Gould Advances Inventor's Claim on the Laser

California court supports a neglected patent claim, rekindling an old controversy among inventors of the laser

Gordon Gould, who has roiled the optics community for two decades with his claim to be one of the first inventors of the laser, won an important victory on 1 March. A federal judge in San Francisco decided that a patent filed by Gould in 1959 and awarded in 1977 is valid. The patent covers perhaps 35 percent of the $400 million laser market.

The judge, Samuel Conti of the U.S. District Court for Northern California, ordered General Photonics of Santa Clara to pay the first royalties ever collected on this patent. The decision has rekindled a smoldering controversy among inventors of the laser and raised doubts about the patent system's ability to sort out hotly contested scientific claims. Twenty-three years is longer than most inventors would care to wait to collect their reward.

Gould won his patent on the optically pumped laser amplifier in 1977 as part of what the Patent Office calls a "continuation" of an application filed in April 1959. The government required him to split the original filing into six parts. One of these was modified slightly, resubmitted in 1974, and finally accepted in its present form as patent number 4,053,854 (see *Science*, 28 October 1977, page 379).

The case brought to trial in San Francisco was the first of three lawsuits that will test the validity of the 1977 patent. No one knows when or whether the other two will be tried. Gould naturally sees the San Francisco decision as a vindication of his struggle to gain recognition.

The laser manufacturers are not so pleased. Many have been fighting Gould for years, motivated by financial concerns, but also by special loyalties to scientists in the field. Laser company executives are angry at being asked to pay for a fundamental laser concept today, 20 years after the first laser was built. Normally a patent expires after 17 years, and fundamental patents, which have the broadest scope, generally expire by the time a technology has reached maturity. Indeed, many companies have already paid royalties on what they considered to be the basic inventor's claim on the laser, a patent held by Nobel laureate Charles Townes, a professor of physics at the University of California at Berkeley. His patent expired in 1977. Now it looks as though companies making solid-state lasers may have to pay royalties until 1994 on another basic inventor's patent.

Six laser company executives, upset at the prospect, met in Anaheim, California, in the fall of 1977, after Gould's patent had been issued, to plot a joint attack on it. They intended to set up a common defense fund, but abandoned the scheme, according to Gould's lawyers, when threatened with an antitrust suit.

Gordon Gould

He waited 23 years to collect royalties.

An element of the laser fraternity is still gunning for Gould. Four senior scientists in this field, including Townes, told *Science* that they think the Patent Office blundered badly in honoring this patent. They claim that the Gould juggernaut will be stopped when Gould attempts to collect royalties in the two cases which have not been tried: one in Chicago against General Motors and General Lumonics, and the second in Orlando, Florida, against Control Laser. All have refused to pay and have been taken to court. These companies will be better financed and better prepared for battle than General Photonics.

The dispute over the record reveals how pliable history can be, especially when it is interpreted by inventors who have clashed in the patent courts. On one side is Gould, and on the other are the two men popularly regarded as fathers of the laser, Townes and his brother-in-law, Arthur Schawlow, a professor of physics at Stanford University who received a Nobel Prize in chemistry last year.

As a measure of the intensity of the clash, consider what Gould's lawyer, Richard Samuel, said about it in his opening remarks in the San Francisco case earlier this year. Gould, he charged, has been "discredited and abused for 20 years" as the man who copied his ideas from Townes. "Nothing could be further from the truth," he said. "If anything, your honor, at the end of this trial you may well find that certain of the subject matter which Charles Townes disclosed in his patents were, in fact, written down first by Gordon Gould, witnessed by Townes, and then put into the Townes patent." The judge did not comment on this question, although he did find Gould's patent valid.

Townes views this charge as "strange and fantastic." He offers a detailed rebuttal. Before getting into these details, some of the background must be filled in.

All three scientists—Townes, Schawlow, and Gould—were working in the same field of physics in New York during the late 1950's when the race to build a laser began. Townes was much the senior figure. He had already been a physicist at Bell Laboratories and a consultant to the military. Between 1951 and 1954 he conceived and directed the creation of the first maser, the acronym for a device that produces microwave amplification by stimulated emission of radiation, an accomplishment that earned him the Nobel Prize in 1964.

In general terms, the maser is an oscillator that does for very shortwave radiation (microwaves) what the radio does for longer radio waves. The principles of wave behavior are the same, but the techniques used to amplify the signals were not an outgrowth of work on the radio. Townes' discovery of a way to use atomic and molecular properties to amplify microwaves was original, opening up a new means of communication and leading to improvements in radar and other remote sensing devices. Similarly, when people began to build light oscillators in the early 1960's—now called lasers—they relied on some of Townes' ideas, but the actual techniques they used were quite different from those used in Townes' maser.

Schawlow worked at Bell Laboratories during this period. (Townes intermittently served as a consultant for Bell,

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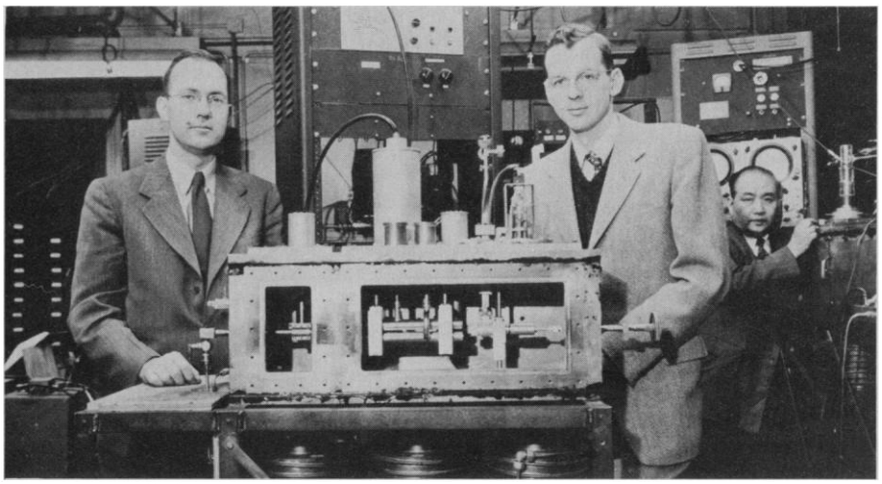
too.) Schawlow helped his brother-in-law produce a basic text on microwave radiation (published in 1955), a groundbreaking *Physical Review* paper on methods of building optical masers and lasers (published in December 1958), and a basic patent on the laser (applied for in 1958 and issued in 1960).

Gould was a graduate student at this time, working on a Ph.D. thesis in the Columbia Radiation Laboratory, where Townes was a professor. Gould had been a student of optics for many years, having earned a B.S. in physics in 1941 from Union College and an M.S. in physics from Yale in 1943. He worked at a scientific mirror company and on the Manhattan Project before enrolling as a Ph.D. candidate at Columbia in the late 1940's. According to his testimony, Gould was stumped for 2 years at Columbia by a problem he encountered in his thesis project: he could not excite thallium atoms to an upper-level energy state required for experimental measurements he was making. Then in 1956, Gould said, the chairman of the physics department, I. I. Rabi, told him about French experiments with a technique called optical pumping. Rabi suggested that Gould use light rather than heat to excite the thallium atoms. Gould tried the new idea, and it worked.

Gould claims that this experience led him to realize sometime in 1956 that optical pumping—shining carefully controlled frequencies of light on a substance to excite it—could be used to create conditions for microwave amplification. Gould discussed this with Townes and even gave a lecture on the subject at Townes' request. Gould, in turn, asked Townes on 3 January 1957 to witness some notebook pages in which Gould set out his general ideas about optically excited masers. Townes read the notes and signed his name.

Gould said during the trial this year that he considered the maser data interesting but not earthshaking. However, in the fall of 1957, Gould says he suddenly realized that optical pumping could be used to create not just a maser, but an intense, narrowly collimated beam of light. Borrowing from Townes' terminology, he called this idea light amplification by stimulated emission of radiation, or laser. Gould's notebook, witnessed by a candy store notary in November 1957, discusses the general scope of this idea and records the first use of the term "laser." (Even today, Townes prefers to use his own term, the "optical maser.")

By the summer of 1958, Gould claims, he had envisioned a technique that would make the laser not only feasible but commercially viable. He thought that his thesis adviser would be against any project that smacked of applied science, and so, Gould says, he wrote up his thallium experiments and quit Columbia. He soon went to work for a company on Long Island called TRG, which helped him file a patent on the laser in April 1959.



The Maser, 1954

*Charles Townes (left), T. C. Gordon, and T. C. Wang with the invention that earned a Nobel Prize, a device that produced microwaves by stimulating ammonia vapor. [Courtesy of A. Schawlow]**

Three key patents were filed at this time. They do not necessarily contain what people have assumed. The first was Townes' alone. It was filed in 1955, revised in 1958, and granted in 1959. The second was Townes and Schawlow's jointly. It was filed in 1958 and granted in 1960. The third was Gould's, filed in 1959, divided, revised, and granted in part in 1977.

Townes filed the first patent to secure his maser concept, in which a beam of ammonia molecules is stimulated by electromagnetic manipulation to emit microwaves at a fixed frequency.

This first patent was still pending in the fall and winter of 1956 when Townes became concerned that others might encroach on his invention. He wrote to his lawyer about this, listing all the recent discoveries that might crowd his claim. As early as March 1955 he had mentioned to his lawyer a brief comment in his 1954 notebook, a note on the possibility that optical pumping might be used to stimulate a maser. It was one of five techniques Townes mentioned but did not describe in detail.

Several months after writing a more concerned letter to his lawyer in 1956, Townes read Gould's notebook and its rather detailed description of optical pumping for masers. Patent applications are secret, and Gould says Townes never mentioned that he hoped to include this idea in his maser patent.

In January 1958 Townes resubmitted his patent with some new material, including a brief disclosure of the optical pumping idea. The discussion was general and gave no specific examples of how to produce microwave radiation by optical means. Most of the disclosures and nearly all the claims dealt with ways in which ammonia beams and electromagnetic stimulation could be used to produce coherent microwaves.

This patent was granted in 1959, and in the late 1960's Townes' agent threatened to sue the largest manufacturer of lasers, Spectra Physics, for infringement. After weighing the alternatives, the company conceded and settled out of court in 1971, paying a royalty of 2 percent. The rest of the laser industry followed suit until the patent expired in 1977. There has never been a large market for ammonia beam masers. Thus the companies that make light amplifiers and oscillators provided the only significant income on Townes' patent.

The extraordinary fact is that the patent does not explain how to build a laser. It says nothing about coherent light waves. It is concerned with microwaves.

Why, then, did laser manufacturers agree to pay royalties? One laser inventor says that his company (Hughes Aircraft) decided it would cost more to go to trial than to pay the royalties.

Townes says it was perfectly correct to charge laser companies under this patent because the principles of laser operation are the same as the maser operation. He stresses that the laser is simply an optical maser, and no one questions his priority in inventing the maser.

*Photo: *IEEE Transactions on Electron Devices*, vol. ED-23, No. 7 (July 1976).

The second patent, filed jointly by Schawlow and Townes, was awarded in 1960. Because much of the work was done at Bell Laboratories where Schawlow worked, Bell was assigned the rights. Entitled "Masers and maser communications system," the Schawlow-Townes patent made broad claims but described only one apparatus: a device that uses potassium lamps to excite potassium vapor, producing coherent light waves. As far as is known, no one has ever built a laser of this description.

Schawlow described the same device in a 1976 article, as follows:

> Townes then [after December 1958] started a graduate student, Herman Cummins, on a project to try and build an optical maser using potassium vapor. He was later joined by another student. . . . Considerable progress was made, but eventually the successes of other researchers led the Columbia University group to abandon work on potassium for easier approaches.

A Bell Laboratories official said that he knew of no company that used the Schawlow-Townes design.

Gould's application was the third of this group. Because he and his employer sought a defense contract to build a laser

The First Lasers

Many people have heard of Arthur Schawlow and Charles Townes, but few would recognize the name of the man who actually invented the first working laser: Theodore Maiman. His device was patented, but it was never used to assert a broad claim on the market, and it was never involved in a priority dispute. The record of the first laser contrasts sharply with that of the "paper lasers" involved in Gordon Gould's patent disputes.

Maiman, now an executive at TRW, built and operated the first laser when he was working for Hughes Aircraft in California during the spring of 1960. His device was a pink ruby crystal excited by a common xenon strobe light. Maiman says the company had to wait 7 years to obtain a patent, and the one it finally got was narrowly drawn, limiting its value as a source of income.

Hughes did not need to challenge Gould's claim because the relevant section was defeated by the Schawlow-Townes patent, the broad claim held by Bell Laboratories. Why didn't Hughes, with its working laser, go on to challenge Bell's claim? Maiman guesses that there was not any need to: Hughes and Bell have a cross-licensing agreement so that they need not pay royalties to one another. "They try not to challenge each other's patents," Maiman says.

As far as Maiman is concerned, Gould's colleagues at TRG and the Townes group "went off on a fruitless venture" in 1959–1960 trying to make lasers using alkali vapors. They spent a lot of money, Maiman says, and although the principles were well understood, "they just didn't figure out how to make a laser."

The situation on the East Coast was more confused than it may look in retrospect, Maiman believes. Schawlow at Bell Laboratories inadvertently threw some experimenters off course in 1959 when he put out the word, based on inadequate calculations, that ruby crystals would not emit laser light. Several months later, Maiman's brute fact proved him wrong. While working on this experiment, Maiman says, "I was aware of the reasons why ruby was not supposed to work, but I also knew that they were wrong."

The story is confirmed by William Bennett, Jr., professor of physics at Yale University who studied under Townes and knew Gould as a fellow student at Columbia. During a 3-year stint at Bell Laboratories, Bennett collaborated with another former student of Townes', Ali Javan, and with Donald Herriott in building the first continuous beam laser, also the first gas laser. (Maiman's laser was pulsed.) The gas laser first operated in 1960, and Bell obtained a patent in 1964. Gould's application came into conflict with this patent, too, but lost because it was less detailed. The government ruled that Gould did not teach how to build a workable oscillator.

Gould's patent, according to Bennett, "could not teach one skilled in the art how to build a laser, although it was good for a long-winded research project." Townes' laboratory at Columbia was no more successful at laser design than Gould and TRG, Bennett says. Both tried to build alkali lasers. The Columbia group gave up after a year because the cesium vapor in its device kept eating through the vacuum seal, Bennett recalls. TRG much later succeeded in making a helium-cesium laser oscillate, but only after Bell had demonstrated the less troublesome helium-neon laser of Javan, Bennett, and Herriott.

Bennett recalls that an atmosphere of skepticism about laser oscillators pervaded Bell Laboratories before Maiman's experiment. At one point, the Bell administration considered cutting off funds for research on the helium-neon laser, just months before it was made to work. It was only after Maiman demonstrated that a laser actually could be built that the clouds of skepticism lifted. Then, Bennett says, money quickly became available for all kinds of laser projects.

Bennett mentions another historical curiosity. Although an American built the first laser, his invention was first reported in the British journal *Nature* after an American journal, *Physical Review Letters* (*PRL*), rejected the report. The editor of *PRL* had recently announced a policy of "no more maser papers," according to Bennett, and hapless Maiman had called his device an optical maser. *PRL* later relented, publishing papers by Schawlow and others on experiments like Maiman's.

PRL adopted the short-lived moratorium because the editorial offices were flooded in 1959 and 1960 with maser papers. One contributor to the flood, Bennett recalls, was Bell Laboratories, which urged its scientists to rush into print with data on optical masers. This was Bell's response to the news in 1959 that the Department of Defense was preparing to classify the entire area of research, a crisis ironically triggered by Gould and TRG. They had briefed the Pentagon on the potential military uses of lasers and won a $1-million contract to explore these ideas. The award was sizable, even by Bell Laboratories' standards. By publishing all that was known about masers and lasers, Bell snatched this field of physics from the hands of the military censors. Bell might not have been so bold if it had won the $1-million contract itself.—E.M.

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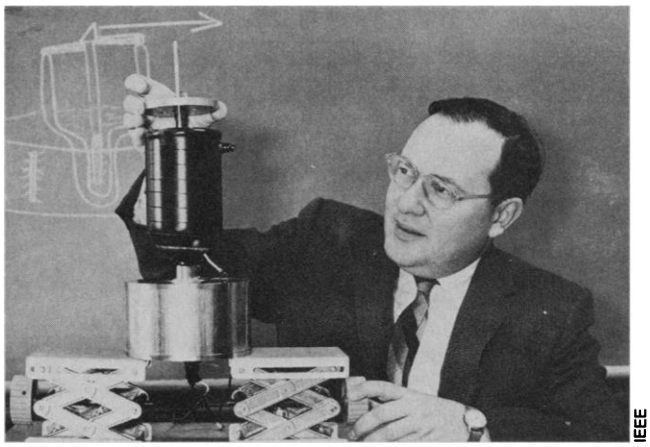
at the same time they filed the patent, all of Gould's documents were immediately classified. Lacking a security clearance, Gould was banned from working on his own project. Eventually the application was declassified and subjected over the next decade to a series of five interferences. These are proceedings run by the Patent Office to determine which of two competing claims has priority.

Gould lost three and won two of these battles. One of the first he lost was a contest with the Schawlow-Townes patent on the question of which had been the first to describe a type of oscillator known as the Fabry-Perot resonator. Although Gould's notes on this device predate those of Schawlow and Townes, he filed his patent 8 months later than they, and he could not satisfy the government that his notes described the design adequately or that he had pursued the idea with enough diligence to warrant the award of a patent. Gould thereby lost his claim to priority on the oscillator, and this is why the present patent refers instead to an amplifier.

Gould's patent is thus a fragment of the original filing, a piece that has not been chipped away by the legal jousts. It describes a scheme in which broadband light from one material is used to excite a different material, thereby generating laser light. The chief distinction from the Schawlow-Townes patent is the use of different materials in the pumping "lamp" and the medium being excited by the lamp. The importance is that this permits the builder to optimize the two media independently, allowing for greater efficiency and stronger light output. This configuration, Gould says, makes the laser commercially viable.

Like Schawlow and Townes, Gould failed to build a working laser before filing his patent. Like them, he described systems he thought would work, hoping this would give weight to the application. Gould included many ideas, some of which proved workable, he says. One idea was to use ruby crystal. Another was to use a sodium lamp to pump rhodamine dye. (To prove it would work, Gould built one of these last year.) Although some of these concepts were later embodied in working lasers, Gould did not give a specific description of any design that became commercially successful. Nevertheless, he hopes to follow Townes' lead in asking laser companies to pay royalties on the concept.

Townes is amazed at the suggestion that he may have used some of Gould's ideas. In the first instance—the idea for optically pumped masers—Townes cites his own notes of 1954 and correspondence in 1955 and 1956, which show that he had thought about optical pumping even if he had not explored it long before he saw Gould's notebook. Townes adds that Gould must know this, because these early notes were discussed in a court battle over Gould's patent in 1966. Gould says he has never seen these early notes.



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The Laser, 1960

Arthur Schawlow holds an early laser that used a strobe flash lamp to excite a dark ruby crystal. The canister contained liquid nitrogen to cool the crystal.

In the second instance—the idea for optically pumped lasers—Townes cites the paper he and Schawlow published in the 15 December 1958 issue of *Physical Review*. Townes says that preprints were circulating during the summer when Gould was writing his detailed notes (witnessed 28 August and 2 December 1958) that became the basis of his patent and military contract applications. However, the paper dealt primarily with potassium-potassium lasers and methods of constructing a Fabry-Perot resonator. It devoted only about ten sentences in ten pages to a general discussion of the concept in Gould's patent: the use of light from one substance to stimulate laser light in another. Townes now says this idea was so obvious that he did not consider it patentable and therefore did not bother to describe it in his own or in the Schawlow-Townes patent.

Several early laser builders agree that Gould's 1959 application contained little that was not obvious to maser researchers at the time. For example, Donald Herriott, a coinventor of the gas laser, and Theodore Maiman, inventor of the ruby laser, support this view. Maiman serves on the board of Control Laser and plans to testify against Gould's claim in the upcoming trial in Florida. Townes himself says that Gould's case is a legal contrivance built upon an early filing date, notebooks filled with obvious data, and clever litigation.

Two of Gould's contemporaries with no vested interest in the dispute say Gould did have original ideas that were later incorporated in working lasers. William Bennett, Jr., a physics professor at Yale and coinventor of the first gas laser, says that while Gould did not solve all the design problems, he seems to have intuited and recorded before anyone else the dimensions and principles of some devices that would produce laser light.

Peter Franken, director of the optical science center at the University of Arizona, defense consultant, and former president of the Optical Society of America, testified as an expert witness on Gould's behalf at the San Francisco trial. He was asked to comment on this 23-year-old dispute because he organized the first international conference on optical pumping, held in June 1959, and is well suited to speak about the state of the art in 1959. Asked about Gould's idea of using one substance to pump another, Franken testified: "I could only describe those notions as exceedingly unobvious at that time. . . . If I had been able to make those connections, I would have changed fundamentally the course of my research at Ann Arbor, gone into my laboratory as soon as possible and done it, or tried to have done it."

One of the few points that is clear in this long, contested record is that several people almost simultaneously hit on the laser concept, and that a few in quick succession built lasers that proved to be well engineered. Those who built the first lasers did not seek the broadest patents, and they have not been widely recognized as inventors.

Gould was not among the first builders, and he cannot claim to have been an important teacher of laser craft, either. His notes, after all, were kept secret by the military and the Patent Office during the early 1960's, when so many inventors burst on the scene. However, through a course of persistent litigation, Gould has established his claim to be one of the first conceivers of the laser, and this, he hopes, will prove to have been worth the fight.—ELIOT MARSHALL