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# 자궁 재활치료를 위한 울트라-스캔 방식의 펄스형 레이저시스템

## Pulsed Laser System of Ultra-scan Way for Uterus Rehabilitation Treatment

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### 요약

레이저 출력은 20w에서 100w까지 연속적으로 조절이 되고 노출시간은 0.01초에서 수초 사이로 조절이 가능 하다. 펄스동작은 레이저 빔을 주기적으로 차단할 수가 있고 슈퍼펄스는 0.1~1ms사이에서 방전을 이루어지며, 순간적인 레이저 출력은 5~10 까지 증가된다. 특히, 자궁암의 경우 자궁구 내벽에서 악성세포를 제거해야 하므로 펄스에 대한 튜브출력의 안정이 매우 중요하다. 따라서, 본 연구에서는 영전압 스위칭동작을 확보하여 컨버터 1 차측 주 회로에 고주파 변압기 누설인덕턴스( $L_f$ ) 증가 및 직렬 인덕터 없이 안정된 소프트 스위칭 동작영역이 확보, 인덕터( $L_f$ )전류의 순환전류 경로차단 컨버터 1차측 주회로 스위칭소자와 고주파 변압기의 도통손실이 크게 줄어, 고주파 2차측 정류부( $D_5$ ,  $D_6$ )도 소프트 스위칭 되고, 스위칭손실 흡수분을 부하로 회생할 수 있는 특징을 갖고, 튜브안정화가 되어 설계 및 제작하여 실험한 결과, 기존장비에 비해 10%의 향상된 결과를 가져왔고, 추후 시스템적으로 보안을 하면 우수한 결과가 될 것으로 사려 된다.

■ 중심어 : | 과학기술 | 자궁 재활치료 슈퍼 울트라 펄스형 레이저 |

### Abstract

Laser output becomes output adjustment from 20 w to 100 w consecutively and time of exposure is available adjustment through water plant in 0.01 seconds. Pulse action can intercept laser beam periodically and supermarket pulse 0.1 ~ between 1ms discharge consist and momentary laser output is increased to 5 ~ 10 . Specially, that must remove malignancy cell in womb nine escarps in the case of uterine cancer first of all stability of tube output about pulse by weight very, stable soft switching action area is defined without high frequency transformer leakage inductance ( $L_f$ ) increase and additional series inductor insertion to converter the first main circuit securing zero voltage and marks of switching action in this research specially, because circulation current path of inductor ( $L_f$ ) current is intercepted, converter the first main circuit switching component and spiritual enlightenment damage of high frequency transformer take decreasing greatly and high frequency the second stoppage department ( $D_5$ ,  $D_6$ ) becomes soft switching, and also, switching damage absorption quantity characteristic that can come to life again as subordinate have, and to become tube stabilization design and result that manufacture and experiment, brought result that improve of 10% than existing equipment, and if supplement as systematic late, it becomes thought to get into superior result.

■ keyword : | Science Technology | Ultra-scan Pulsed Laser Super Uterus Rehabilitation Treatment |

I. 서론

Laser is getting into the spotlight in wide field of back for medical and basis research because can generate stable higher hrust pulse laser beam. Lately, is getting into the spotlight in wide scope field. Lately, according as medical of 20 W output and demand of making pulse CO<sub>2</sub> laser that have the pulse repeat rate fewer than 100Hz increase, request about miniaturization of laser power supply, easy of output control and low-cost aggravation etc. To satisfy convenience of preservation and repair as well as user's accommodation is augmented. So that power supply of existent pulse style CO<sub>2</sub> laser fits in the pulse repeat rate that want, switching element "on" speak "off" and is way to approve energy that is charged to condenser to laser discharge tube through high tension pulse transformer. That is, form supply the pulse energy to discharge tube after change DC by pulse energy through switching process. However, this need control department to control stoppage department and switching that change AC by DC. Though stoppage department is consisted of diode for stoppage, resistance for current limitation, archery practice bow condenser etc., capacity of condenser must great to get DC that ripple is low and switching department IGBT etc.. of use. Because is consisted of high speed switching small letter and control time, implementation of low-cost aggravation is difficult. Laser that try first time by medical emits wave length 10.6um of infrared rays area as co<sub>2</sub> laser and average output is announced from 20 w to 100 w. Beam in formation's water transmission deeply in about 1/100 mm strong absorption have and formation's evaporation which organization by this strong absorption is heightened fast and reach in high temperature and gather to focus of beam happens.

II. 부인과 전용레이저

Non liner process happens when is high power density and short pulse. Light-minute state of only pulse continuance in 10ps to 10ns tell. Laser beam must have transmission depth that is less to operate tissue. As a result, high surface temperature is formed and tissue vaporizes. In case ignore heat conductivity, beam energy W for evaporation of volume V are same with equation (1).

$$W = pt = L\rho V \text{ -----(1)}$$

L expresses formation's density which increase being evaporation heat. In case required energy is 2.3J and uses carbon dioxide laser to issue additional paper volume 1mm 3's formation, big error does not occur in this approximate. For formation exclusion necessary energy 4 ~ because 5J need incision depth for formation incision with equation (2) save can .

$$D = P/(L\rho dX/t \text{ -----(2)}$$

D is beam diameter, increase by linear if dX/t displays incision speed and beam diameter of incision depth decreases.

$$D = 4Pt/(L\rho d^2) \text{ -----(3)}$$

Finally, exclusion displays method to investigate short higher hrust pulse to establishment and make formation bate in Plasma state in gas state. Also, formation which lightting exclusion region should be tasteful through minimum thermal damage and drop flies by gas state. Therefore, incision region temperature 100°C exceed. Before formation which absorb beam energy transmits heat to surroundings organization, exclusion must happen first. These

condition can get, and can calculate maximum pulse continuance time in case ignore thermal conductivity in storehouse exclusion using transmission depth heat spread coefficient  $A = 1.5 \times 10^{-7} \text{ m}^2/\text{s}$  and optic enemy in only short laser pulse.

$$\tau = \delta^2 / 4a \text{ -----(4)}$$

Specially, attempt laser is carbon dioxide laser first time by medical, and this laser emits wave length 10.6um of infrared rays area and average output is announced from 20 w to 100 w.

Beam in formation's water transmission deeply in about 1/100 mm strong absorption have and formation's evaporation which organization by this strong absorption is heightened fast and reach in high temperature and gather to focus of beam happens. Solidification area is using much by integrity by thin relation. Laser output becomes output adjustment from 20w to 100w consecutively and time of exposure is available adjustment through water plant in 0.01 seconds. Pulse action can intercept laser beam periodically and supermarket pulse from 0.1 ~ 1, ms, interval discharge consist and momentary laser output is increased to 5 ~ 10.

There is average output becomes similar or low. If use super-pulse can reduce formation's thermal conductivity. Low output laser acts by basis mode and high output mode can operate by multi mode operation and multi mode's beam becomes about double than basis mode beam.

### III. 시스템의 설계와 구현

Pumping gas (pumping source) makes energy in ground state by here state (excited state) as device that laser consists of vitality media that surround by

optical activity (optical cavity). If collision between particle of two of excited state occurs, photon that receive stimulator (that high level energy is massed) happens and it is that extended magnetic-energy comes out by laser.

Special quality of laser beam is as following. Highly parallel electrode(collimations), single directivity light (indirection beam) that refractivity smiles, monochrome (monochromaticity), energy that emit are spectrum on narrow wave length distance inside extremely.

By next time, all photons of interference (coherence) agree space and time sacred ground. Vitality medium of laser gas, liquid, solid what possible. Most gas laser consists because atom or small molecule or atom or molecule is mixed. Archaism laser is consisted of atom that include in archaism matrix or ion. Liquid laser consists of numerator of old tomb self-examination weight that is smelted in liquid. [Fig 1] is showing Abridged general view of pulse style CO<sub>2</sub> laser resonator. [Fig 2] is showing Current detection circuit for units electric current detections.

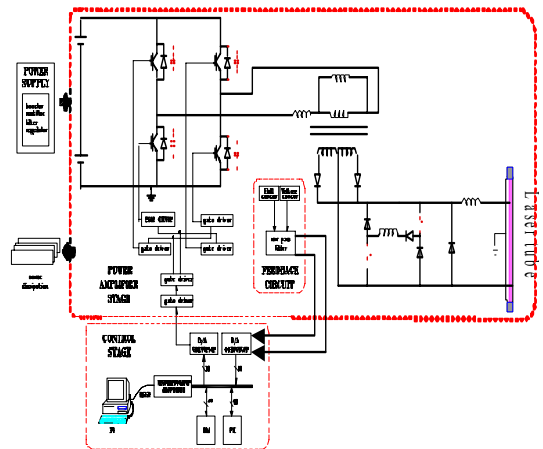


Fig. 1 Abridged general view of pulse style CO<sub>2</sub> laser resonator

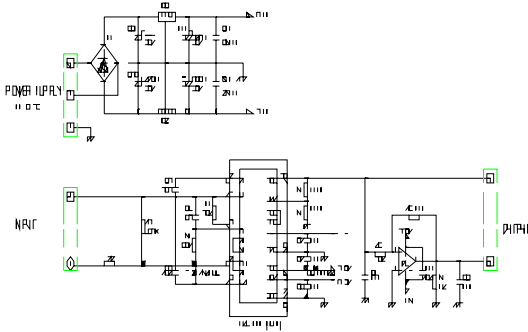


Fig. 2 Current detection circuit

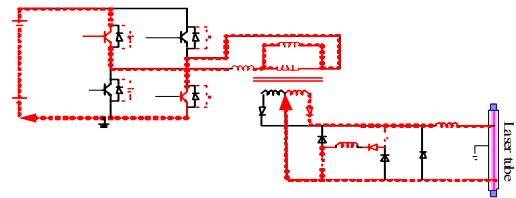
All materials are laid in the unstable state lowering by population inversion (population inversion) in particular pumping state, laser energy is emitted in peculiar wave length special quality of vitality whipping by this result. CO<sub>2</sub> laser tube sealed up within Dream pulse laser is built-in. Used vitality medium consists of gas mixture. Gas mixture has electrode and is built-in inside glass laser tube. Laser tube two optical activity (optic cavity) between situated. While behind mirror takes charge reflection function entirely, but reflection function that front mirror is partial is same and CO<sub>2</sub> laser beam guides refraction into (articulated arm) surely.

Whole system is composed, and do number cold storage beside him by resonator and pulse power supply dividing greatly, there is vacuum pump and nanometer etc. Discharge respect for the old and optical axis selected equal plano-concave resonator. Total reflection for laser eruption used molybdenum lens that is diameter 1.5 inch, radius curvature 10m, reflexivity 99.5% and is, and partial reflection selected ZnSe (Zinc Selenide) lens that reflexivity is 90% to lower do eruption threshold.

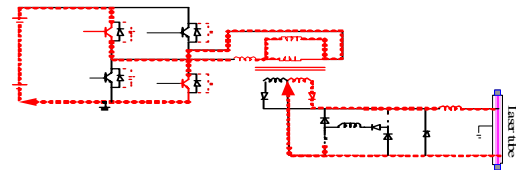
Used Pyrex pipe that laser discharge tube is length 85cm, inside diameter 16mm, thickness 2mm and volume of discharge tube to generate discharge plasma is 75 mm<sup>3</sup> × π × 64mm<sup>2</sup>. Discharge department made attaching cathode of cylindrical and anode of saliva shape that

make from aluminum to discharge tube, and distance between electrode did by about 75cm. Manufacture Pyrex tube that is inside diameter 30mm, thickness 2mm doubly to prevent ailment of causable output by temperature rise by discharge Plasma at series action in discharge tube outer wall and composed water circulation chiller.

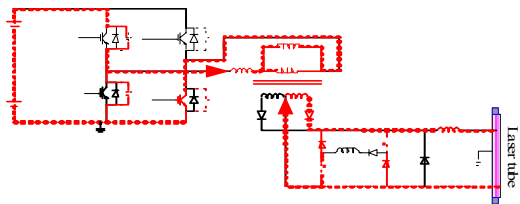
If momentary complete work kind passes to discharge tube, pressure difference occurs cathode of discharge tube and anode. Laser eruption efficiency drops on this account and state of eruption suspension and so on happens. In [fig 2] to prevent this with bypass pipe establish and reduced occurrence of impurities by CO<sub>2</sub> molecular Harry when flowing of gas minish temperature upswing and pressure difference of discharge within the jurisdiction by gas overheating round electrode as help and discharges because inserting small fan. Switching devices used suitable IGBT (Insulated Gate



a) mode 1



a) mode 2



a) mode 3

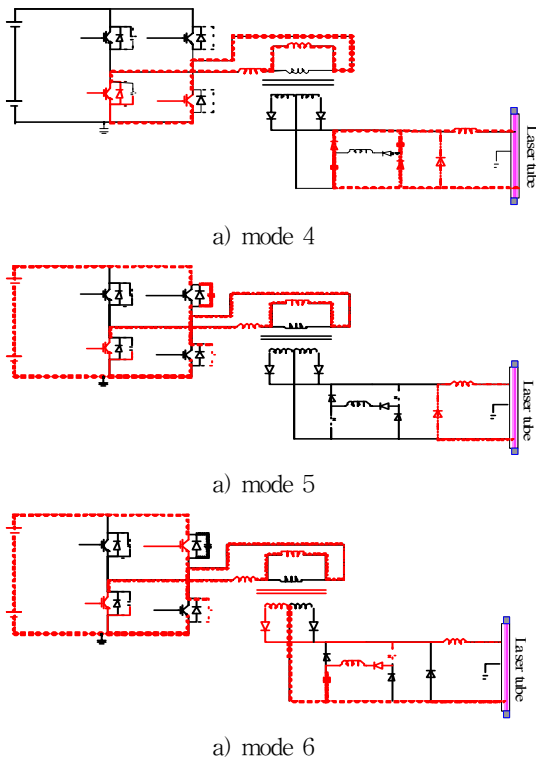


Fig. 3 operation mode CO<sub>2</sub> laser

Bipolar Transistor) to switching of tens kHz and approved to discharge tube after change energy that is charged to capacitor (marcon company products: 2 μF) by high voltage's pulse using high voltage · high frequency pulse transformer. Laser output made control to be possible as that change the pulse repeat rate in fixed pulse width.

Designed so that can be variable to repeat rate 100 Hz ~ 1kHz and maximum pulse voltage that can get in rural districts were about 20kV. Is composed at control that use high frequency pulse transformer department, Micro-processor. When [fig 3] approved pulse of high tension to discharge tube in pressure 12 torrs, is waveform that measure voltage waveform between quantity electrode using 1000:1 potentiometer Tektronix: P6015A Opt.1R. As can know in picture,

when glow discharge is continued to stabilize in working pressure 12 Torr, it was about 40μs as catch pulse waveform and measured pulse width (FWHM : Full Width at Half Maximum). If explain fig cycle (f) when time that it is known that this time is all time (On-time) and malfunction during cycle is continued when this is continued between space city during time between serial two pulse number of times of 1 thatched cottage separated from the main building of a pulse is cycle or cycle time (T) - tooth waveform time off time (off-time) la be and do.

Time that it is known that this time is all time (on-time) and laser malfunctions during cycle of all time and off time is continued when time that laser operates within cycle is continued. Efficiency does that (duty cycle) expresses ratio between all time and total cycle by percent.

Maximum output voltage (P peak) is being supplied maximum output while laser emits, and average output voltage (P av) expresses mean value of output that occur while laser emits, pulse width (r) as continue that pulse width at way point of maximum output from this part all time (on-time), off time, efficiency terminologies such as (duty cycle) are thing about laser operation mode cell exposure mode be. To change by average output in rated power (constant peak power) by this way, efficiency (duty cycle) according to this adjust must. Solidification area is using much by integrity by thin relation. Laser output becomes output adjustment from 20 w to 100 w consecutively and time of exposure is available adjustment through water plant in 0.01 seconds.

Pulse action can intercept laser beam periodically and supermarket pulse from 0.1 ~ 1, ms, interval discharge consist and momentary laser output is increased to 5 ~ 10.

Specially, stability of tube output about pulse is very important first of all that must remove

malignancy cell in womb nine escapes in the case of uterine cancer. Between the second rectifier (D5, D6) of high frequency transformer behind and filter output high inductor (Lf) in existent ZVS switching phase shifted full bridge DC-DC converter in this research resonant inductor of fast recovery diode (Ds1, Ds2, Ds3) and 2 resonant capacitor (Cs1, Cs2), 1 low value (Lr: Can be ignored because can alternate by high frequency transformer L).

As illustrate to [fig 3] (a), (b) as thing about new challenge loss reduction style high frequency soft switching FB DC/DC converter which insert Energy return to life snubber, to spiritual enlightenment mode interval (t0 - t2, t5 - t7) energy return to life resonant capacitor (Cs2, Cs1) accumulative energy high frequency transformer the second voltage during Freewheeling section (t2 - t4, t7 - t9) make up of Zero in section output rectifier diode (D5, D6) according to discharge of resonant capacitor (Cs1, Cs2) reverse bias become and high frequency transformer's the second winding open do.

Therefore, primary current (IT1) and the second current (IT2) of high frequency transformer Zero is done and only very few magnetizing current  $I_m$  circulates (t3 - t4, t8 - t9) for Freewheeling nine. Therefore, high frequency transformer and RMS current stress about switching element are decreased very. That is, main circuit Left Leg's switching element (Q1, Q3) can accomplish zero voltage switchings according to output current ( $nI_0 = I_{t1}$ ,  $n = N_s/N_p$ ) that is reflected by the first during Left Leg Transition section (t2 - t3, t7 - t8), and right leg's switching element ((Q4, Q2) can get marks of honor kind switching almost according to circulation current ( $I_l = I_m$ ) that is reduced very during Right Leg Transition section ((t4, - t5, t9 - t10). Stable soft switching operation area is defined without high frequency transformer leakage inductance (Ll)

increase and additional serial inductor insertion to DC-DC converter the first main circuit securing zero voltage and zero current switching operation, specially, because circulation communication path of output inductor (Lf) current is intercepted, switching devices and high frequency transformer's spiritual enlightenment loss lift Jule greatly by DC-DC converter the first main circuit and high frequency the second rectifier (D5, D6) becomes soft switching, and also, switching loss absorption quantity characteristic that can come to life again by load have, and to become tube stabilization design and result that manufacture and experiment, brought result that improve of 10% in existing equipment, and will be bought to get into superior result if supplement as systematic late.

#### IV. 실험결과

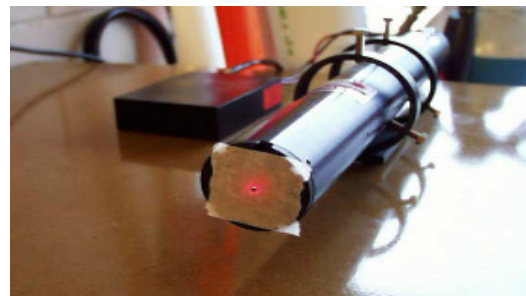


Fig. 4 Laser beam guide experimental set



Fig. 5 CO<sub>2</sub> laser tube Cooling department attachment

[Fig 4] is showing Laser beam guide experimental set where it follows in experiment. [Fig 5] is showing Co2 laser tube Cooling department attachment for experiment. [Fig 6] in order experiment description below stands is showing Co2 laser Experiment total equipment. Studied the pulse repeat rate and working pressure and laser output characteristic by rate of laser whipping gas ( $\text{CO}_2$ ,  $\text{N}_2$ , He) that is important urea that influence in output of pulse style  $\text{CO}_2$  laser in this research. After experiment method does to endure background Gas up to 10 - 2 Torr in storehouse resonator by rotary pump, pour  $\text{CO}_2$ ,  $\text{N}_2$ , He mixing gas to schedule pressure, and approve high tension pulse on both end electrode and caused glow discharge. Changing the pulse repeat rate and working

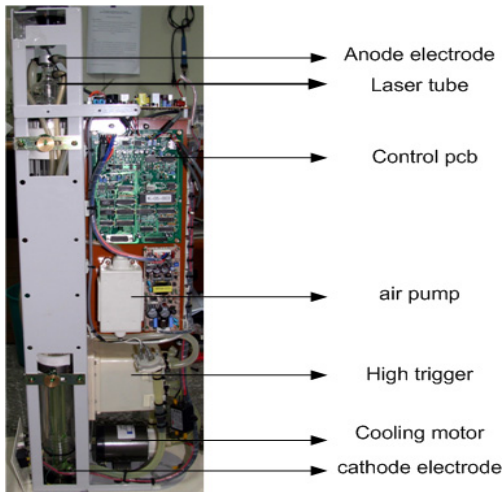
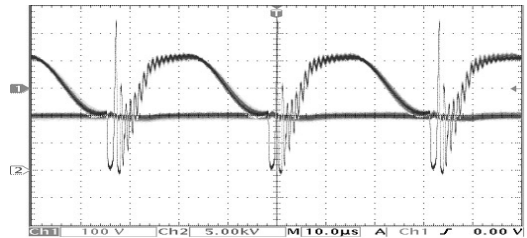


Fig. 6 Co<sub>2</sub> laser experiment total equipment

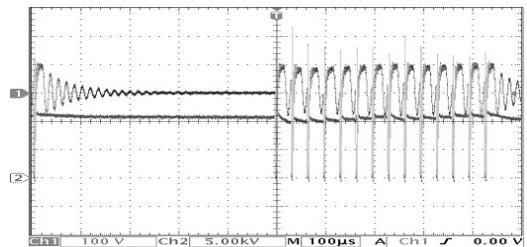
pressure at visual point that glow discharge is stabilized change of laser output comparison examined. Did to pulse repeat rate 100Hz - 900Hz and working pressure 6-15 torr that laser broke out in working pressure 6 torrs and experiment extent is continued as glow discharge stabilizes.

Mixture ratio of laser whipping gas is  $\text{CO}_2 : \text{N}_2 : \text{He}$

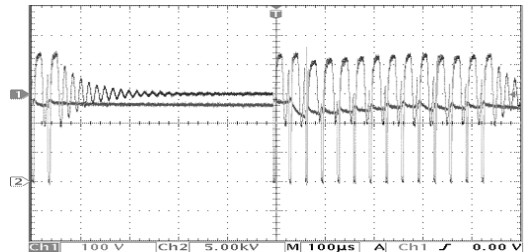
= 1 : 3 : 10, 1 : 1.5 : Experimentalized with, 1 : 9 : 15 three and output measured by energy meter (Gentec Studied the pulse repeat rate and working pressure and laser output characteristic by laser whipping gas ( $\text{CO}_2$ ,  $\text{N}_2$ , He) that is important urea that influence in output of pulse style  $\text{CO}_2$  laser in this research. After experiment method does to times.



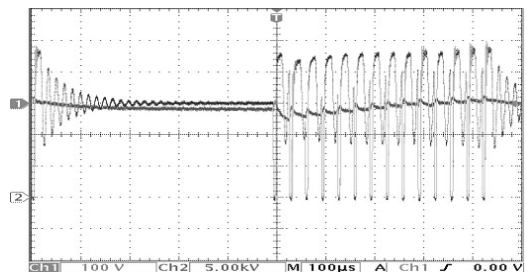
(a) High frequency transformer output waveform



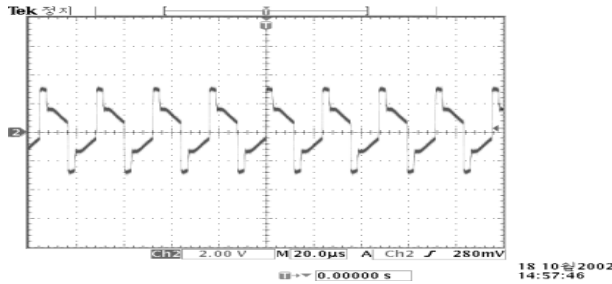
(b) High frequency transformer output waveform : 3W



(c) High frequency transformer output waveform: 4W



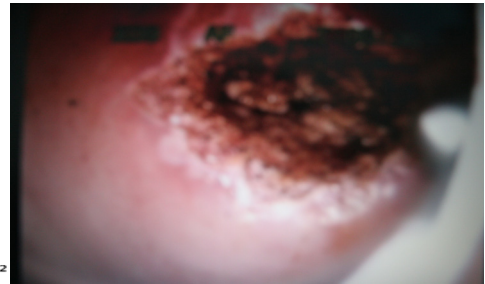
(d) High frequency transformer output waveform: 5W



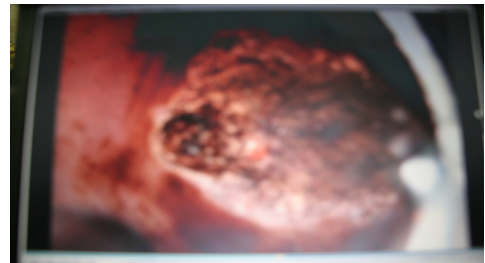
(e) High frequency transformer 1's output waveform

Fig. 7 High frequency transformer output waveform units

endure background Gas up to 10 - 2 torr in store resonator by rotary pump, pour  $\text{CO}_2$ ,  $\text{N}_2$ , He mixing gas to schedule pressure, and approve high tension pulse on both end electrode and caused glow discharge. Changing the pulse repeat rate and working pressure at visual point that glow discharge is stabilized change of laser output comparison. Examined. did to pulse repeat rate 100Hz - 900Hz and working pressure 6-15 torr that laser broke out in working pressure 6 torrs and experiment extent is continued as glow discharge each experiment data is marking mean value with wave that experiment five. It shows High frequency transformer 1 ' S output waveform from [fig 7] and generally it shows. [Fig 7] High frequency transformer output waveform units. [Fig 8] is showing A it shows the presence at a sickbed experiment which it follows in the various pulse, a) General  $\text{CO}_2$  laser pulse, the b) Super  $\text{CO}_2$  laser pulse, the c) Ultra  $\text{CO}_2$  laser pulse (5W), the d) Ultra  $\text{CO}_2$  laser pulse (10W).



a) General  $\text{CO}_2$  laser pulse



b) Super  $\text{CO}_2$  laser pulse



c) Ultra  $\text{CO}_2$  laser pulse (5W)



d) Ultra  $\text{CO}_2$  laser pulse(10W)

Fig. 8 Clinical experiment



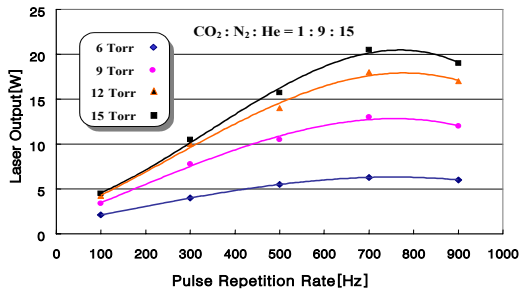


Fig.9 Laser output characteristics as the change of repetition frequency

[Fig 9] is showing experiment where in Laser output characteristics As the change of repetition frequency it follows. Output reached in outside in 700 Hz beginning departure in 100Hz, and specially gas mixture ratio  $\text{CO}_2 : \text{N}_2 : \text{He} = 1 : 9 : 15$ , working pressure 15 torrs. This time, because electricity input that measure by single phase interchange wattmeter (Hwashin company Model Name 7013) was about 260 W, output efficiency about whole electrical input becomes about 8%.

According as the repeat rate increases, laser output is increasing but decreases gradually from the increase width 500Hz and 900Hz can know that the output is decreasing quantity in 700Hz.

## V. 결론

Laser output until 100w becomes the control continuously from 20w and exposure time the control is possible between the waterweed from 0.01 seconds. Pulse operation laser being empty, there is a valence which it will intercept with periodic and the super pulse comes to accomplish a discharge from between 0.1~1ms, the Laser output which is instantaneous increases until 5~10.

Specially, it must remove the malignant cell from the uterus cancerous justice case person exhaustive investigation inner wall and in about the pulse from

the research which the stability of tube output sees is important with, very secures a promotion pressure switching operation to be bitter high frequency transformer leakage inductance increase and the series inductor the soft switching operational territory which is stabilized without high frequency secondary side stop dishonor soft switching, the feature it will be able to regenerate by load secures in converter first side week circuit, continuity loss of the circulating electric current course interception converter first side week circuit switching element and the high frequency transformer of inductor electric current on a large scale to decrease, it becomes switching loss absorption minute it has, becomes the tube stabilization, plan and it produces and the result which it experiments in existing equipment and, it compares 10% improves the result which and it brings following it complements system and with the fact that the result which is excellent will become it sees.

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