High-tech superconductors allow high currents to flow without resistance through slender wires just a few millimeters in diameter. Here too, these effects would be impossible without magnetic fields and their associated forces. Countless other applications exist for permanent magnetism and electromagnetism, many of which we take for granted in modern life (e.g., electric motors, generators to produce electricity, loudspeakers, automatic opening doors, electrical locomotives, medical devices and electric meters).

Consequences for Watches

Our wristwatches are exposed to the influences of magnetism every day. Magnetism can be particularly problematic for the components (i.e., pallets, escape-wheel, guard-pin, balance-staff, roller, balance-spring and collet), which collaborate to divide the uniform flow of time into small, exactly defined segments. These components, usually made (at least in part) from steel, can become magnetized. Steel can orient itself magnetically if it's exposed to a sufficiently strong magnetic field, and such exposures are by no means infrequent nowadays. The negative effects of these forces make themselves felt on the affected components. Massive "infection" by magnetism can cause a watch's rate to become less accurate or, worse yet, cause the entire mechanism to grind to a halt. This phenomenon is like a virus that can infect and even totally paralyze a computer.

The soft-iron inner case (blue) protects the movement against magnetic fields

IWC to the Rescue

High above the clouds, in the cockpit of an aircraft, where time is especially precious and magnetism is a fact of daily life, a malfunctioning timepiece could precipitate grievous consequences. We're primarily talking here about the era before the blessings of modern electronics and precise satellite-supported navigation – the early days of flight, when a pilot or navigator was utterly reliant on the ticking companion he kept strapped to his wrist. The technicians and engineers at IWC were acutely aware of the problems and dangers that beset aviation. After all, IWC's specialists pioneered the pilot's watch, a new genre of timepiece designed expressly for pilots and other airborne personnel. IWC first implemented an effective solution to protect a watch's movement against the effects of magnetism in the Mark 11, which debuted in 1948. This protection was essential, because without it a mechanical pilot's watch wouldn't keep time accurately under adverse conditions. The solution that IWC's specialists found for the problem was as ingenious as it was revolutionary. It was based on the idea of simply conducting magnetic fields around the movement. To accomplish this, they enclosed the hand-wound Caliber 89 inside a mantle made of a special, highly conductive alloy. Magnetic fields were almost entirely prevented from forming inside this protective container. In other words, the Mark 11 had two nested cases. The inner case, which protected its contents against the ill effects of magnetism, consisted of an inner back, a movement-holder ring, and the dial, all of which were made from the same soft-iron alloy (so-called "mu-metal"). Magnetic fields had almost no chance of penetrating this protective inner case and causing lasting damage to the sensitive mechanisms inside it.

This raises a question: What does the mysterious-sounding word *antimagnetic* mean in the context of watches? The answer can be given in a very few words. If an ordinary mechanical timepiece is exposed to a magnetic field of 4,800 amperes per meter (A/m), if it continues to run in that field, and if it afterwards deviates by no more than 30 seconds per day from the time kept by an official clock, then that timepiece fulfills the requirements specified by the Swiss norm. Thanks to its cunningly designed architecture, the legendary Mark 11 pilot's watch can withstand much stronger magnetic fields. IWC significantly enhanced the protection for the exemplary antimagnetic wristwatch, the "Ingenieur." Its perfectly protected movement enables it to withstand magnetic fields up to 80,000 A/m. That's 17 times stronger than the norm value, so it's no exaggeration to describe this wristwatch as "super-antimagnetic."

Not content to rest on its antimagnetic laurels, IWC debuted the "Ingenieur 500 000 A/m" in 1989. IWC turned the magnetic-protection principle on its head. Though it no longer had a ferromagnetic inner case, this extraordinary Ingenieur significantly outperformed all preceding antimagnetic watches. It allows a magnetic field's lines of force to move freely through its movement, but they pass through the caliber without exerting any influence on the materials and without causing any undesired effects on the rate. This was only possible through the use of very costly materials that neither attract nor repel strong magnetic fields. The Ingenieur 500 000 A/m isn't merely antimagnetic – it's genuinely diamagnetic. Magnetic resonance tomography tests showed that this Ingenieur was unaffected by a magnetic field with a strength of 3.9 million A/m. Unfortunately, the intensity of the field couldn't be increased because the tomography unit had reached the limit of its capacity. This Ingenieur's world record still stands today.

Extreme conditions of this sort are highly unusual, so the degree of protection against magnetic fields offered by the current Ingenieur models and IWC's various other pilot's watches is almost always sufficient. It's highly unlikely that these ticking systems will malfunction under ordinary or extraordinary conditions. Anyone who has ever seen a watch with a rate that deviates significantly placed on a watchmaker's anti magnetizing device and afterwards restored to proper accuracy knows that protection against magnetic fields is an important feature, even for a watch that's used under ordinary conditions.

Pars Pro Toto

Protecting the movement against strong and therefore deleterious magnetic fields is one thing; protecting it against harmful everyday influences is another. These common culprits include dust, moisture, and severe temperature variations, for which no panacea has yet been discovered. The

Tough treatment for the case: the droplet test and the high-pressure test

A frigid ordeal: the watch became covered with ice at −20°C

only effective expedient is to take meticulous pains in the design and manufacture of the case. IWC has traditionally recognized the extreme importance of a wristwatch's case. So when IWC develops a new timepiece, its case enjoys at least as high a priority as the movement that will ultimately be enclosed inside it. No matter how precise and reliable a caliber is when it leaves the factory, if the case shirks the responsibilities associated with its all-important job, the watch soon stops keeping time with precision.

Thus begins an elaborate genesis at IWC. The story starts with the drafting of a detailed list of specifications. This list summarizes all of the criteria which the designers, engineers, producers and quality controllers are expected to uphold. It serves as a guide-book that accompanies a new watch on its way through the manufactory's various departments. No deviations from this predefined path are permitted without prior authorization.

The first prototypes, of which there will ultimately be ten, must withstand the tests administered to them in the Schaffhausen laboratory of the 35-year-old technician Matthias Oppold. He afflicts them with tortures that they're not likely to suffer in ordinary daily usage. But, then again, one never knows...

When the sledgehammer strikes the rim of the case, the force of its blow corresponds to the impact suffered after a plunge from a height of one meter onto a hardwood floor. It's also equal to the forces experienced during an acceleration of 5,000 Gs (i.e., 5,000 times the object's weight). The case must withstand the brunt of this blow. If it fails, it's summarily sent to the scrapheap. Equally rigorous stresses, far beyond those encountered in ordinary use, are imposed in the laboratory with regard to heat, cold, and atmospheric humidity. When the prototypes in the so-called "zero series" are complete, their cases are subjected to tests in a spectrum of temperatures ranging (depending on the reference of the particular case) from minus 20°C to plus 70°C, and at humidity levels up to 95%. These conditions can create hot surfaces or ice-encrusted cases. The ordeals are reflected in the dismayed expressions on the faces of the *manufacture*'s visitors when they see these precious timepieces undergoing such cruel mistreatment.

Before the parts of the case are assembled, they're first immersed in a bath, where they spend two weeks in chlorinated, highly oxygenated saltwater, which mercilessly exposes any weak points. If traces of corrosion are evident after this prolonged immersion, the materials scientists are called in again and it's "back to the drawing board." This process is repeated over and over again until the demanding Mr. Oppold can find nothing more to criticize. The first specimens of the zero series are likewise submerged in this briny bath, where they remain in corrosive saltwater for 72 hours or three full days. This ordeal is followed by the no less rigorous "box text." Each candidate is placed inside a plastic box inside of which it has 10 centimeters of leeway on all sides. Then the box begins to flip. The box continues to rotate for 16 hours, during which interval the watch inside it undergoes one somersault after another. The timepiece's rate behavior is tested afterwards to assure that the thousands of involuntary tumbles haven't adversely affected the watch's accuracy.

All that now remains is to check the watertightness. This test is administered to all of IWC's cases, including its serially produced ones. Immediately after the preliminary installation of the movement, each case must prove that it can sufficiently withstand penetration by water. A second watertightness test is performed on the completed wristwatch, first with pressurized air, then with actual water. The final test is the obligatory "droplet" check. A cold droplet is allowed to fall onto the crystal above the dial of the pre-warmed case. If the glass fogs up, the hapless timepiece fails the test and is "returned to sender." IWC will not accept anything less than perfection. After all, this *manufacture* has an excellent reputation to uphold as a maker of sport watches and pilot's watches.