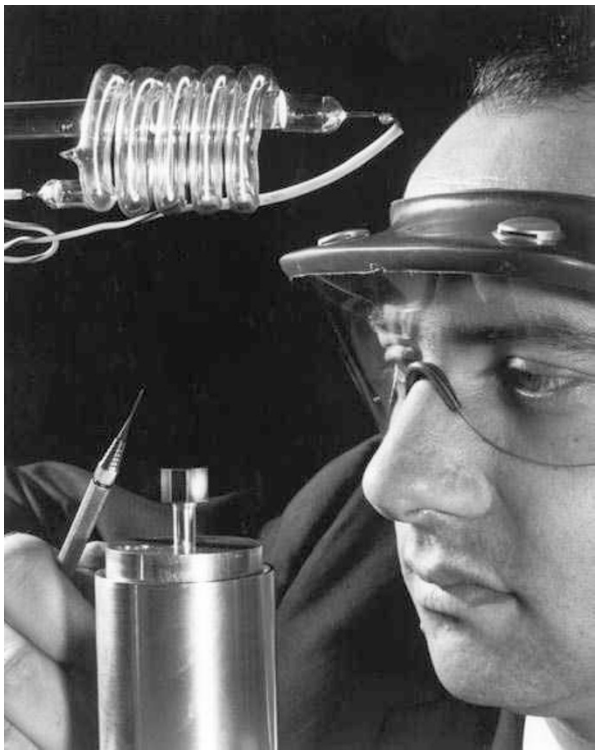
MILESTONE 9

All together now



Courtesy of HRL Laboratories, LLC

There are only very few occasions when discoveries are made that start an entire new research field and at the same time revolutionize our everyday life. The transistor is one example — it led to modern electronics. At least as important is the invention of the laser, which heralded the field of photonics.

The foundations of laser operation were laid in 1917, when Albert Einstein studied the interaction of electromagnetic radiation with electrons that can occupy two energy levels. In the presence of an incident photon equal to the energy separating the two states, an electron in the higher state can be stimulated to relax, emitting a photon of the same energy as the incident one. The photons are coherent, that is, they have not only the same wavelength but also the same phase.

However, the fact that stimulated emission can amplify light fields to generate coherent light beams was not realized until the 1950s. Then, Nikolay Basov and Alexander Prokhorov developed the principle of the maser — which stands for 'microwave amplification by stimulated emission' — along with James Gordon, Herbert Zeiger and Charles Townes, who independently built the first maser in 1954. Their maser used a microwave transition between two energetic states of ammonia molecules. They sent a beam of ammonia molecules past an electric field to focus excited molecules into a microwave cavity, while defocusing the others. This provides an amplifier and oscillator that emits coherent radiation.

An extension of the maser concept to optical light waves was developed in 1958 by Arthur Schawlow and Townes. Gordon Gould, who coined the term laser, is also credited with independent contributions to the laser scheme, and after a prolonged court battle was granted a subsidiary patent on the laser. For their work that led to the concept of masers and lasers, Townes, Basov and Prokhorov were awarded the 1964 Nobel Prize in Physics.

After the first demonstration of the maser, a deluge of similar research papers flooded the office of *Physical Review*, the editors of which consequently decided to stop accepting any further papers on the topic. So it came that they also turned down the paper on the first working laser, which was demonstrated on 16 May 1960 by the 32-year-old physicist Theodore Maiman from Hughes Research Laboratories (pictured). Instead, Maiman sent his manuscript to *Nature*, where it was published in August 1960.

The Maiman laser was based on a ruby crystal doped with chromium atoms to provide the energy levels for the laser process. In order to excite a sufficient number of electrons to pass the laser threshold, Maiman came up with the idea to use a bright flashlight as a pump source. It worked brilliantly.

The importance of lasers cannot be overstated. Among a plethora of applications, lasers are used in nonlinear optics (MILESTONES 7 and 10), telecommunications (MILESTONE 13), optical disks (MILESTONE 15) and spectroscopy (MILESTONES 16 and 22). With the help of the laser, photons have become a commodity the properties of which can be designed almost at will. This makes the laser one of the lasting achievements of modern science.

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