

## Chapter II

### MATERIALS AND METHODS

#### 2.1 Instrument

##### 2.1.1 Mechanical

The nitrogen gas laser is a long, thin rectangular channel of nitrogen gas across which is applied a pulsed high voltage discharge. The housing for the discharge is a gas tight box, 5 cm. square and 30 cm. long. The housing is made of plastic sheet, 0.65 cm. thick. The end plates are thicker than the plastic on the sides. They are made of plastic, 0.9 cm. thick. A hole is drilled through the edge of each plate for hose connection. The ends of the laser housing are cut at an angle of  $25^{\circ}$  to prevent the reflection of radiation from the surfaces of glass windows back into the plasma. Glass windows are made of microscope slides, 13 x 51 x 1 mm. Over 80% transmission at 337.1 nm can be obtained through ordinary glass slides.

The discharge electrodes of copper sheet, 0.05 cm. thick, are cemented between two strips of plastic which form each side of the laser housing. The discharge electrodes are separated by 1 cm. apart. They are soldered directly to the discharge capacitors which will be discussed in the electrical part.

Figure 7 shows the laser housing with the discharge electrodes.

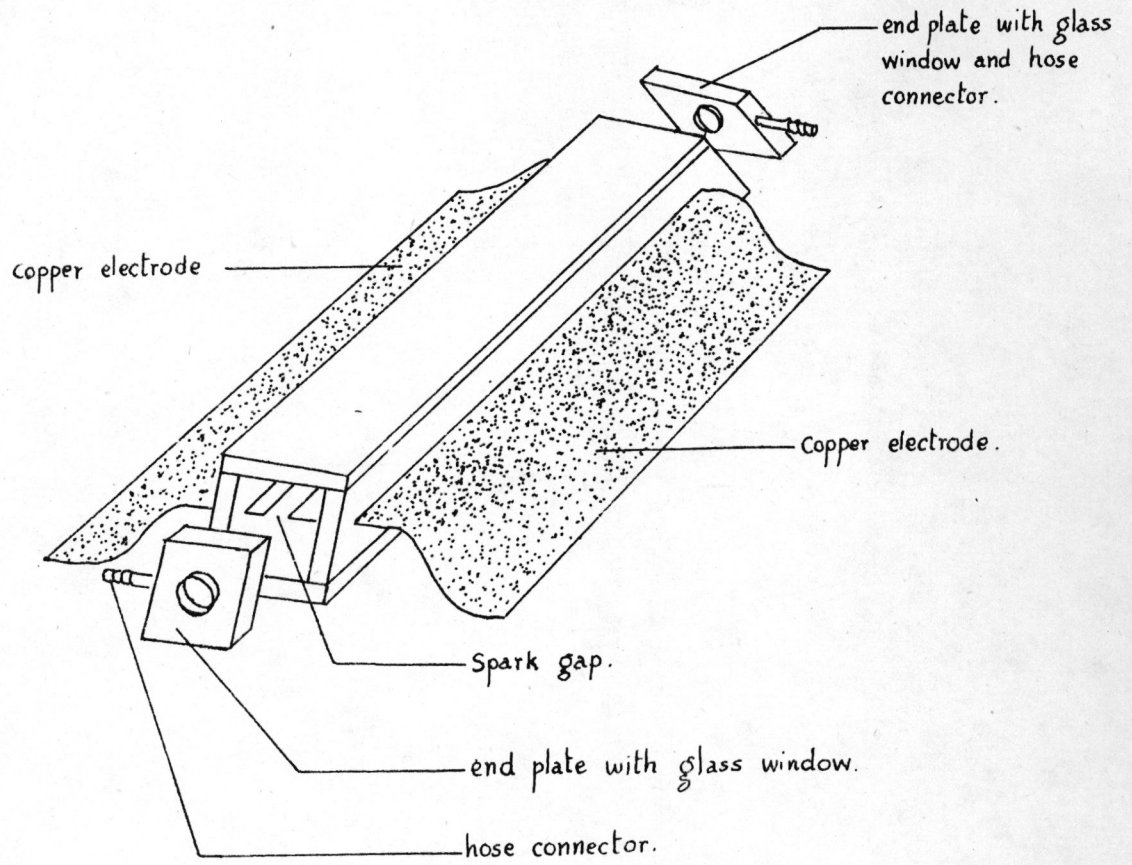


Figure 7 The laser housing with the discharge electrodes.

### 2.1.2 Gas handling

Nitrogen gas enters and leaves the laser housing via 0.65 cm. pipes with inner diameter of 0.15 cm. With a certain electrical and geometrical condition of the laser housing design, laser lasing in nitrogen gas is observable in flowing nitrogen gas at pressure about 100 torr.

Any type of vacuum pump can be used in this experiment. The pump must provide sufficient gas evacuation to remove the hot nitrogen gas from the laser housing. A mercury manometer is used to measure nitrogen gas pressure in the laser housing. The manometer is connected between the nitrogen tank and the laser housing. A pressure regulating valve is connected at the output of the nitrogen gas tank. Nitrogen gas of commercial grade can be used in this experiment, see figure 8.

### 2.1.3 Electrical

The stratagem of inducing laser lasing action in nitrogen gas lies in constructing an electrical system that can instantaneously send a huge current at a high voltage transversely through a column of the nitrogen gas at low pressure. An appropriate electrical system used in this experiment is the switching mechanism, which can handle thousands of amperes within a short period of time. The Blumlein switching technique is used in the experiment and will be discussed.

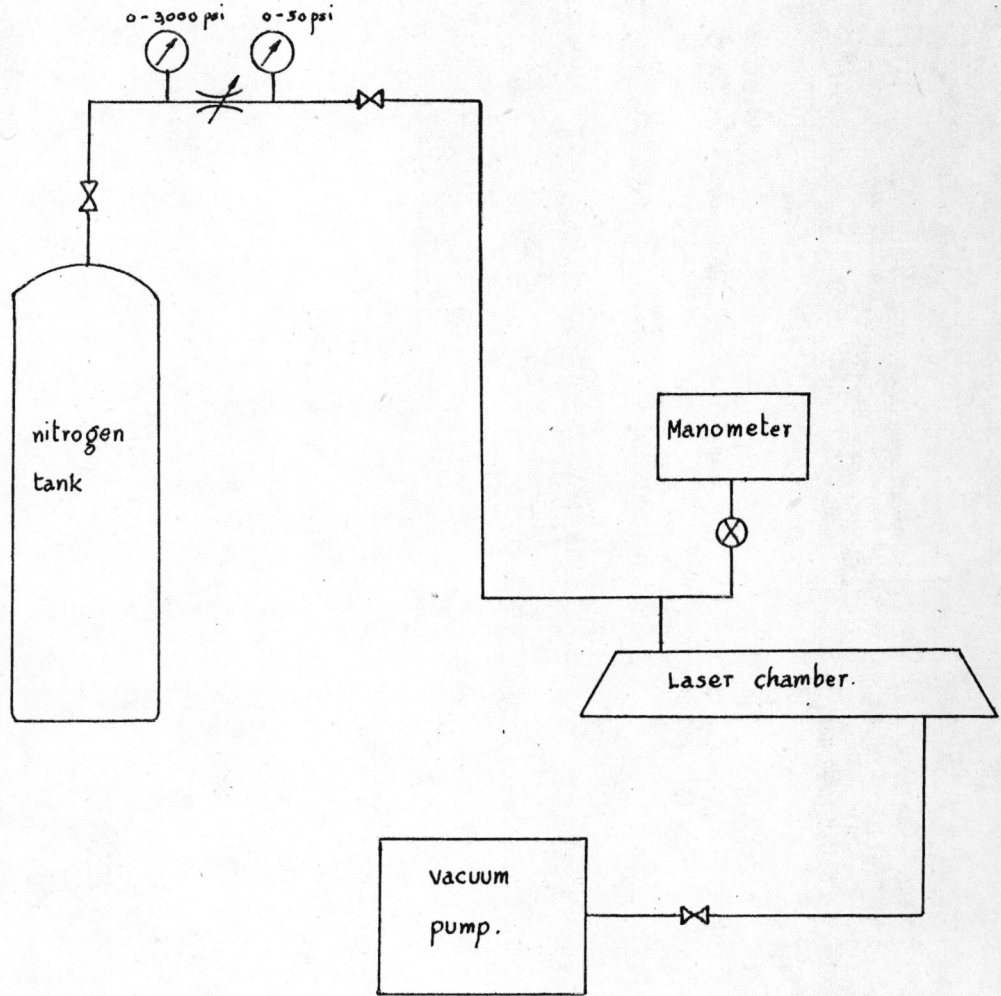


Figure 8 Gas handling diagram

## 2.1.3.1 The Blumlein switching circuit

The simplified Blumlein switching circuit is shown in figure 9

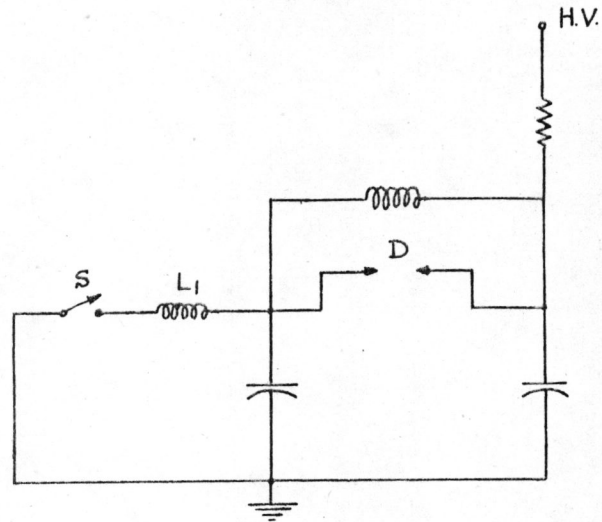


Figure 9 The simplified Blumlein Switching circuit.

In this experiment, the Blumlein switching device consists of two adjacent metal plates separated from the third plate (mutual plate) of equal total area by a thin sheet of insulator. This is illustrated in figure 10

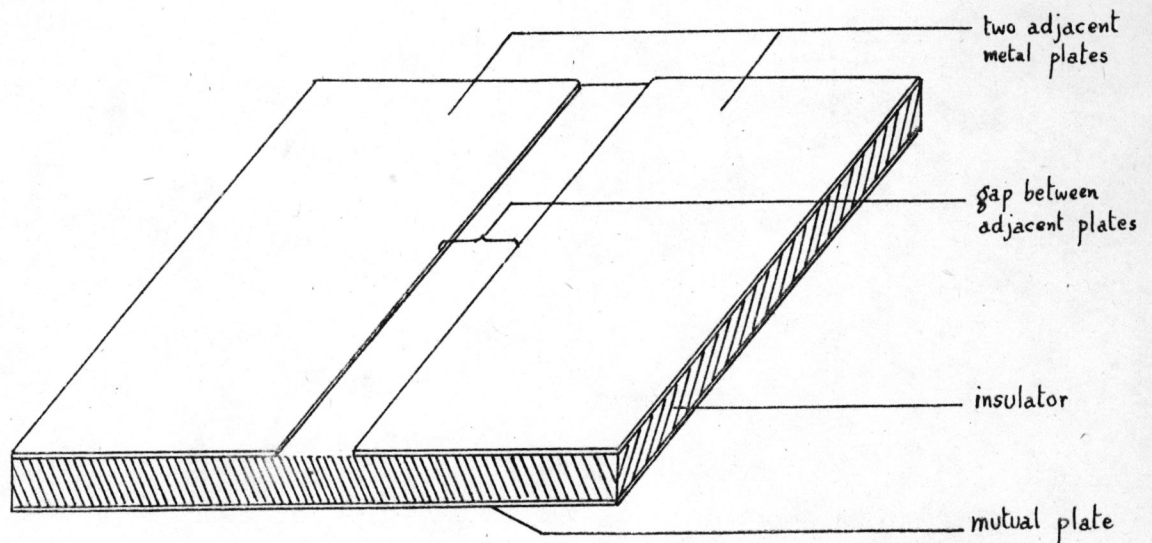


Figure 10 The capacitors in the Blumlein switch.

The two adjacent metal plates behave as an adjacent pair of interconnected capacitors. The space between the capacitors serves as the gap (gap D) across which electric current can be discharged through the nitrogen gas when the discharge electrodes are connected.

Between one of the adjacent plates and the mutual plate another spark gap (gap S) is constructed. A coil of copper wires is connected electrically between the plates of the interconnected capacitors. The Blumlein switch is shown in figure 11

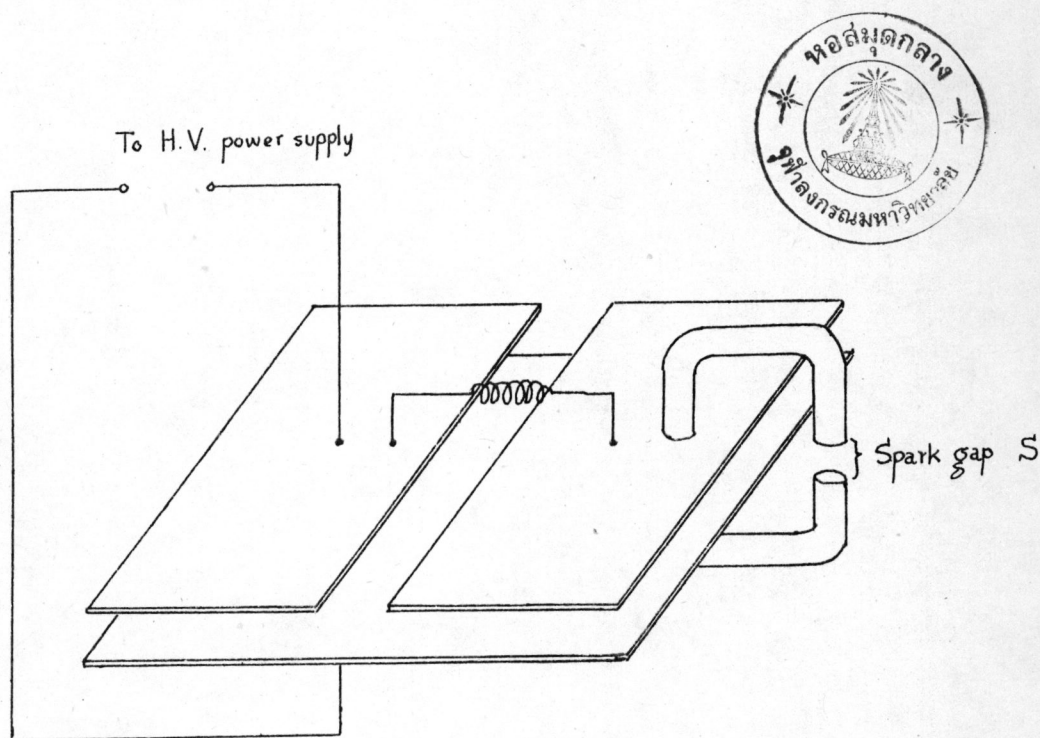


Figure 11 The Blumlein switch.

In this experiment, the capacitors are made from an electronic circuit board which is clad with copper on both sides. The capacitors are formed on a single sheet of electronic circuit board, 32 x 45 x 0.16 cm.

copper is etched from a 3 - cm margin around the edge on both the top and bottom sides of the electronic circuit board. Across the top side a strip of 5 cm. wide is etched to form two adjacent plates of the capacitors, 17 x 26 cm. on each plate.

The spark gap between one of the adjacent plates and the mutual plate (gap S) is made of wide strap of aluminium sheet instead of wire to minimize inductance ( $L_1$  in figure 9 ). The spark gap (gap S) is adjustable via a brass screw, connected to the aluminium strap. The gap is enclosed by an opaque tube of plastic to absorb the emitting radiation. The coil of copper wire is 10 turns of number 20 SWG. copper wire and 2 x 2 cm. in dimension, see figures 12, 13 and 14

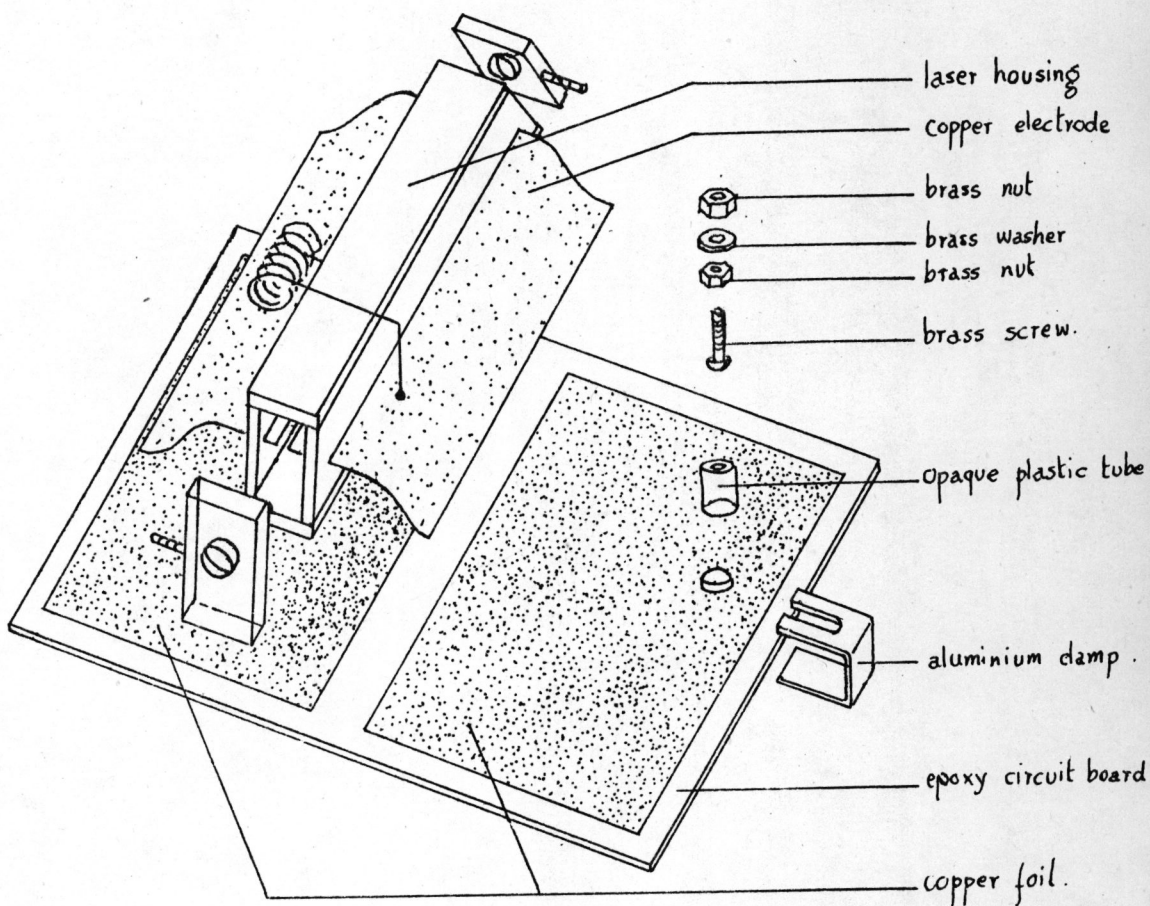


Figure 12 The exploded view of the laser





Figure 13 The photograph of the laser

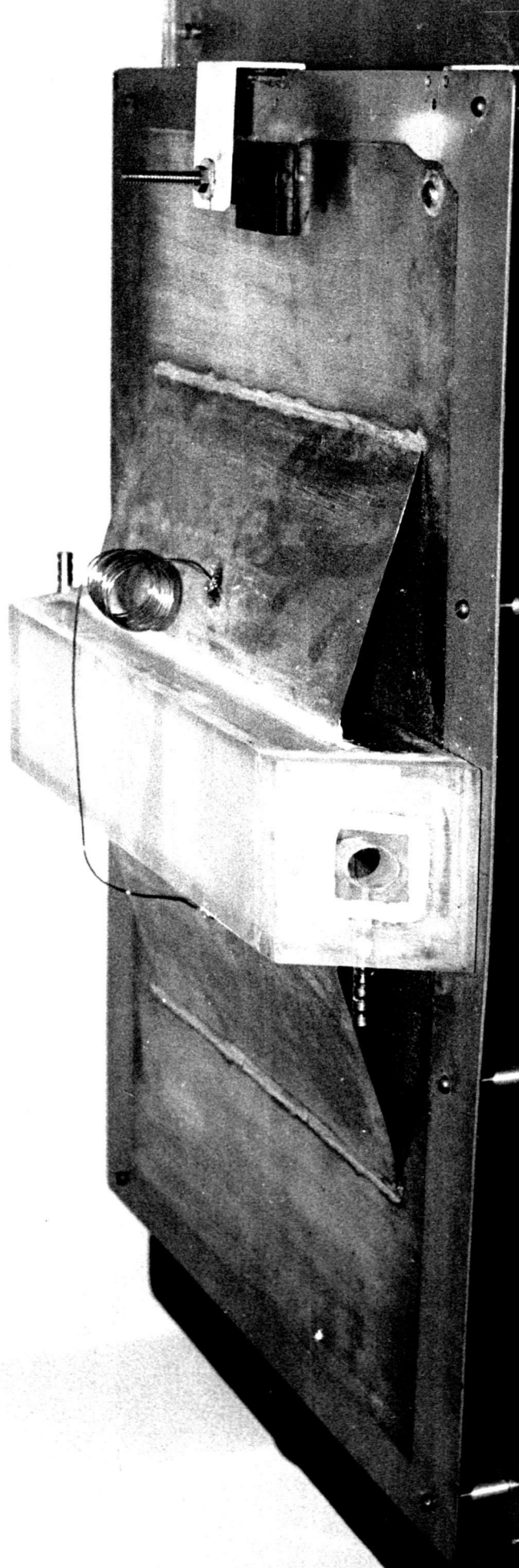
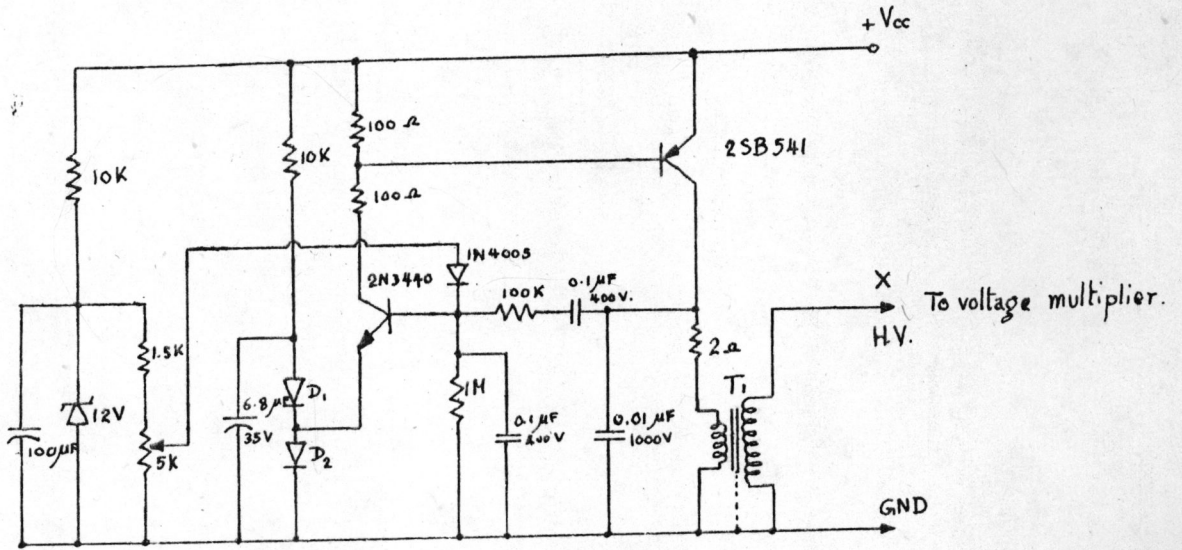


Figure 14 The top view photograph of the laser



### 2.1.3.2 The high voltage DC power supply

In the experiment, the power source used in inducing laser lasing in nitrogen gas is a high voltage DC. power supply. The power supply can deliver high voltage up to 25 kilovolts, with the output current much more than 1 milliamperere. The high voltage power supply is powered by any 12 volts low voltage high current DC power supply. The high voltage DC power supply circuit is shown in figure 15, and the photograph of the constructed high voltage power supply is illustrated in figures 16 and 17



$D_1, D_2$  light emitting diode. ;  $T_1$  ignition coil (12V)

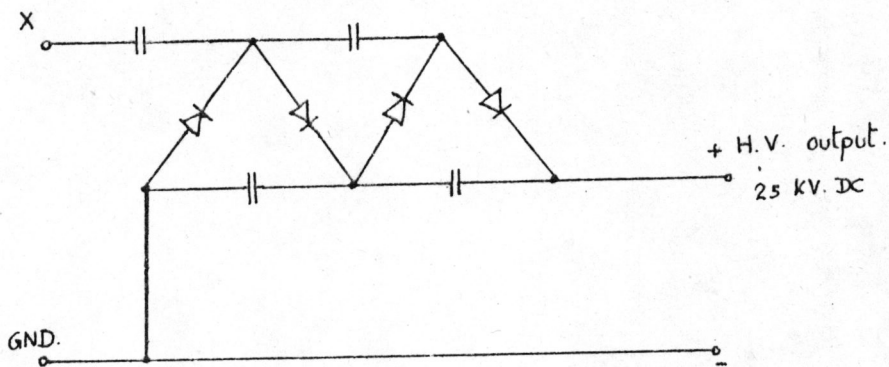


Figure 15 The circuit of the high voltage DC power supply

Figure 16 The photograph of the constructed high voltage DC  
power supply

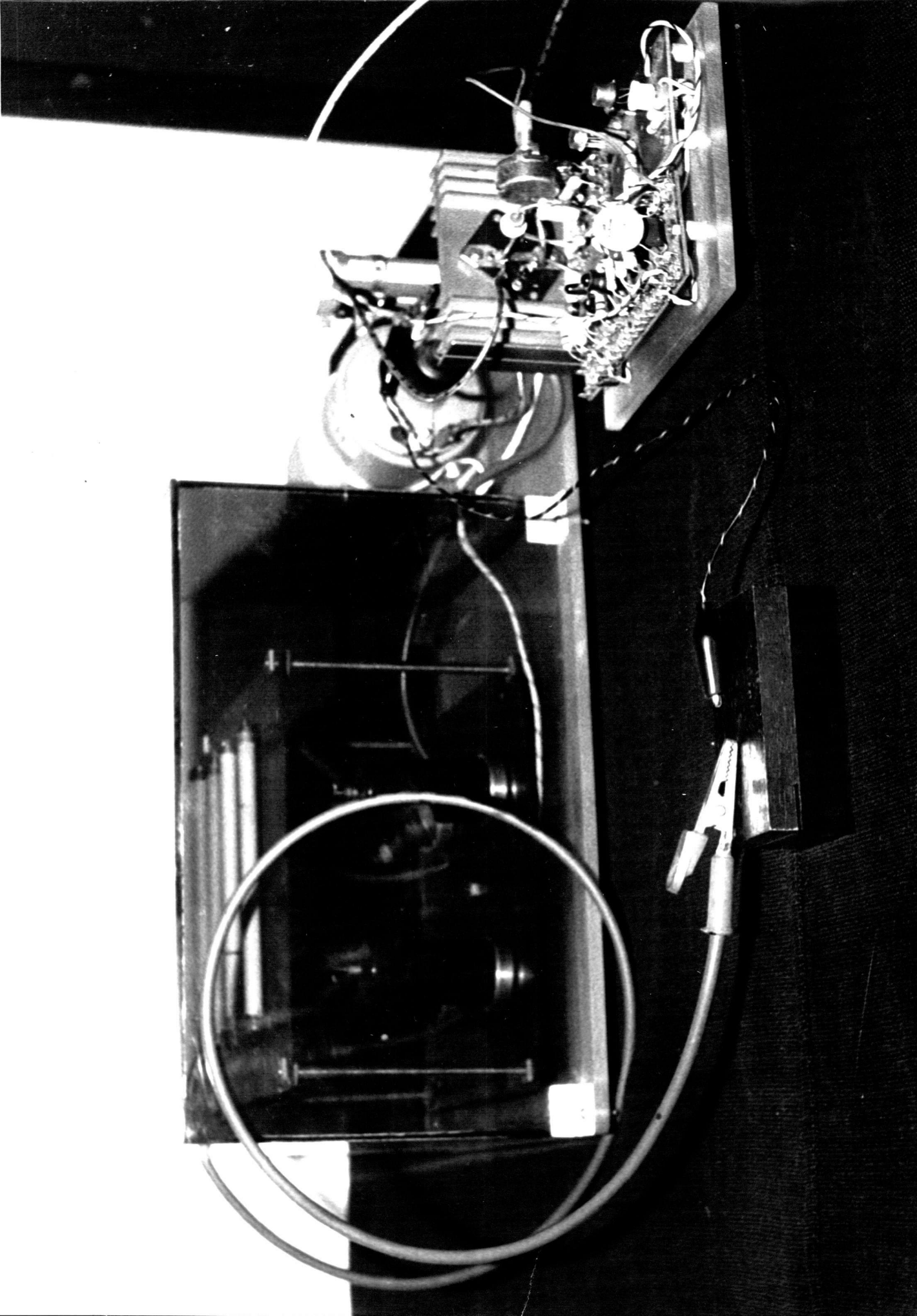




Figure 17 The top view photograph of the high voltage DC power supply

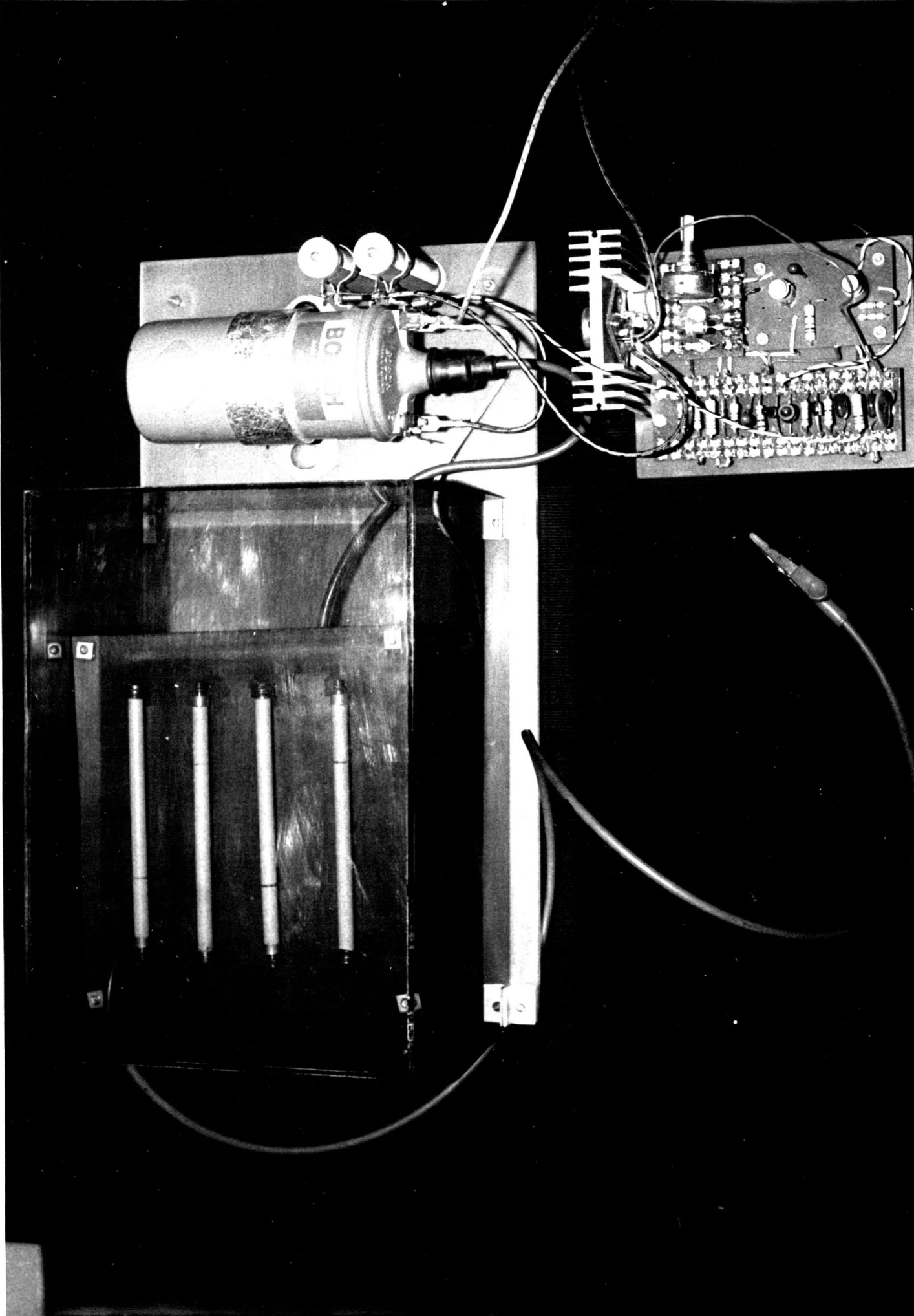
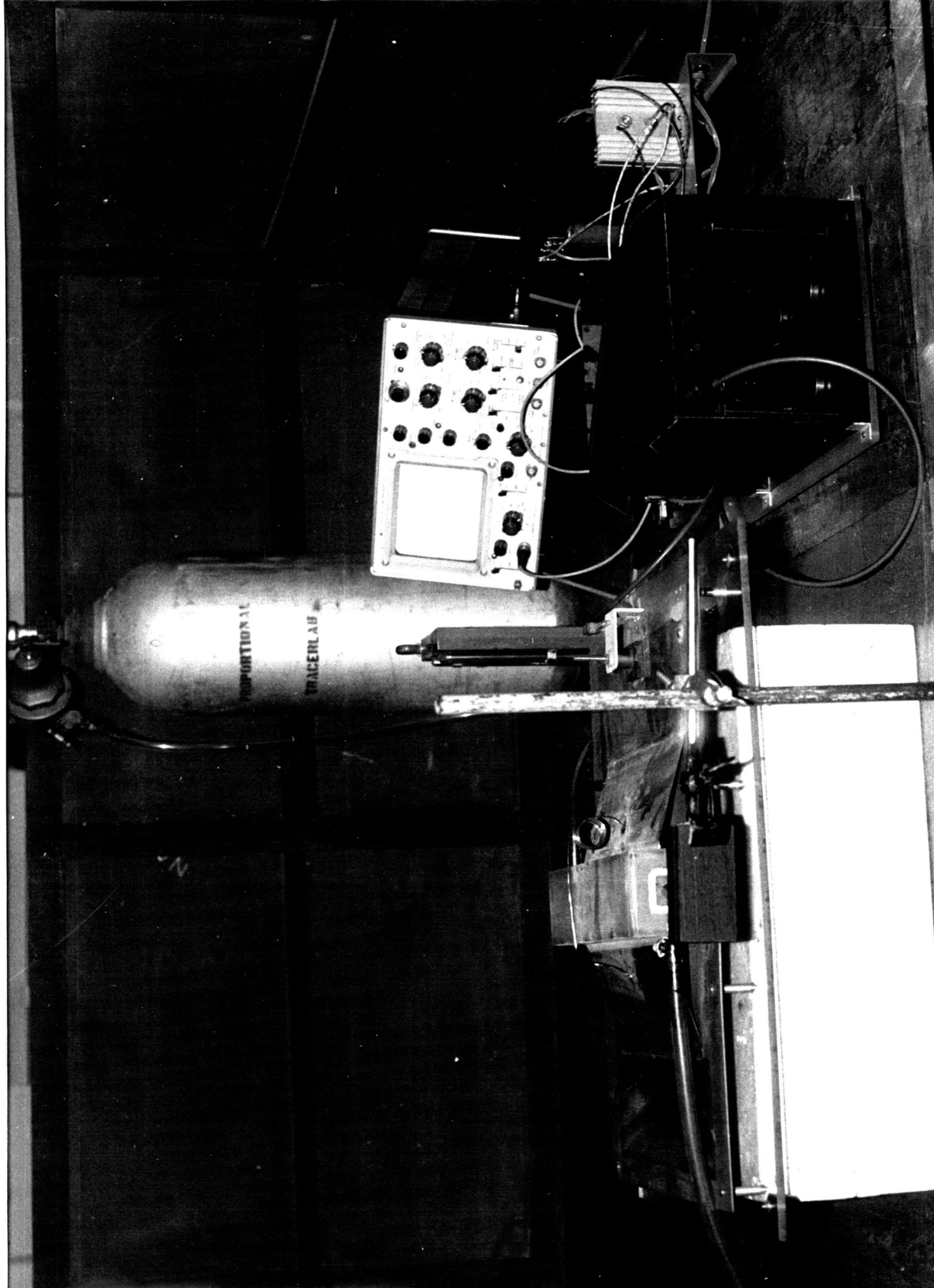


Figure 18 The photograph of the apparatus



## 2.2 Operation

As has been discussed, laser lasing action occurs only when running high current transversely through the nitrogen gas in the laser chamber in a short period of time. That is to induce high current electric discharge across the copper electrodes (gap D) in the laser chamber with flowing nitrogen gas at the pressure about 100 torr via the Blumlein switching circuit.

### 2.2.1 The Blumlein switching phenomenon

The two capacitors are charged by applying a potential difference between the interconnected plates and the mutual plates via an electronic high voltage DC power supply. Since the capacitors are interconnected electrically by a coil of copper wire, both capacitors are charged to the same potential and the same polarity. No potential difference exist across the gap between the adjacent plates (gap D) of the capacitors; that is between the copper electrodes in the laser chamber when the chamber is mounted on the capacitors.

The switching action develops, see figure 19, when one of the capacitors abruptly discharges through the spark gap S between one of the adjacent plates and the mutual plate, resulting a steep potential difference between the adjacent plates of the capacitors. (The copper coil now acts as an open circuit switch). That is a steep potential difference occurs between the copper electrodes in the laser chamber.

By adjusting the distance of the spark gap S to a suitable separation and the appropriate gas pressure, about 100 torr, in the laser chamber. Laser lasing in nitrogen gas is obtained.

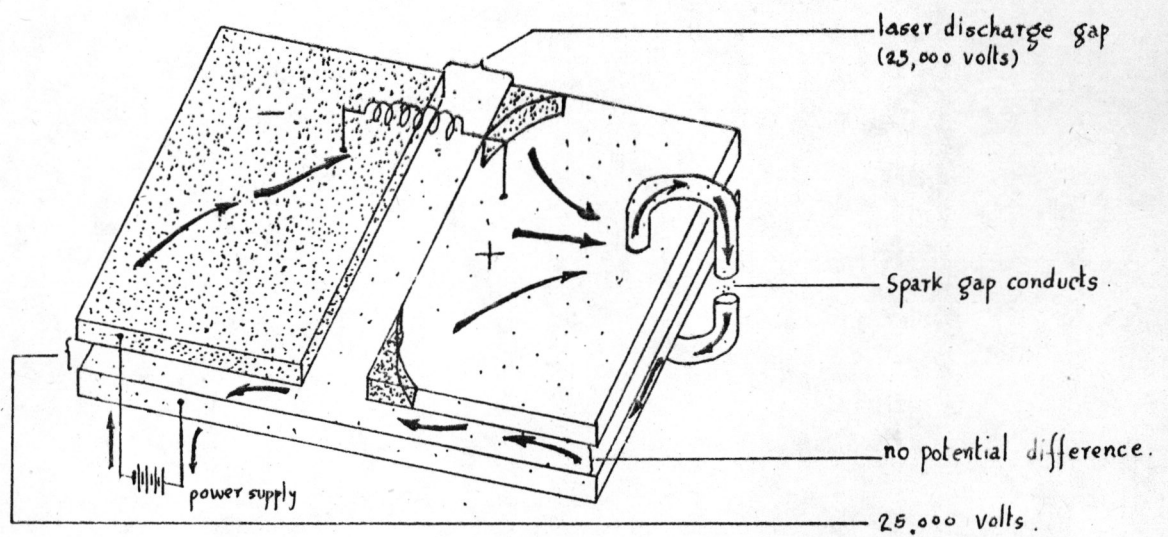
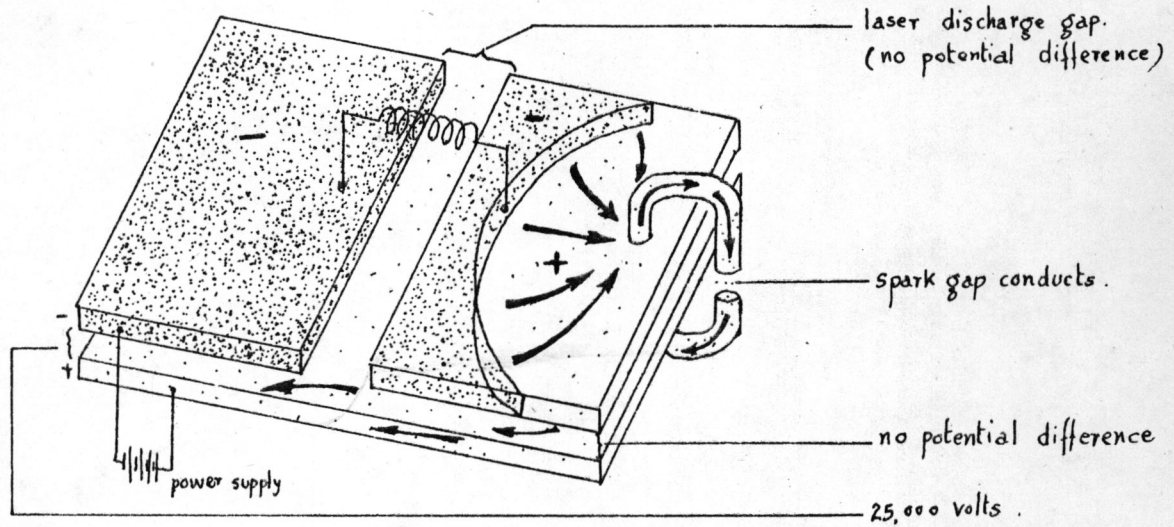
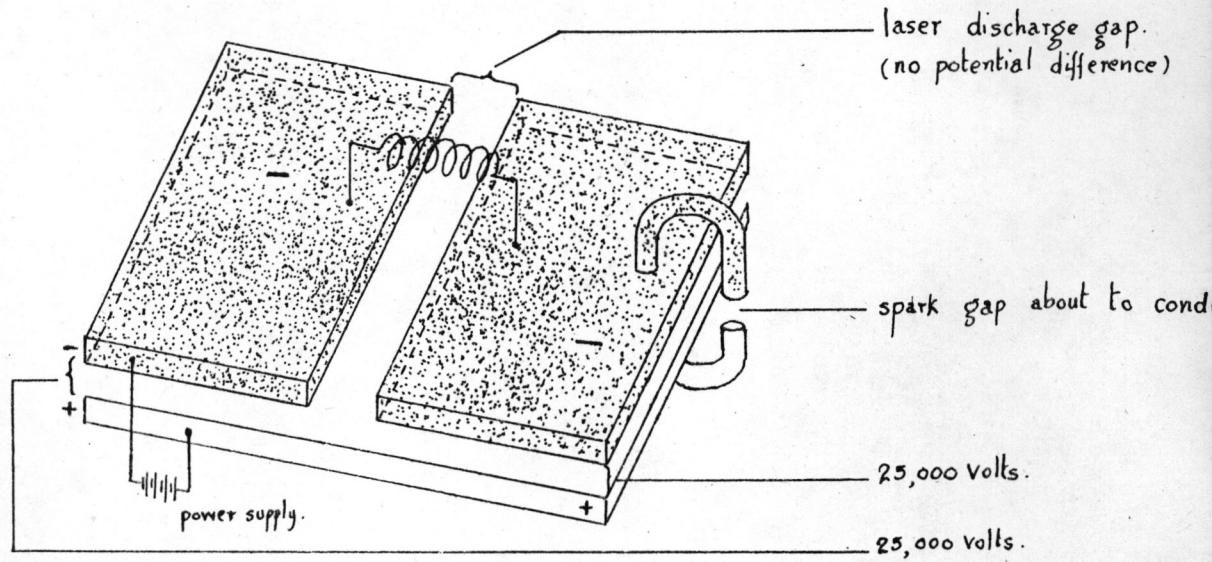


Figure 19 The Blumlein switching action