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INVESTIGATIONS ON A HOLLOW CATHODE He-Cd ION LASER

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Since the application of hollow cathode devices for metal vapour lasers [1,2] a large number of new cw laser lines have been observed in hollow cathode discharge lasers. Many of these laser lines are absent or operate only by pulsed excitation in positive column lasers. In the negative glow, due to the presence of fast electrons accelerated by the cathode fall, the ion spectrum is rather strong. Most of the new cw laser lines are excited by charge transfer collisions between noble gas ions and metal atoms [3,4,5,6]. The hollow cathode laser, on the other hand has some technical difficulties; eg. the discharge current should be uniform along the tube, the cathode becomes rather hot due to the high current density, the latter makes the temperature of the metal used for laser action undefinite etc. For this reason, the first investigations were restricted to merely qualitative statements of laser action in different lines. Only recently were results published which described an improvement of the hollow cathode laser systems and reported measurements concerning the intensity of the laser lines as a function of different discharge parameters [7,8,9]. In the following, a new hollow cathode device is described which proved to be very suitable for this kind of investigation.

First the details of the construction are outlined, and then our experimental results are presented concerning the influence of the discharge current, He gas pressure and Cd concentration on the intensity of different He-Cd-ion laser lines in a broad range of these parameters. The main attention was paid to the 5378 Å green line.

The scheme of the laser tube is shown on Fig. 1.

In an outer pyrex tube a stainless steel slotted hollow cathode /50 cm long, 4 mm inner diameter/ was placed on a ceramic body. The laser had 21 anodes and resistances of 270 Ω were connected to each of them in order to ensure the homogenity of the discharge along the tube. Cd metal was evaporated in the two furnaces and the Cd vapour was distributed in the cathode region by diffusion. The tube itself was heated only by the discharge current, but it proved to be enough to increase the temperature in the tube always higher than that was in the furnaces. Thus, the Cd vapour pressure in the tube was determined by the furnace temperature. Two water-cooled ends protected the Brewster windows from the metal vapour. Half-wave rectified 50 Hz a.c. current

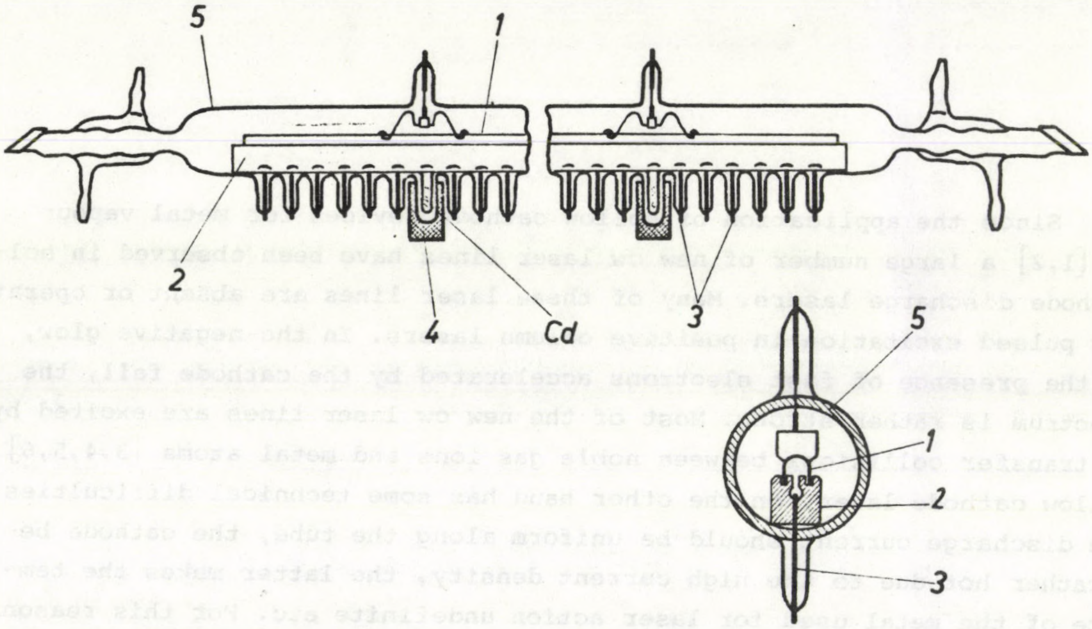

Fig. 1 Hollow cathode laser tube. 1, cathode, 2, ceramic body, 3, anodes, 4, furnaces, 5, pyrex tube

was used to excite the discharge; this allowed us to increase the discharge current range significantly without overheating the tube. By this way, measurements could be performed well above the optimum current of all laser lines. Laser oscillation was observed on four transitions of Cd II: 4416 Å, 5337 Å, 5378 Å and 6360 Å, respectively. The laser intensity - discharge current curves were measured using a double beam oscilloscope. On Fig. 2 typical oscilloscope pictures are shown.

Fig. 3 shows the intensity of the different laser lines investigated as a function of discharge current. The 5337 Å line had the same character around 20 torrs as that of the 5378 Å line and therefore it was not investigated at higher pressures. The two green lines were always lasing simultanously by using mirrors with high reflectivity at 5350 Å. The blue and the red transitions lased only when dielectric mirrors appropriate for their wavelength were used, simultaneous oscillation with broadband mirrors could not be obtained.

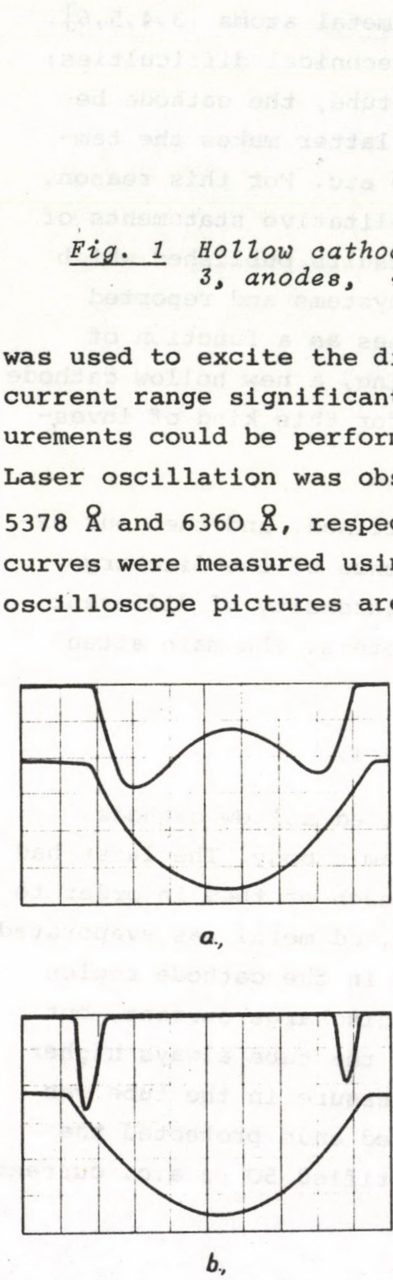

Fig. 2 Oscilloscope curves of two laser lines. The upper line is the laser line, the lower is the discharge current. a/ λ = 5378 Å 18 torr, I_{max} = 4,8 A. b/ λ = 6360 Å 14 torr I_{max} = 4,4 A.

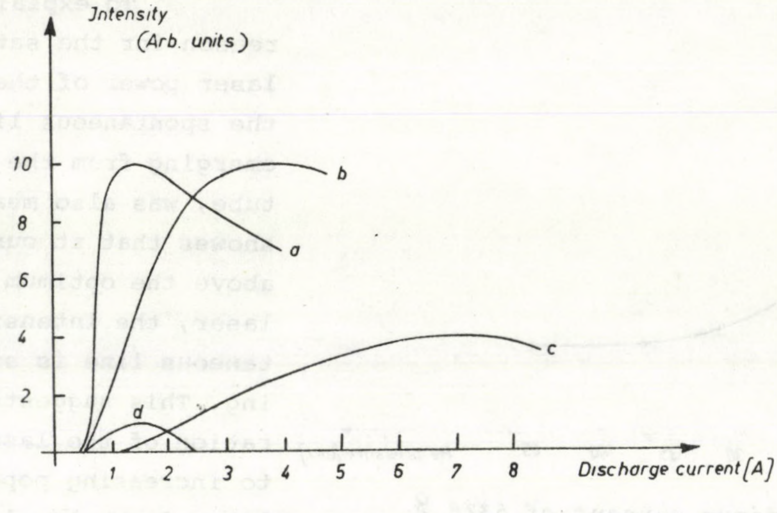

Fig. 3 *Current dependence of different laser lines.*
a/ 5378 Å, 36 torr, 520°,
b/ 5378 Å, 19 torr, 450°,
c/ 4416 Å, 16 torr, 400°,
d/ 6360 Å, 12 torr, 400°

On Fig. 4 the He pressure dependence of two Cd II laser lines is shown. The 5378 Å lines has practically the same power between 14 and 40 torr, but it has to be noted that with increasing pressure the optimum current significantly decreases /Fig. 5./, while the optimum temperature slowly increases /see Fig. 3/.

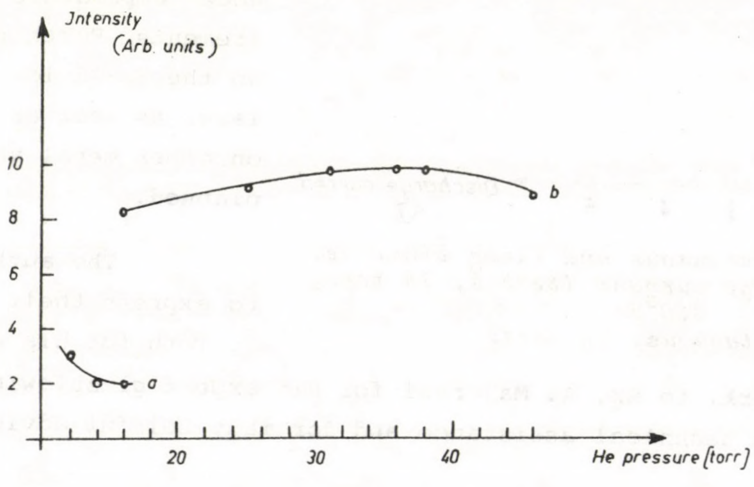

Fig. 4 *Pressure dependence of two laser lines. a/ 4416 Å, 3,9A, 400°, b/ 5378 Å at its optimum current and temperature*

It is also worth to mention that the current dependence of the 5378 Å line becomes more and more steep with increasing pressure.

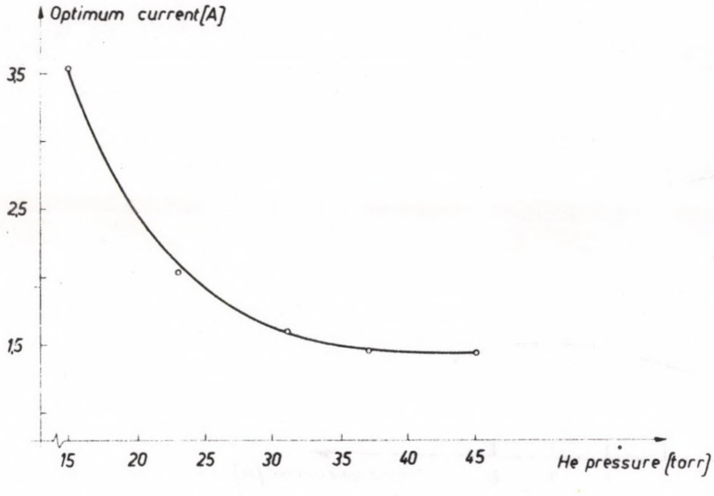

Fig. 5 *The optimum current of 5378 Å line as a function of He pressure. The furnace temperature is 500°*

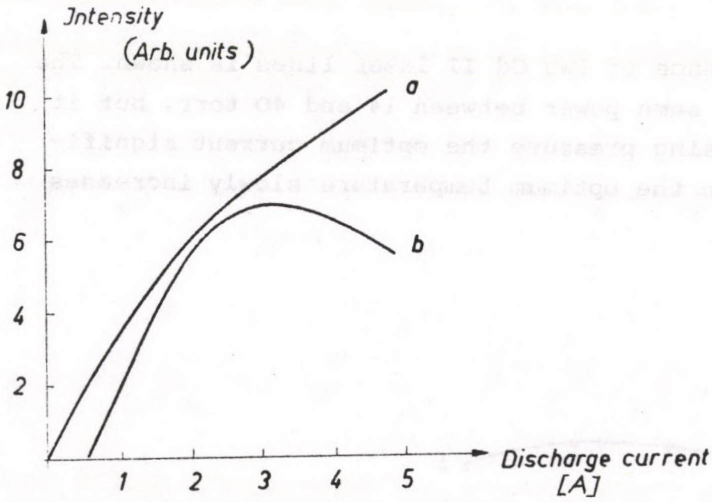

Fig. 6 *The spontaneous and laser lines vs. discharge current (5378 Å, 18 torr, 450°)*
a/ spontaneous, b/ laser

To explain the physical reason for the saturation of the laser power of the green line, the spontaneous light intensity emerging from the end of the tube, was also measured, Fig. 6 showes that at current values above the optimum current of the laser, the intensity of the spontaneous line is still increasing. This suggests that the saturation of the laser power is due to increasing population of the lower laser level.

The optimum furnace temperature measured seems to be too high and this suggests that the problem of the exact determination of the Cd concentration inside the cathode has still to be solved. Our temperature values therefore served only as reference temperature for the measurements. Further investigations on the He-Cd ion hollow cathode laser as well as investigations on other metal vapour lasers are planned.

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ABSTRACT

A slotted hollow cathode multiple anode device was constructed in order to perform measurements in He-metal vapour lasers. Metal temperature, gas pressure and discharge current could be changed independently from each other in a wide range of parameters. Dependence of different Cd II laser lines on these parameters was investigated.

РЕЗЮМЕ

Сконструирована разрядная трубка с полым и щелевым катодом и с многочисленным анодом для исследований лазеров на парах металлов. Осуществлена возможность независимого изменения давления пара металла, давления газа и тока разряда в широких интервалах. Исследованы зависимости разных лазерных линий гелий-кадмиевого лазера от перечисленных параметров.

KIVONAT

Üreges katódot és anódsort tartalmazó kisülési csövet készitettünk, amellyel fémgőz lézereken lehet vizsgálatokat végezni. Széles tartományban, egymástól függetlenül lehetett a fém gőznyomását, a gáznyomást és a kisülési áramot változtatni. He-Cd lézerben vizsgáltuk a különböző lézervonalakat az emlitett paraméterek függvényében.

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