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The 50th anniversary of the laser

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ABSTRACT

One of the greatest inventions of the 20th century, the laser, first appeared in 1960. Fifty years on, its technological innovations have revolutionized the modern world. Since the first few patents were approved to the laser inventors, numerous patents involving the laser have been granted on a worldwide scale. Rewards to the inventors were immense, including Nobel Prizes. Unsurprisingly such a rewarding area of invention led to intellectual property and patent rights disputes. This paper explores these exciting, but contentious, early years of the laser.

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1. Introduction

The laser¹ is beyond doubt one of the greatest inventions of the mid 20th century – technological innovations utilising its exceptional properties have beneficially revolutionized the way we live. Consider its use in medicine; for example in the fields of ophthalmology, dermatology, diagnostics, surgery, dentistry and medical imaging. Also consider the important use in telecommunications such as in the transmission of laser light along transatlantic fibre optic cables from 1988 onwards.

The first laser appeared in the USA in 1960 and at that time was directly put to work as a scientific tool in the laboratories. Nevertheless the scientists were optimistic of its greater potential and during the 1960s and 1970s progress was rapid with the development of various types of lasers [1] and the emergence of the first important applications; the CD player (derived from US3430966, 1969) and barcode scanner in 1974 with the first commercial use of Universal Product Code (UPC).

Many innovators reaped great rewards from their laser endeavours and to a few the ultimate honours – the Nobel Prize (see Table 1). As expected in a rapidly growing technology, numerous patents involving lasers have been granted on a worldwide scale throughout the last 50 years. This article takes a glimpse at the early pioneers in the developments of the laser and the role of research and patents in driving the technology forward.

The European Patent Office (EPO) at esp@cenet[®], the US patent and Trademark Office and the UK Intellectual Property Office user interface GB_esp@cenet[®] were particularly valuable sources of information used by the author in identifying key laser patents. Note that the author quotes the year of publication of the patents unless otherwise stated.

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¹ Light amplification by stimulated emission of radiation.

2. Inventors of the laser

Many dedicated people throughout the world have played a role in the rapid progress of laser technology. This section reviews the early key figures in the laser's theoretical conception, its invention and subsequent development in various fields.

2.1. Arthur Schawlow and Charles Townes

The American scientists, Charles Hard Townes (born 1915 in Mount Vernon, New York) and Arthur Leonard Schawlow (1921–1999) are credited with developing the maser (microwave amplification by stimulated emission of radiation), an essential precursor to the laser. In 1955, J.P. Gordon, H.J. Zeiger and Charles H. Townes published a description of the first maser built at Columbia University, New York [2]. Townes applied for a patent 'Production of electromagnetic energy' on 6th May 1955; after a continuation-in-part filing in early 1958 based on his 1955 application a patent (US2879439, 1959) was granted. In addition, three patents by other inventors (US2743366, US2745014 and US2749443) published in 1956 were included in the references cited. Townes was more than determined to keep up with recent developments applicable to his ground breaking work on electromagnetic energy. His diligence and attention to detail certainly played a major role in his eventual success in a hotly contested area.

Since microwaves are one type of electromagnetic radiation, Schawlow, a Bell Labs researcher and Townes endeavoured to extend the principle of the maser to other areas of the electromagnetic spectrum, the infrared and visible light. They applied for a patent 'Masers and maser communication systems' on 30th July 1958 (US2929922, published 1960). Fig. 1 shows the key features of their 'optical maser'. The key point in the patent is that their 'masers' were relevant to the generation of infrared, visible and ultraviolet waves. Although a working optical maser (or laser) had not

Table 1
Nobel Laureates in Physics and Chemistry – laser technology.

Year	Recipients	Research Field	Subject
1964	Nicolay G. Basov ($\frac{1}{3}$) Alexsandr M. Prokhorov ($\frac{1}{3}$) Charles H. Townes ($\frac{1}{3}$)	Fundamental work in quantum electronics and laser theory	Physics
1971	Denis Gabor (1)	Theory of holography	Physics
1981	Nicolaas Bloembergen ($\frac{1}{4}$) Arthur L. Schawlow ($\frac{1}{4}$)	Development of laser spectroscopy	Physics
1989	Norman F. Ramsey ($\frac{1}{2}$)	Hydrogen maser	Physics
1997	Steven Chu ($\frac{1}{3}$) William D. Phillips ($\frac{1}{3}$) Claude Cohen-Tannoudji ($\frac{1}{3}$)	Laser cooling techniques	Physics
1999	Ahmed Zewail (1)	Laser spectroscopy	Chemistry
2000	Zhores I. Alferov ($\frac{1}{4}$) Herbert Kroemer ($\frac{1}{4}$)	Semiconductors in opto-electronics	Physics
2001	Eric A. Cornell ($\frac{1}{3}$) Wolfgang Ketterle ($\frac{1}{3}$) Carl E. Wieman ($\frac{1}{3}$)	Laser cooling applications	Physics
2005	John L. Hall ($\frac{1}{4}$) Theodor W. Hänsch ($\frac{1}{4}$)	Developed laser-based precision spectroscopy	Physics
2006	John C. Mather ($\frac{1}{2}$) George F. Smoot ($\frac{1}{2}$)	Laser measurements of cosmic microwave background radiation	Physics
2009	Charles K. Kao ($\frac{1}{2}$) [*]	Optical communications	Physics

^{*} A specific fraction of the prize is awarded to each recipient; in 2009 the total value of the Nobel Prize was ~\$1.4 M.

yet been constructed they submitted a paper on the theory of 'Infrared and Optical Masers' to *Physical Review*, published in December 1958 [3]. International recognition for Charles Townes was rapid for in 1964, he shared a Nobel Prize with Alexsandr M. Prokhorov and Nikolai G. Basov for fundamental work in laser theory (see Table 1). A good number of years later in 1981, Arthur Schawlow shared a Nobel Prize with Nicolaas Bloembergen and Kai Siegbahn (see Table 1).

2.2. Robert H. Dicke

In their significant 1960 patent (US2929922) Schawlow and Townes cited a patent (US2836722, 1958) by Princeton physicists Robert Henry Dicke (1916–1997) and Thomas R. Carver titled 'Atomic or molecular oscillator circuit'. Dicke, in another patent 'Molecular amplification and generation systems and methods' (US2851652, 1958) included claims of an apparatus that we could now recognise as an infrared laser: quoting claim 13 'Apparatus including an electromagnetic resonator, for coherently generating infra-red waves'. Although never commercially viable to Dicke, his patents are historically important in that they helped lay the basic framework for future laser developments and were cited in many of the early significant laser patents.

2.3. Alexsandr M. Prokhorov and Nikolai G. Basov

The Russian scientists, Alexsandr Mikhailovich Prokhorov (1916–2002) and Nikolai Gennadievich Basov (1922–2001) of the Lebedev Physics Institute, Moscow independently developed a maser at the same time as Townes and Schawlow. Prokhorov and Basov described their concept in a 1955 issue of the USSR journal *JETP* (Journal of Experimental and Theoretical Physics) [4]. In June of 1958, Prokhorov published a brief proposal for a maser operating in the visible spectrum, with the light reflected back and forth in an optical cavity consisting of a pair of mirrors. In 1959 they were awarded the most prestigious Soviet award, the Lenin Prize and in 1964 shared the Nobel Prize for Physics with Charles Townes.

In 1962 at a meeting of the Presidium of the USSR Academy of Sciences, and later at the International Conference on Quantum Electronics in Paris (1963) Basov advanced the idea of obtaining thermonuclear reactions using laser irradiation of targets. Basov was later awarded patents for a laser screen cathode ray tube (US3558956, 1971), a carbon dioxide laser (RU2012966 (C1), 1994) and 'Method for treating the cases of glaucoma by applying laser radiation' (RU2125426 (C1), 1999). Prokhorov has been cited as co-inventor in a number of patents, including fairly recent patents, such as laser-diode devices (US5930279, 1999; US6101206, 2000)

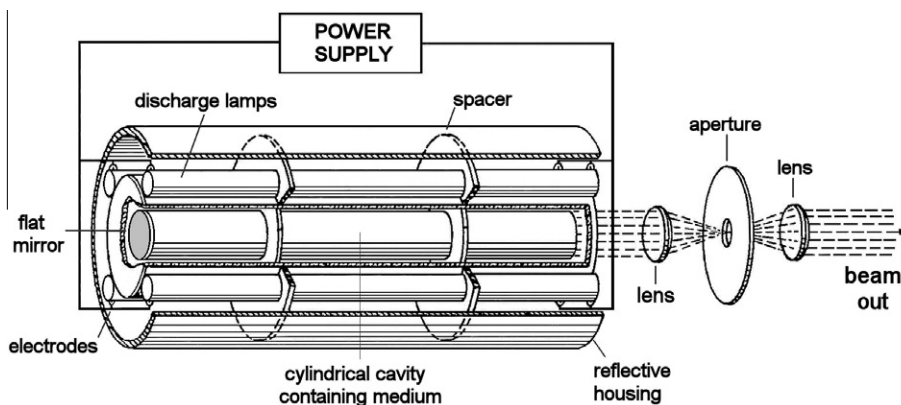


Fig. 1. Schawlow and Townes maser (refer to US2929922, 1960).

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