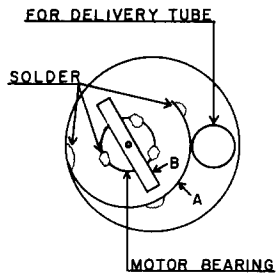

FIG. 2. Top end plate of pump showing installation of deflector plate (A) and impeller bar (B).

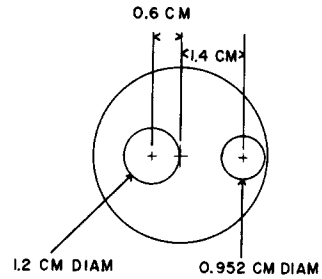

FIG. 3. Configuration of pump end plates (omit 0.952-cm hole for the lower plate).

approximate plot of flow rate as a function of head rise at an operating voltage of 4.5 V dc. The flow rate and maximum head rise appear to be directly proportional to the square of the applied voltage. The unit has been tested successfully to an upper limit of 12 V dc but is currently being operated at 4.5 V dc to reduce waste when filling small cold traps.

The unit described here has a simple and compact design. The end plates for the pump are made from available printed circuit board material (G-10 epoxy glass). These were cut into 3.81-cm-diam circles using metal shears. The dimensions given in Fig. 2 are for a motor sold by Radio Shack (catalog No. 273-310). The motor is rated 30 000 rpm at 12 V dc. It is approximately 2.5 cm long and 2.5 cm in diameter. The bearing material is Oilite. If a substitute motor is used, particular attention must be given to the brushes, as these must carry about five times more current than required in normal usage. The only part that requires particular care is the manufacture of the aluminum impeller bar ($2.22\times0.635\times0.317$ cm). The shaft hole should be drilled with a good #47 bit in a drill press. This will ensure a good press fit on the motor shaft. The hole should be carefully located to ensure proper balance. The outer pump casing and the deflector plate were cut from a duplicator fluid can. Thin copper or brass may also be used. A 1.587×10.149 cm strip, fabricated into a cylinder of 3.180 cm diam with 0.159 cm overlap at the ends, constituted the pump casing. The deflector plate consisted of a 0.952×5.319 cm strip bent to 1.27 cm radius. The motor is pressed into the upper end plate and soft soldered. Using a vise as a press, the impeller is then pressed onto the motor shaft. The deflector plate and the pump casing are soldered to the upper end plate (as shown in Fig. 3). The lower end plate is then soldered in place, taking care to align the inlet hole with the motor shaft. The delivery tube is now inserted into the outlet and glued with low-temperature epoxy. Our model operates on 4–6 V dc, drawing approximately 5 A in normal operation. A thin-walled, stainless-steel delivery tube with the power wires wound around it should decrease the heat flow. This alteration should allow the pump to remain submerged with little loss of LN_2. This would also reduce the strain on the motor due to continual exposure to extreme temperature changes. Cavitation appears to occur at all normal submergences, the flow rate increasing almost linearly with the depth of submergence. The unit will, however, continue to operate as long as the pump housing remains submerged.

The pump has proven to be both reliable and effective. Prolonged operation in a glass or other high-vacuum Dewar that has been emptied could lead to damage to the pump and Dewar due to excessive heating. This should not be a factor in metal Dewars that rely on low temperature to maintain their insulating properties. It is expected that this device will have other applications. While the unit described here works quite well for LN_2, it is not recommended for use in liquid air or oxygen. The sparks produced at the commutator would then constitute an explosion hazard.

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Fast, high current, high repetition rate pulse generator for injection lasers

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The circuit described is capable of generating high-current (2–50 A), fast-rise-time (10 nsec), square-wave pulses into a 50-Ω load. This circuit may be used for driving injection lasers at high repetition rates (up to 1.5 kHz) when connected to coaxial cables.

The commercially available injection laser sources may be operated efficiently at room temperature by high-current pulses (10–100 A) of perfect square-wave shape and short duration (10–200 nsec).[1] There are applications where such pulses are to be delivered to injection lasers which are connected to the end of a 50-Ω coaxial cable. The laser source

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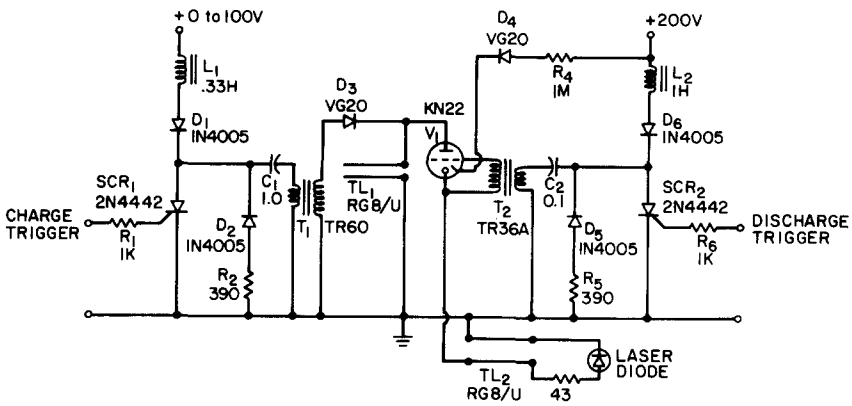

FIG. 1. Krytron pulse generator. Manufacturers: V_1, T_1, T_2—EG & G, Inc.; D_3, D_4—Varo, Inc.

may be driven by a pulse generator which consists of a switch and a transmission line charged to a high voltage. When the line is discharged it produces a square-current pulse whose duration is proportional to the length of the line. Pulse generators which incorporate SCRs as switches[2] are not fast enough, while those incorporating avalanche transistors[3,4] cannot hold the high voltages required. Instead, mechanical switches were tried, but their use was limited to low repetition rates.[1,5]

The Krytron (EG & G type KN-22) is a valuable device for the generation of short, high-current pulses. It is particularly useful where the pulses need to be transmitted over standard transmission lines because of its voltage rating, which is high enough to permit current levels of 40–50 A into a 50-Ω load.

For low repetition rates, it is sufficient to charge a transmission line through a resistor, and discharge it through the Krytron.[6] However, a problem arises as the resistance is decreased in order to increase the repetition rate, because if the rate of rise of anode voltage is too high, the gas in the Krytron does not have time to de-ionize after a pulse, and the device remains in a state of continuous conduction, which rapidly destroys the cathode.

A simple means of avoiding this difficulty is to charge the transmission line resonantly through a high-voltage pulse transformer, as shown in Fig. 1. With an appropriate choice of capacitor (C_1) and transformer (T_1), the line (TL_1) may be charged to the rated voltage of the Krytron in a period of a few tens of microseconds, upon applying a trigger pulse to the silicon controlled rectifier (SCR_1). The voltage to which the line is charged (and thus the amplitude of the current pulse) is proportional to the supply voltage of this stage, which need have a maximum value of less than 100 V.

A similar circuit, with lower stored energy, may be used to trigger the Krytron. After the discharge, it is necessary to delay the charging of the transmission line for several hundred microseconds to allow the Krytron to de-ionize.

With this type of circuit, it has been found possible to achieve repetition rates of up to 1.5 kHz. It is necessary, however, to keep the average current down to a level that will not overheat the Krytron.

Some attention has to be paid, in designing the SCR circuits, to making sure that they will operate at the required repetition rate without the SCRs remaining in the conducting state and, in effect, the circuit transfers this problem from the Krytron to the charging SCR, where it is more easily solved, and where the economic penalty is less severe.

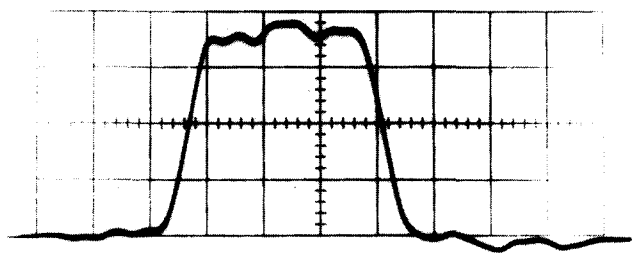

FIG. 2. Current through a laser diode connected across a 50-Ω coaxial cable. Horizontal scale—10 nsec/div; Vertical scale—10 A/div (10 sec exposure at 1.5 kHz).

If the supply voltage for the Krystron triggering stage is adequate (about 200 V), the keep-alive electrode may also be operated from it.

Typically we used a length of 5 m of RG-58 cable as a charging line (TL_1), and the current pulse obtained at 1.5 kHz is shown in Fig. 2. It is clear that the rise time is short, there is very little voltage reversal at the end of the pulse, and the jittering is rather low. When operating the circuit continuously at the highest rating (40 A and 1.5 kHz), the jittering becomes noticeable after about 45 min, and the rise time increases, but one can operate the circuit for 5–6 h before the Krytron burns out.

Where higher currents are required, lower impedance transmission lines, such as two or more 50-Ω cables connected in parallel, may be used, with a correspondingly lower load resistance.

[1]R. L. Carroll, Electronics **44** (No. 26), 59 (1971).
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