PRA LN107 DYE LASER

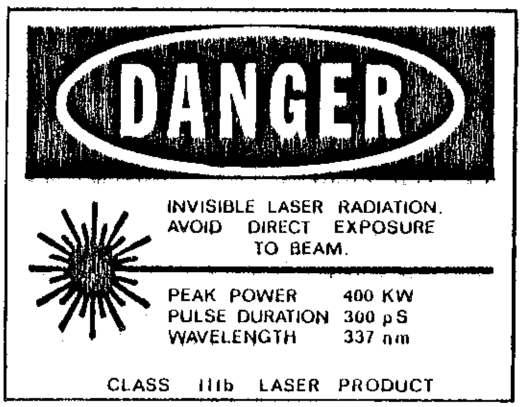
OPERATING MANUAL

PRA®

CAUTION: USE OF CONTROLS OR ADJUSTMENTS OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN HAZARDOUS RADIATION EXPOSURE.

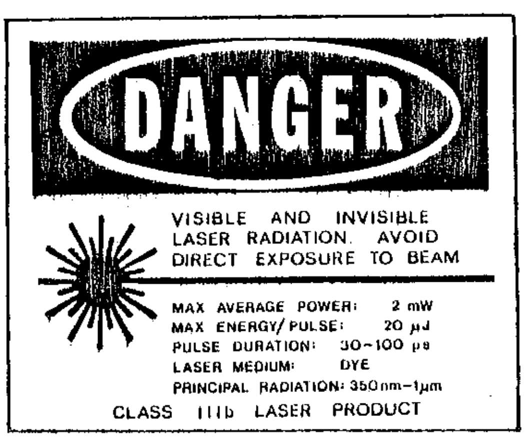
NITROGEN AND DYE LASERS

These are legible reproductions of warning logo types required to be affixed to the products described in the brochure. The labels are required for the nitrogen laser Models LN100/103 and dye laser Models LN102, LN104, LN105A, and LN107.

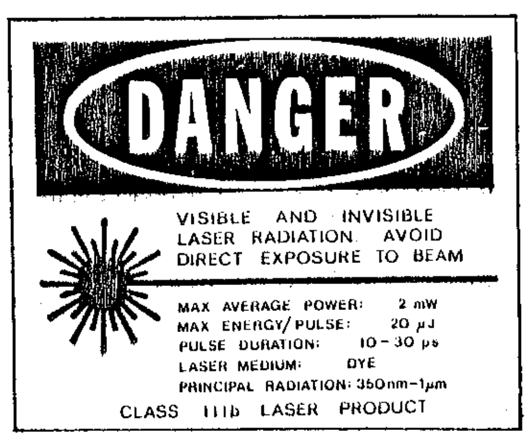


LN100/103

LN102/107



LN104



LN105A

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PRA LN107 DYE LASER

TEST SHEET

Laser Serial Number: 86010-LN7

Laser Dye: 7A579, lases between 5680-6050 A
R590 in ethanol

Control Settings:

- (i) Wavelength: 5900 Å
- (ii) Focus (Osc): 3.0
- (iii) Cell Rotation (Osc): 6.0
- (iv) Cell Translation (Amp): 7.5
- (v) Focus (Amp): 5.0

Output Energy/Pulse (uJ) @ 2 Hz

LN1000 Nitrogen Laser: 1.2 mJ

Dye Laser: 125.0 μJ

Tested By: Tom B[signature]

Dated: MAY 1986

1.0 INTRODUCTION

1.1 Initial Instructions

a) Your dye laser has been aligned on an optical table. Before operation, please read the manual, especially Section 3.

Do not attempt to align components within the unit. Ensure that the laser is set-up on an optical table and follow all set-up instructions carefully. If the unit does not perform to specifications, contact PRA.

Your laser should be secured to your optical bench to prevent any movement during operation: The 'Clamp Down' devices (page 1-3) are recommended for this purpose.

To prevent misalignment during shipping, the following locks have been incorporated into the design:
1) Leg locking nuts.
2) Cell rotation lock.
3) OSC output coupler lock.
4) OSC prism lock.

The cell rotation lock (2) must be loosened prior to operation to permit adjustment of the rotational position of the cell. It is recommended that the other locking devices remain intact.

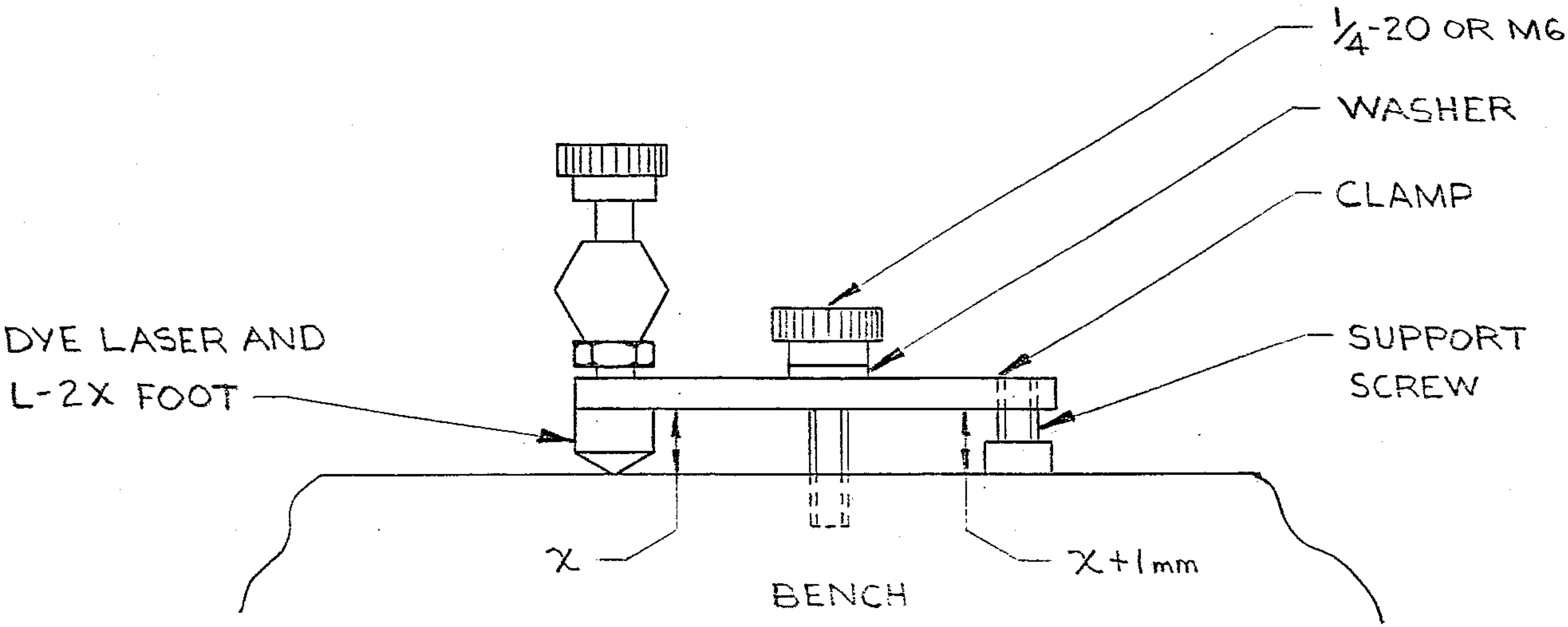
b) Do not touch controls prior to consulting Section 3.0, Operating Instructions.

c) Appoint a "designated user" (of the group) who will be solely responsible for the set up, adjustment and maintenance of the unit. This will avoid considerable confusion and lost time. This person could be a "regular user" who will operate the unit in a normal manner.

d) Return warranty card fully identifying the "designated user" including address and phone number. This will assure prompt service in the future.

e) If any shipping damage is evident, notify PRA immediately.

CLAMP DOWN DIAGRAM



PRA

1.3 An Overview

A laser may loosely be defined as an electro-optic device, which utilizes an appropriately confined suitable medium which emits a directionally narrow, intense and monochromatic light beam.

In the case of the (pulsed) PRA LN107 dye laser, the "suitable medium" is one of a select group of organic dye solutions. These are contained in a 1 cm ultraviolet light transmitting cuvette mounted within an optical subsystem. The dye solutions absorb nitrogen laser ultraviolet light and emit, within a few nanoseconds, light of longer wavelengths. The emitted wavelength can be changed by changing the dye.

The optical subsystem produces a very directional, temporarily fore-shortened (less than 1 ns) monochromatic (wavelength selective), intense beam (laser). The LN107 is a two stage device. In addition to the previously described "laser" or "oscillator", a second stage (amplifier) is also used.

The amplifier consists of a cuvette which contains a dye solution identical to that of the oscillator. By suitable precisely aligned beam steering optics and focussing lenses, a portion of the nitrogen laser beam and the laser beam from the oscillator are brought into coincidence just inside this cuvette. The resulting beam is more intense than that of the oscillator alone.

Because of the small beam sizes (~1 mm or less) and (relatively) long path lengths (10's of cm), alignment of all optical components must be precisely maintained.

Want to know more about dye lasers?

REFERENCES:

"Dye Lasers". Ed: F.P. Schafer Springe - Verlag, New York, 1977 (TA1690.S33). (Text)

"Lasers: Physics, Systems, and Techniques". Ed: W.J. Firth and R.G. Harrison, Published by Scottish Universities Summer School in Physics, 1983 (TA1673.S38). (Text)

"Lasers and Light": readings from Scientific American, San Francisco, W.H. Freeman (1969) (QC 351.L35).

"Laser, supertool of the 1980's New Haven: Ticknor and Fields, 1982 (TA 1675.H43).

"Spectrally narrow pulsed dye laser without beam expander; Littman and Metcalf App. Optics 17, 14, 2224 (1978).

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1.4 SPECIFICATION SHEETS

* * * * * * * * * * * * * * * * * *

PRA
International
Inc.

45 Meg Drive
London, Ontario, Canada N6E 2V2
(519) 686-2950
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100 Tulsa Road
Oak Ridge, Tennessee
U.S.A. 37830
(615) 483-3433

LN107

HIGH RESOLUTION DYE LASER

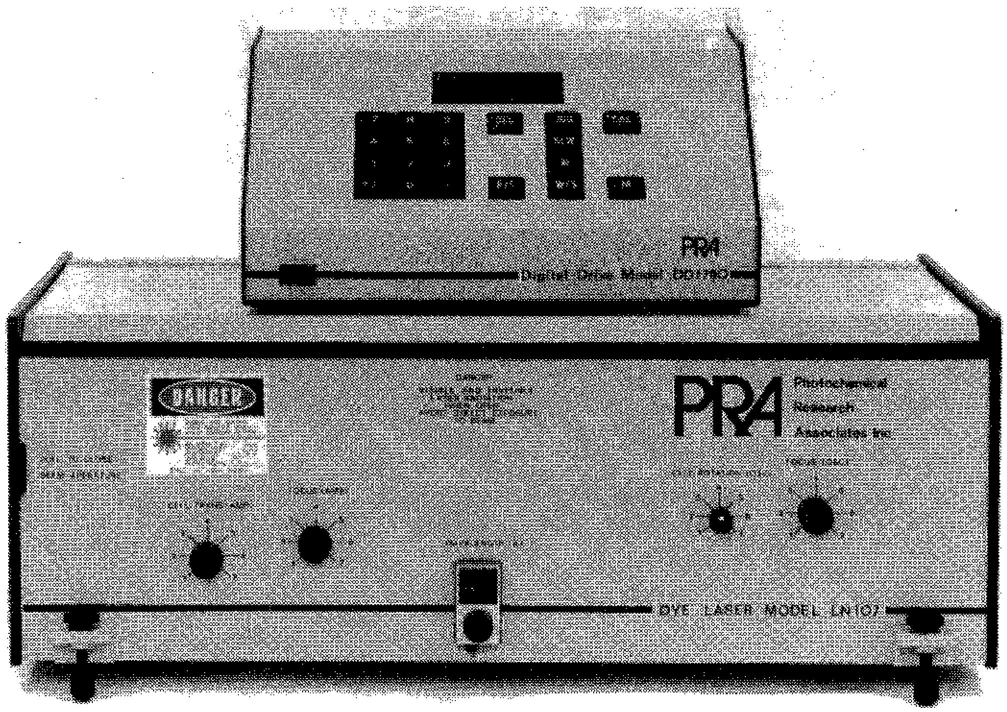

Photo Illustrates Optional DD1790 Digital Drive.

The LN107 is a high resolution dye laser companion for the successful PRA 2 MW LN1000 Megaplus nitrogen laser.

The LN107 has been designed and manufactured for simplicity of use and reliability of operation. There are only a few front panel mounted controls for dye cell position adjustment and wavelength selection.

The LN107 epitomizes the modular concept which is basic to PRA design philosophy. The unit is a two stage device comprised of oscillator and amplifier sections contained within a single cabinet. The design utilizes a grazing angle incidence grating configuration to produce spectral widths narrower than .04 nm.

PRA International Inc.

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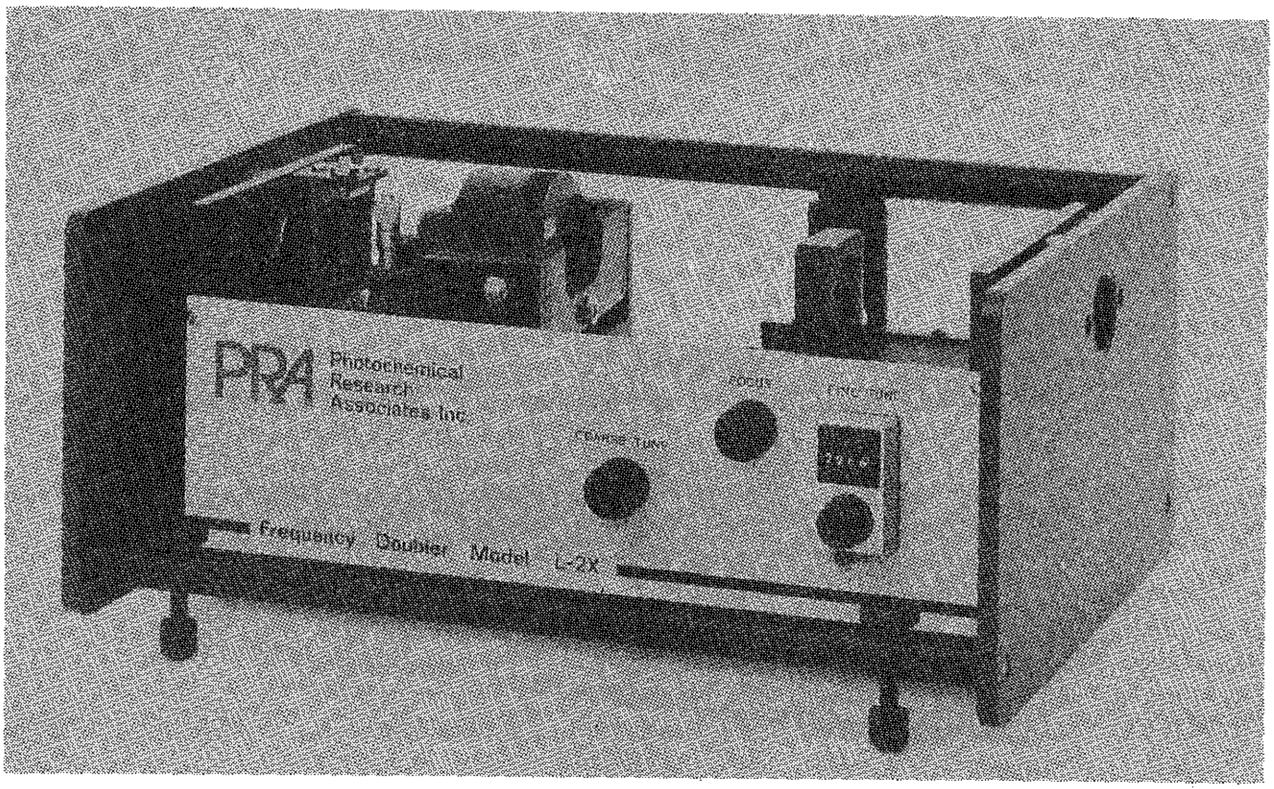
L-2X

FREQUENCY DOUBLER



The L-2X Frequency Doubler generates 'frequency doubled' (or 'wavelength halved') output (ultraviolet 240-330nm) of laser systems operating in the visible spectral range 480-660 nm. While designed as a companion accessory to the PRA nitrogen dye laser system, the L-2X can be used with a wide variety of laser systems. Applicability will depend on the type of laser used since efficiency, as with any second harmonic device, derives from particular input power, beam quality and spectral bandwidth characteristics.

Up to three hermetically sealed crystals spanning the wavelength range 240-330 nm can be installed inside the rotating mount. This design facilitates rapid, convenient and accurate interchange of crystals corresponding to different spectral regions as indicated in the accompanying table. This provision results in a range of usable wavelengths greater than that available with single crystal systems due to optimal utilization of the wavelength characteristics of each crystal.

IN NORTH AMERICA, CALL TOLL FREE 1-800-265-1226

2.0 DESCRIPTION OF OPERATION

The PRA Model LN107 is a narrow band picosecond dye laser system, designed for use with the PRA high-power nitrogen laser (Model LN1000). Referring to Figure 1, the system consists of a near-grazing incidence grating design dye oscillator and a transversely pumped single stage dye amplifier. Both the oscillator and amplifier are accommodated within one cabinet and when properly aligned, only a few front panel mounted controls are needed for dye cell position adjustment and wavelength selection during operation.

The complete front panel configuration is shown in Figure 2. The laser controls are numbered one through eight and a functional description for each is given in Table 1. The spectral range of the laser extends from 360 to 980 nm (extended to 240 nm with frequency doubling) at a bandwidth of less than .4A and with peak power up to 200 kW. Stepper motor control (model DD1790) permits a minimum step interval of 0.01 nm.

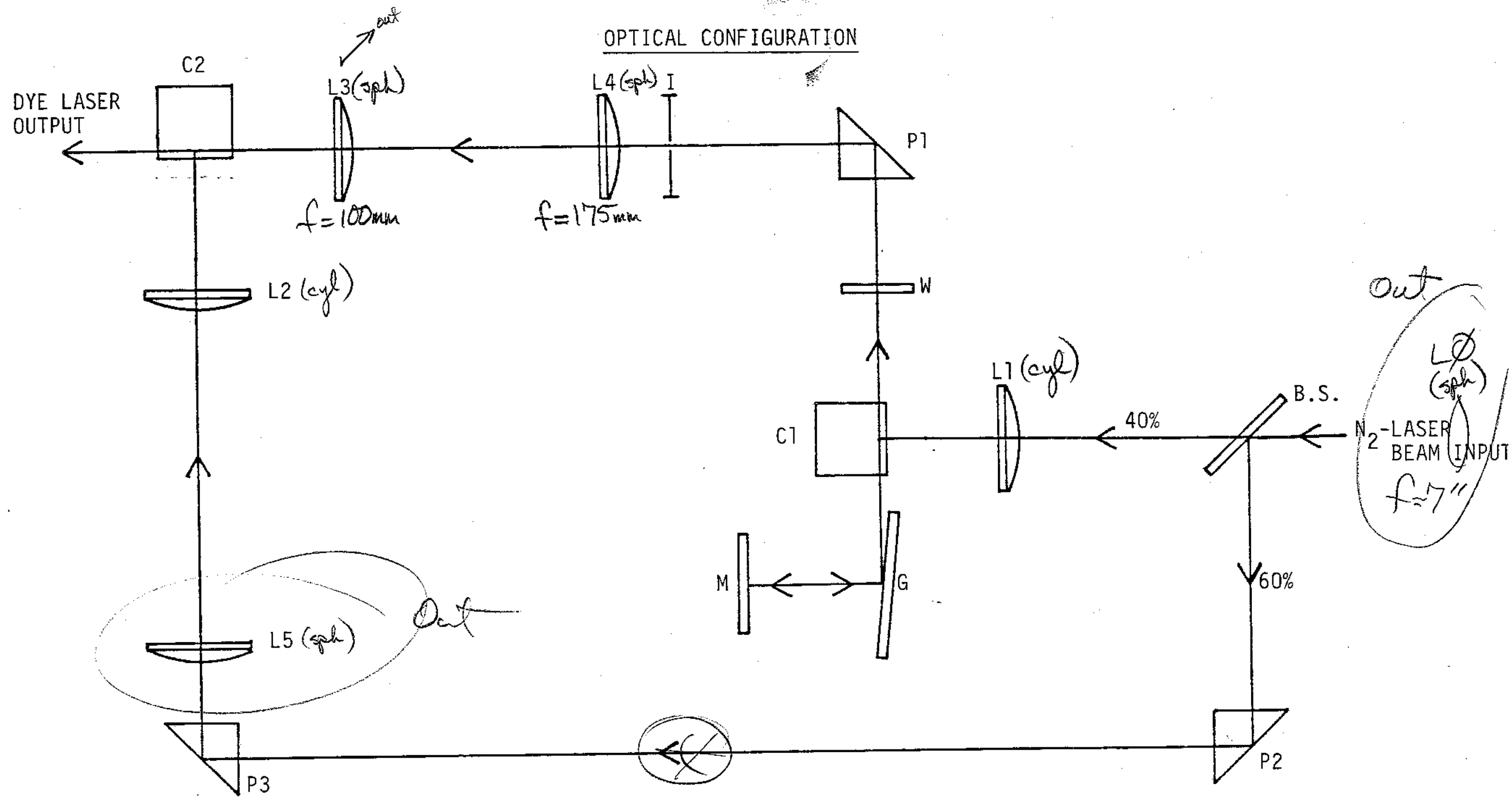
The dye solutions are contained in standard 1 cm fluorescence cuvettes. The cuvette holders are designed to facilitate rapid interchange of dye solutions.

2.1 Oscillator Operation (Refer to Figure 1)

The oscillator portion of the LN107 consists of a quartz cylindrical lens (L1), oscillator cuvette (C1), holographic grating (G, 1800 grooves/mm), mirror (M1), and output coupler (W). After splitting by a 40/60 dichroic beam splitter (BS), part of the U.V. Nitrogen pump beam (40%) is focussed into a line image by L1 just inside the window of the dye cell, C1. Absorption of the beam within the narrow focal volume results in broadband excitation and population inversion of the dye's molecular levels. This "active" volume is provided with feedback by the mirror, M and the output coupler W, which form a reflective cavity to stimulate emission from the excited focal zone (i.e. to cause lasing). To narrow the bandwidth of the feedback and hence, the lasing, a grazing incidence grating (G) is placed within the cavity to act as a variable wavelength filter between the cavity ends. In this configuration, the grating is actually fixed in such a way that the angle between the grating normal and the light incident from the dye cell is 87 degrees. The tunability is thus achieved by varying the azimuthal angle of the end mirror normal with respect to the grating normal. In this way,

FIGURE 1

OPTICAL CONFIGURATION



NOMENCLATURE

L1, L2, L3	- Focussing Lens	M	- Mirror
L4, L5	- Collimating Lens	I	- Iris
P1, P2, P3	- Right-Angle Prism	B.S.	- Beam Splitter
C1, C2	- Dye Cell	W	- Output Coupler
G	- Grating		

FIGURE 2

LN107 DYE LASER CONTROLS

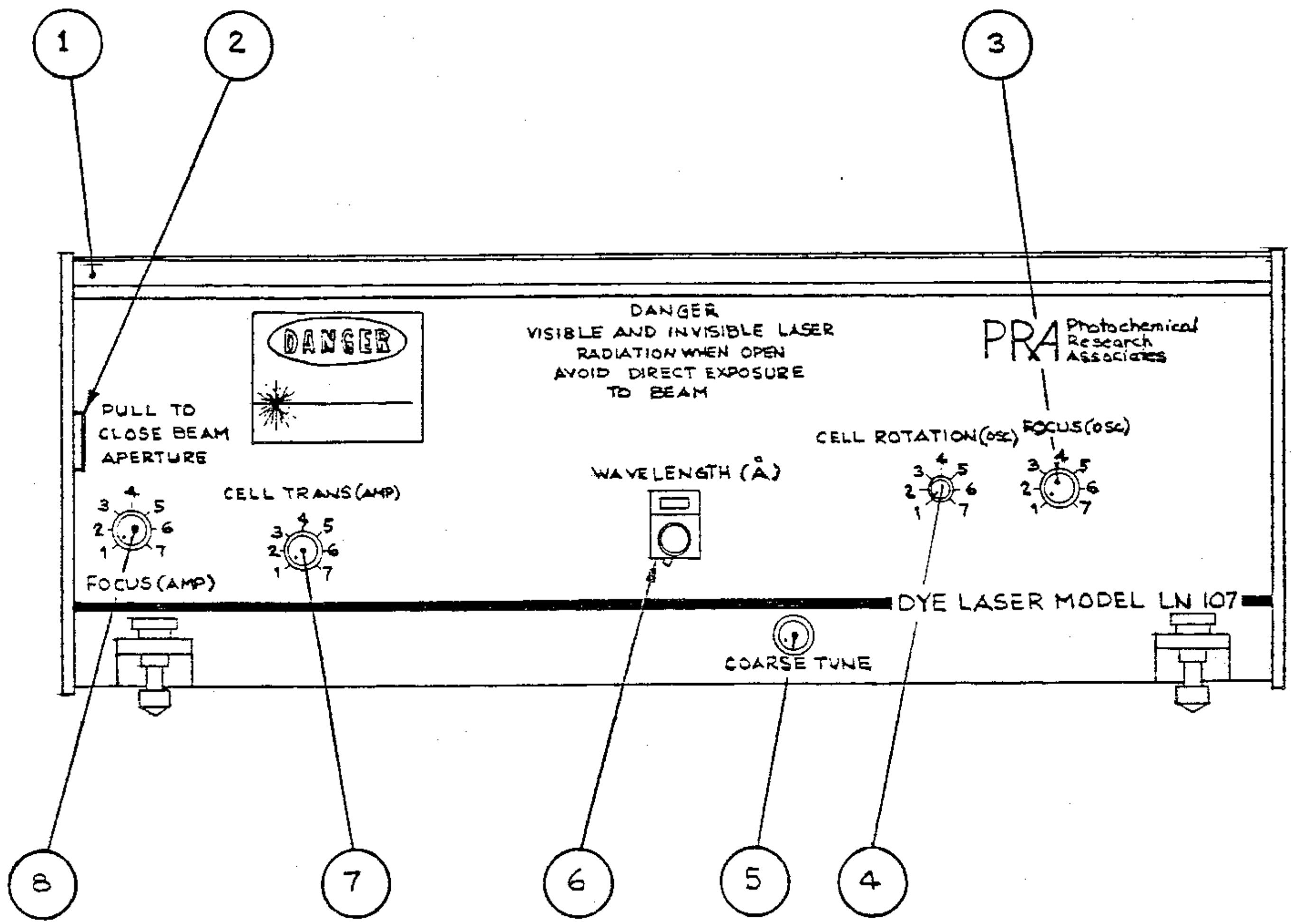
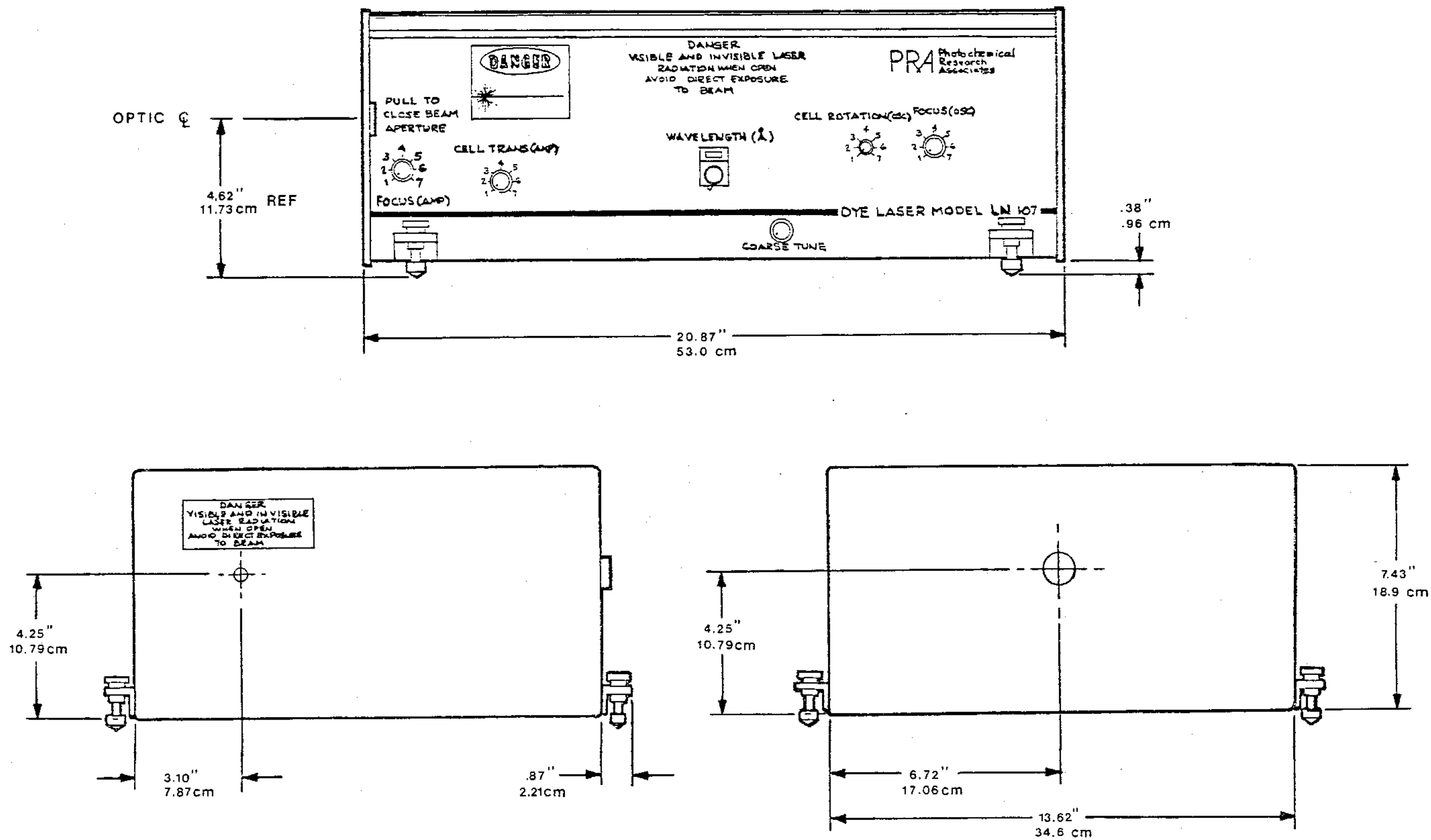


FIGURE 3

PRA LN107 DYE LASER OUTLINE



only first order light is reflected to the mirror, and only a narrow region of the bandwidths are allowed to return from the mirror along the same path of incidence. As a result, narrow bandwidth light is returned to the active zone where further stimulated emission occurs to further amplify the narrow bandwidth light.

The cavity also serves to severely limit the possible spatial radiation modes available to the light and consequently, the oscillator laser "beam" emerges from the output coupler, W, in a highly directional manner.

The total transit time within the cavity approximates the pulse duration of the nitrogen laser (~600 ps) and as a result, the distance between the output coupler and the end mirror is restricted to 80 mm. Since this is the length required to accommodate the cavity components, only single-pass operation is achieved in the LN107.

To operate properly the cavity components must be carefully aligned. The output coupler orientation is very important in initiating the lasing process and must be aligned to direct light through the narrow active volume. The grating and mirror must be able to accept light from the active volume, narrow the bandwidth, and return it via the same optical path.

Furthermore, the cuvette output faces must be tilted with respect to the oscillator beam (7^{o}) to minimize regenerative feedback by window reflections. This would compete with and degradate the primary oscillation process.

Thus, all the components of the cavity are linked in the optical sense and their relative alignment is critical. Therefore, extreme care should always be exercised during any adjustment procedure.

When properly tuned, the output profile of the oscillator beam will appear as a bright diffuse disk of background radiation, with an intense "pin point" spot approximately at the center. The output can be viewed by inserting a small screen (e.g. business card) between the output coupler and P1. If a second card is placed between the grating and the mirror, the laser spot will disappear. (This is referred to as "spoiling" the cavity and, at least initially, will serve to identify the presence of lasing).

The bandwidth of the beam, $\Delta\lambda$, is given theoretically by an expression of the form,

$$\Delta\lambda \simeq \frac{\sqrt{2}\ \lambda a}{\pi\ \ell}$$

where

λ = laser wavelength
a = grating constant (in mm; i.e., $\frac{1}{1,800 \text{ grooves/mm}}$)
ℓ = active length of grating

In this case, a = ~~5555A,~~ 5.555×10^{-4} mm, ℓ = 20 mm so that for λ = 6000A, $\Delta\lambda \simeq 0.1$. The observed linewidth is less than .4A which is slightly larger than the theoretical one-pass estimate for our design.

After exiting from the output from the output coupler, the narrow-band oscillator beam is then directed by the right-angled steering prism (P1) to an adjustable pin-hole iris (I) which is used to reduce the super fluorescence (by-product) background created by the broadband excitation.

2.2 Amplifier Operation

To obtain better intensity and dye lifetime, the LN107 utilizes an amplification stage. Refering to Figure 1, the remaining (60%) pump radiation from the N_2 laser is directed by two beam steering prisms (P2 and P3) to a second cylindrical focussing lens (L2). At the focal line, a second cuvette (C2) is located in a similar configuration to C1, creating another "active" volume. The oscillator beam, meanwhile, is collimated by a plano-convex lens, L4, (175 mm f.l.) to reduce the beam divergence to approximately 1 mrad (half-angle), and then further focussed by a 100 mm f.l. lens (L3) into the amplifier active region (~0.1 X 0.1 X 10 mm). The oscillator beam thus makes the second pass through an active volume which could not occur in the single pass oscillator cavity. As a result, an output beam emerges from the amplifier stage with significantly improved intensity.

The alignment of the amplifier stage, although not quite as critical as the oscillator, is still very important. The oscillator beam must be focussed sufficiently to concentrate the spectral intensity, but not to increase the background fluorescence and beam divergence. It must be exactly collinear with the active volume created by the amplifier pump, and both beams must intersect close to the window face to minimize absorption of the pump before the focal zone.

When both oscillator and amplifier stages are operating properly, an intense, slightly elliptical, beam exits from the laser within a weak, diffuse, fluorescent background. This beam will fade almost completely when either the amplifier pump beam is blocked, or the oscillator cavity is "spoiled".

2.3 Control Description

TABLE 1

LN107 DYE LASER

LASER CONTROLS (See Figure 2)

Control	Function
1. Cover	Dye cell insertion. Close cover before operating.
2. Beam Aperture	To block the laser beam from passing through the aperture with a shutter.
3. Focus (Osc)	To focus the nitrogen laser beam onto the dye cell window of the oscillator.
4. Cell Rotation (Osc)	To rotate the oscillator dye cell up to 2 degrees from the lasing axis.
5. Coarse Tune	To manually change wavelength output quickly from one spectral region to another without Digital Drive Unit.
6. Wavelength (Å)	To manually finely tune to desired wavelength.
7. Cell Trans (Amp)	To properly position the amplifier dye cell laterally with respect to the oscillator beam.
8. Focus (Amp)	To focus the nitrogen laser beam onto the amplifier dye cell.

3.0 OPERATING INSTRUCTIONS

NOTE: The PRA LN107 operates best when placed on an optical bench. Failure to use the bench, or an equivalently flat solid platform, normally results in unstable operation.

Follow these steps carefully:

One person should be designated as "the user" and be responsible for the set-up and subsequent adjustments;
any adjustments detailed in Section 4 should be:

1) done very carefully. This is a sensitive instrument requiring a very "light" touch,
2) done one at a time, in small increments,
3) recorded so that any "starting position" can be regained e.g. W tilt adjustment 1/8 revolution counter clockwise.

3.1 Initial Installation

Before leaving PRA, each dye laser is aligned and tested. Provided at the front of this manual is a test sheet which indicates the output energy and energy conversion efficiency for the standard dye (7A579; peak output wavelength is 590 nm), at a repetition rate of approximately 5 Hz (pulses per second). To ensure proper operation, the central settings on the test sheet should be used for the initial set-up. Once the user becomes familiar with the control devices, other settings may be used to suit the beam character requirements. Of particular importance, is the allowance for the properties of the dye solution. Since each dye has different absorption characteristics, the optimum focussing lens positions for the two cells may vary when dyes are interchanged. (A second property of the dye, which we note in passing, is the lifetime. In general, each dye will differ in this respect. The Rhodamine dyes, for example, will outlast the Coumarin dyes).

In the sections which follow, procedures are given, assuming the standard dye is used. If you remain uncomfortable with laser operation and control after reading these procedures, we recommend you, repeat them to gain confidence. Do not hesitate to contact PRA for assistance.

3.2 Initial Operation Procedure

(i) Optimize Nitrogen Laser

Before installing the dye laser, ensure the LN1000 nitrogen laser is operating satisfactorily. Check the output beam energy with an energy meter, if possible, and/or visually, by examining the beam image incident on a fluorescent target. NEVER VIEW ANY LASER BEAM DIRECTLY OR BY SPECULAR (MIRROR) REFLECTION. If the N_2 pump beam is found to be unsatisfactory, refer to the LN1000 operating manual before proceeding. Once the LN1000 is operating properly turn the laser off or block the output beam.

(ii) Position the Dye Laser

Position the dye laser is front of the nitrogen laser - the end plates of the two lasers should be in contact and the center of the nitrogen laser output aperture would be carefully aligned with the center of the LN107 input aperture. The proper height has been predetermined by "locking" the vertical adjustments of the LN107 at PRA prior to shipment. The cover of the dye laser consists of a lid hinged along the side opposite the control panel. Raise the cover completely, until it remains in the "Open" position. Install the cuvette containing the standard dye in the oscillator cuvette holder. Un-block the nitrogen laser beam, dim the room lights, and place a white card behind the oscillator cuvette (C1), (Refer to Figure 1) on the side opposite the incident pump. The line focus image of the pump should be weekly visible, with the cuvette eclipsing the central, intense, portion of the beam. Using the white card, check the position of the nitrogen pump at the dichroic beamsplitter (BS), the input aperture of the cylindrical lens (L1) holder, and the entrance face of the prism, P2. If the pump is not centered properly on each component, slightly translate the two end faces of the lasers.

Repeat the adjustments, in the following sequence, until all optical components are centered with respect to the nitrogen laser beam.

a) translation of end faces

(iii) Adjust Oscillator for Lasing

NOTE: Ensure proper precautions are taken when the LN107 exit aperture is opened.

The onset of lasing action depends critically on the relative orientations of the oscillator components. If the LN107 has been positioned properly, and no oscillator misalignments occurred during shipping, the operator should observe an intense small spot (approximately 2 mm in diameter) when a white card is placed between P1 and W. (Make sure all settings of the laser are in agreement with the test sheet provided). To optimize the lasing action, use the following procedure:

a) Carefully repeat the adjustments in part (ii).
b) Try all cuvette window faces to select the one which provides the best beam quality with minimal background fluorescence. DO NOT TOUCH THE WINDOW SURFACES OF THE CUVETTE. Make sure the cuvette is secured in its holder.
c) Unlock and slightly adjust the cell rotation (osc), control "4", for best beam quality. If two beams are observed, then cell rotation is incorrect; readjust until a single circular spot appears.
d) Turn the focus (osc) control "3" to obtain the brightest spot possible with minimum background fluorescence.

3.3 Final Adjustments

(i) If necessary, adjust the tilt controls on the small prism, P1, until the oscillator beam passes through the center of the iris aperture, I. (First remove locking device)

(ii) Insert the amplifier cuvette, C2.

(iii) Monitor the output energy of the beam emerging from the LN107 exit port.

(iv) Optimize for best energy, and beam quality by iterating through the following sequence:

a) amp cuvette translation, control "7"
b) amp focus, control "8"
c) iris aperture (I)

(v) Turn the wavelength setting until the laser is operating just above threshold. (As a result, all controls will be much more sensitive to their optimum value). Iterate through the following sequence of adjustment, and repeat until beam intensity and quality (monitored at both the oscillator and amplifier locations) are optimum:

a) oscillator cuvette rotation, control "4"
b) oscillator focus, control "3"
c) P1 tilt adjustments (only fine adjustment) (Remove locking device)
d) amp cuvette translation, control "7"
e) amp focus control "8"

Care should be exercised when controls, "7" and "8" are changed since energy and beam quality tend to maximize at slightly different settings. There is thus a "trade-off", to a certain extent, with these controls.

When the beam is satisfactory, close the cover on the LN107 and secure the legs to the bench surface while observing the quality of the output beam to ensure no change occurs during this procedure.

FIGURE 4

DYE LASER TUNING CURVES WHEN LN107 PUMPED BY LN1000 NITROGEN LASER

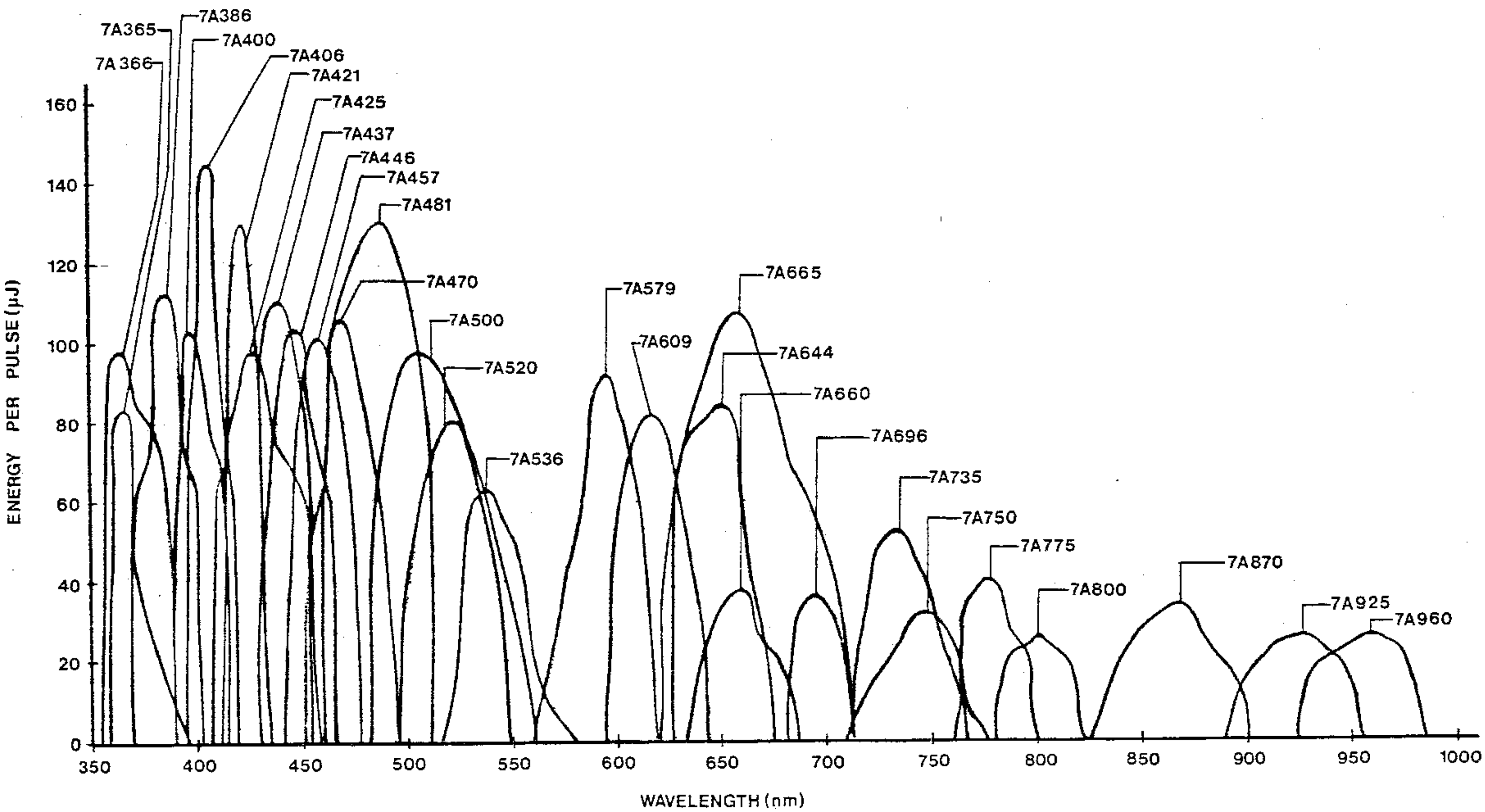


TABLE 2

PRA LASER DYE LIST

***** C A U T I O N *****

It is highly recommended that disposable surgical gloves be worn while handling these chemicals. Special caution must be taken when using DMSO as the solvent for infrared dyes, since DMSO passes readily through the skin and can carry the dissolved dye into the bloodstream.

PRA ORDER NO	DYE	Molecular Weight (gm)	Concentration (M)	Solvent	Wt. (mg) per 50 cc	Maximum (nm)	Range (nm)
7A365	BPBD	354	4.0×10^{-3}	toluene	70.9	365	357 - 395
7A366	PBD	298	5.0×10^{-3}	toluene/ethanol 50/50	74.6	366	360 - 386
7A386	BBQ	675	2.5×10^{-3}	toluene/ethanol 50/50	84.4	386	373 - 399
7A400	PBBO	347	5.0×10^{-3}	toluene/ethanol 70/30	82.7	400	391 - 411
7A406	DPS	332	1.2×10^{-3}	p-dioxane	19.9	406	396 - 416
7A421	Bis-MSB	310	1.2×10^{-3}	p-dioxane	18.3	421	411 - 430
7A425	S-420	562	1.8×10^{-3}	methanol	50.6	425	408 - 453
7A437	C-440	175	5.0×10^{-3}	ethanol	43.8	437	427 - 457
7A446	C-450	217	1.0×10^{-2}	ethanol	108.6	446	428 - 465
7A457	C-460	231	1.0×10^{-2}	ethanol	115.7	457	440 - 478
7A470	C-480	255	1.0×10^{-2}	ethanol	127.7	470	453 - 495
7A481	C-481	285	2.0×10^{-2}	p-dioxane	285.6	481	460 - 518
7A500	C-500	257	1.0×10^{-2}	ethanol	128.6	500	473 - 547
7A520	C-485	257	1.0×10^{-2}	ethanol	128.6	520	490 - 560
7A536	C-540A	309	1.0×10^{-2}	ethanol	154.7	536	515 - 583
7A579	R-590	479	5.0×10^{-3}	ethanol	119.8	579	568 - 605
7A609	R-610	479	5.0×10^{-3}	ethanol	119.8	609	594 - 643
7A644	R-640	591	5.7×10^{-3}	ethanol	168.5	644	620 - 673
7A665	DCM	303	5.0×10^{-3}	DMSO	75.8	665	655 - 700

PRA ORDER NO	DYE	Molecular Weight (gm)	Concentration (M)	Solvent	Wt. (mg) per 50 cc	Maximum (nm)	Range (nm)
7A660	CV670/R590	362/479	$2.5\times10^{-3}/3.3\times10^{-3}$	ethanol	45.3/30.0	660	641 - 687
7A696	NB690/R610	418/479	$3.8\times10^{-3}/8\times10^{-4}$	ethanol	79.4/46.0	696	683 - 710
7A735	HIDC	510	5.0×10^{-3}	DMSO	127.5	735	710 - 775
7A750	OX725	424	5.0×10^{-3}	DMSO	106.0	750	720 - 770
7A775	OX750	470	5.0×10^{-3}	DMSO	117.5	775	760 - 800
* 7A800	DOTC	512	5.0×10^{-3}	DMSO	128.5	800	785 - 825
* 7A850	DTTC	544	5.0×10^{-3}	DMSO	136.0	850	830 - 870
7A870	HITC	536	5.0×10^{-3}	DMSO	134.0	870	825 - 890
7A925	IR-125	774	5.0×10^{-3}	DMSO	193.5	925	890 - 945
7A960	IR-140	779	5.0×10^{-3}	DMSO	194.8	960	940 - 990

NOTE: This dye with * is preweighed for 50 cc solution and shipped separately along with their solvent.

I Internal obstructions in dye laser - remove e.g. business card, removed component

J Oscillator misalignment - check - see Section 3.2 (iii)

K Amplifier misadjustment - check - see Section 3.3 (iv)

Please note the following:

The oscillator optical plane (determined by the laser beam path), the optical plane, described similarily, and the nitrogen laser optical plane (the plane defined by the direction of travel and beam width i.e. the focussed "line" image of the beam after passing through a cylindrical lens), must all be "coplanar" i.e. lie in the same plane.

Please note and rigorously follow: "designated user only"

1) perform carefully
2) perform one at a time
3) record

4.1 b) Oscillator Misalignment

To determine whether or not the oscillator unit is operating properly, place a small white (business) card [wbc] between P1 steering prism and W output coupler. An intense spot, approximately 2 mm diameter, should be observed roughly centered within a larger (approximately 1 cm diameter) more diffuse halo of background radiation. That lasing is indeed present can be determined by inserting a wbc between the mirror M and grating G at which point the intense spot will disappear. Also, the "color" of the spot will be sensitive to wavelength tuning.

To optimize lasing, carefully recheck "weak laser output" Table 4.0.

At this point if misalignment persists one of two situations will obtain:

The laser may have become misaligned due to the rigors of shipping
or
Other personnel may have made adjustments. Determine, if possible, what adjustments have been made.

If no lasing spot is observed from the oscillator cavity, proceed as follows:

(i) Repeat the procedures of Section 3.2 (iii).

(ii) Scan the wavelength setting ± 100A while observing oscillator output. If lasing occurs during scan, optimize output (Section 3) and notify PRA of miscalibration.

(iii) If the laser cannot be made to lase and all procedures have been followed properly, notify PRA of the problem.

NOTE: Although a complete alignment procedure is given in Section 4.2, it is intended for future reference only. Do not attempt the procedure, without contacting PRA, beforehand, if the system is being set up for the first time. Read Section 4.2 b): "Oscillator Cavity Alignment" but do not attempt any adjustments. Merely note discrepencies and contact PRA if possible. If not possible follow the procedure very carefully making slight adjustments as indicated one at a time and record the adjustments.

4.1 c) Amplifier Misalignment

If the oscillator beam is good, and misalignment is suspected in the amplifier stage, proceed as follows:

(i) Ensure pump laser is centered on beam steering prisms, P2 and P3. If not loosen the screws in the mounting base, and readjust the prism holders to correct (screws are mounted in oversized holes).

(ii) Check the horizontal centering of the pump beam on cylindrical lens L2. If off center, adjust the P3 holder.

(iii) Block the pump beam successively to ensure the line focus from L2 overlaps the oscillator beam in the amp cuvette (C2). If the two beams are not coincident, but are angled with respect to each other, slowly adjust the rotation control of the L2 lens (First loosen set screw lock at top), while monitoring output. If the beams can be made parallel, but not coincident, carefully adjust the tilt screw on P3 (First, release the lock-nut) until beams are spatially matched. Repeat the two adjustments until no more increase in signal is observed. When the coincidence is correct, the weak oscillator beam, emerging from the amp cell when the amp pump beam is blocked, should overlap the most intense region of the fluorescence emerging from the pump when the oscillator beam is blocked (Check the far field in this test).

(iv) If the output beam is split into two, carefully adjust the rotation control of the amp cuvette until a single spot appears (first release set screw lock).

(v) Ensure amp cuvette is installed properly and window surfaces are clean. Try all four sides of the cuvette to find the one which is optimum.

(vi) To optimize, proceed to Section 3.3. If misalignment persists, refer to Section 4.2 c).

4.2 Designated User (Refer to Figure 1)

The following is a detailed procedure for the alignment of the LN107. It is assumed that all optical components may require alignment. This detailed procedure will only be required in the case of:

a) severe misalignment incurred during shipping;

b) component replacement, particularly oscillator elements e.g. grating.

NOTE: At this point you should have read the previous sections of the manual and hence understand the operation of the LN107.

4.2 a) Initial Procedure

(i) Follow the initial set up procedure in Section 3.1.

(ii) Observe the line focus region from the lens, L1. If the line is not parallel with the plane of the optical bench, locate the small set screw holding L1 in place. Loosen the screw and carefully rotate the lens holder. Retighten the screw when the focus line has the correct orientation.

(iii) Observe the face of the oscillator cuvette, C1 closest L1. If the face is not normal to the incident pump beam, use the rotation control, to correct. (First release set screw lock).

(iv) Place the lens, L1, in the mid-position of the translatable mount (control "3").

4.2 b) Oscillator Alignment

(i) Locate the tilt adjust of the mirror M1 and observe the mirror surface. If the plane of the mirror is not perpendicular to the laser platform, loosen the lock nut holding the mirror set screw in place. Carefully turn the screw to correct the tilt, and re-tighten the lock nut. When the tilt is set correctly, the small gap between the mirror holder and the mounting behind it, should be of uniform width from the top of the holder to the bottom.

(ii) Ensure that the grating is flush with the mount surface and centered in the mount. If not, loosen the two screws holding it in place, adjust and re-tighten. DO NOT TOUCH THE GRATING SURFACE when positioning. When properly oriented, the grating should be illuminated along approximately 70-80% of its length by the diverging fluorescence line from the dye cell. If necessary, slightly adjust the cuvette rotation control until the end of the fluorescent arc that illuminates the grating is approximately 1 cm from the vertical edge (of the grating) closest to the cuvette.

Also, ensure the arc is vertically centered on the plane of the grating, by slightly re-adjusting the leg mounts. Since the output of the LN107 is critically dependent on proper illumination of the grating, a large degree of patience is essential during this step. For optimum performance, iterate through the following adjustment sequence until no more improvement of the grating illumination is observed:

1) focussing lens, L1 (translation and rotation, if necessary)
2) cuvette rotation, C1
3) leg mounts

(iii) Locate the top and bottom adjustments for the output coupler W (Remove locking device). Turn the top adjustment (tilt) to the mid-position. Place one white card between the beam splitter and prism, P2 to block the amp pump beam. Place a second white card between P2 and P3, directly behind the grating and locate the fluorescence from the dye cell. Turn the bottom adjustment of the output coupler until a single bright spot is observed, approximately 5 mm in diameter. If a double spot is observed, re-adjust the cuvette rotation to correct.

(iv) Move the second card to the opposite side, directly in front of the prism, P1. Turn the top adjustment of W until one or two small (~2 mm dia.) intense laser spots are found. If two spots occur, carefully turn the bottom adjustment of W until there is only a single intense lasing spot. If the lasing spot is found to be weak in intensity, slightly adjust the cell rotation to optimize. Test for lasing by blocking the mirror M1; when blocked, the spot should fade into the background fluorescence.

(v) Remove P1 by removing the pedestal retaining screws and check the beam position. If the beam ascends or descends with respect to the bench surface, carefully re-adjust the lens rotation of L1 to correct. Re-optimize the beam by adjusting (in order), mirror tilt, bottom adjustment of W, top adjustment of W.

(vi) Place a card at the P1 location and observe the laser spot with respect to the circular region of background fluorescence. If the intense laser spot is significantly off-center in the horizontal, adjust the cuvette rotation appropriately and compensate with the bottom adjustment of W.

(vii) Optimize beam intensity and quality by iterating through the following sequence of adjustments:
a) L1 focus control
b) C1 rotation
c) M1 tilt
d) bottom adjustment of W
e) top adjustment of W
f) L1 rotation

Try all faces of the cuvette for best quality, minimum background fluorescence and greatest intensity. DO NOT TOUCH THE FACES OF THE CUVETTE.

4.2 c) Amplifier Alignment

(i) Replace the prism, P1 and remove the amplifier cuvette. Loosen the screws which attach lens mount, L3, and iris mount, I, to the base plate. Remove both components.

(ii) Using the two adjustments on the turning prism, P1, centre the oscillator beam through the output aperture.

(iii) Replace the iris and centre with respect to the horizontal. With the iris apertured down, completely, observe the beam at the output aperture. If the beam is vertically off-centre with respect to the iris centre, readjustment of the oscillator will be necessary. If the beam is high (low) on the iris, carefully adjust the mirror normal 'downwards' ('upwards'), and compensate with the top adjustment of W appropriately.

(iv) Replace lens, L3, and centre horizontally with respect to the beam axis. Open the iris aperture to approximately 5 mm.

(v) Remove the card blocking the amplifier pump beam and ensure the beam is centered on the P3 face. If necessary, loosen the screws holding P2 in place, optimize and re-tighten.

(vi) Check the position of the amp pump beam on the lens, L2. If correction is required in the horizontal, loosen the screws holding P3, and adjust. When beam is centered properly block the amp pump beam from the C2 position. (Vertical centering is not important at this point).

(vii) Insert the amplifier cuvette in the holder. Place focussing lens L3 in the mid-position of the mount, and place a business card approximately 1 meter from the exit aperture of the LN107. Adjust the amplifier cuvette translation control "7", until the focussed oscillator beam just grazes the inner wall of the cuvette which is closest to the amplifier focussing lens, L2.

(viii) If the focussed beam does not enter and exit parallel to the wall, locate the rotation control for the amp cuvette, release set screw lock and adjust. Afterwards, re-adjust the cuvette translation and if necessary, repeat the adjustment sequence until the beam position is correct.

(ix) Remove the card blocking the amplifier pump beam and follow the procedure of Section 4.3. For final optimization, iterate through the following sequence of adjustments for best energy and beam quality. (Monitor the beam quality at P1 position as well as at the exit port). To increase the optimization sensitivity, turn the wavelength setting until the laser is near threshold operation before commencing with the adjustments. (An energy monitor is essential for final optimization).

1) L1 rotation
2) M1 tilt
3) W adjustments
4) C1 rotation
5) L1 focus
6) I diameter
7) L3 focus
8) C2 rotation - (this is adjusted by the thumb screw control located at the base of the C2 assembly)
9) C2 translation
10) L2 translation
11) L2 rotation

Replace all locking devices while monitoring output to ensure misalignment does not occur due to vibration.

5.0 WARRANTY

5.1 General Information

All PRA manufactured instruments are warranted against defective materials and workmanship for one year from date of shipment provided that the equipment has been used in the proper manner as detailed in the Instruction Manuals.

During the warranty period, repairs or replacement will be made at PRA's option. No instrument should be returned without informing PRA, either in writing or by telephone, of the nature of the fault, model number and serial number of the unit.

If PRA gives authorization for a return please REFER TO SHIPPING INSTRUCTIONS AT THE REAR OF THE MANUAL. These instructions are for a warranty return from the USA. An identical procedure must be followed when the return is made from any country, with the exception that notation for "US CUSTOMS CLEARANCE..." is deleted. An example with instructions of a CUSTOMS INVOICE is included as well as a blank invoice that can be used in the event of a warranty return. Follow the simple directions carefully in order to avoid delay and extra charges.

Instruments that are returned should be packed so they will withstand normal transit handling, and must be shipped PREPAID to PRA or a qualified distributor. Instruments that are damaged in transit due to inadequate packing will be repaired at the Sender's expense and it will be the Sender's responsibility to make claim with the shipper.

5.2 Expired Warranty

Instruments not under warranty shall be repaired at the standard charge. Customer Service will send a quotation for all non-warranty repairs. A Purchase Order must accompany the item to be returned.

5.3 Warranty on Equipment not Manufactured by PRA

PRA's basic one year warranty applies only to equipment manufactured by PRA. Although PRA may frequently supply, as part of a system, equipment manufactured by other companies, the only warranty that shall apply to such non-PRA equipment is that warranty offered by the original manufacturer.

5.4 On-Site Repair

The basic PRA warranty applies only to equipment manufactured by PRA which is returned to the factory. If equipment must be repaired at the customer's site, the actual repair labour and parts will be provided at no charge during the warranty period. However, travel expenses to and from the site as well as living expenses while on-site will be paid by the customer.

5.5 Damage in Transit

Shipments should be carefully examined when received for evidence of damage caused by shipping. If damage is found, notify PRA and the carrier immediately. Preserve all packages, cartons and documents. PRA will provide all possible assistance in damage claims.

RETURN AUTHORIZATION (R/A) NUMBER IS REQUIRED BEFORE RETURNING ANY ITEM TO PRA. CONTACT CUSTOMS AND TRAFFIC FOR R/A NO. AND FOLLOW THE SHIPPING INSTRUCTIONS FOR RETURN PROCEDURES AS LISTED BELOW:

6.0 SHIPPING INSTRUCTIONS

WHEN SHIPPING BY TRUCK, BUS OR COURIER:

1. Canadian Customs Invoices, in quadruplicate, must accompany the shipment. Attach Customs form to a copy of the Bill of Lading.

2. Canadian Customs Invoices and Bill of Lading SHOULD CLEARLY BE MARKED AS FOLLOWS:

   U.S. CUSTOMS CLEARANCE CONTACT: J.V. CARR, 560 Delaware Ave., Buffalo, N.Y. 14201 or J.V. CARR & SON INC., 1600 W Lafayette Detroit, MI 48232 for T.I.B. BOND.

   FOR CANADIAN CUSTOMS CLEARANCE: CONTACT PEACE BRIDGE BROKERAGE LTD.

3. Mail two extra copies of Canadian Customs Invoice, the Original Bill of Lading, and your commercial invoice or purchase order on date of shipment to PRA.

WHEN SHIPPING BY AIR FREIGHT OR AIR CARGO:

1. Canadian Customs Invoices, in quadruplicate, must accompany the shipment. Attach to the Air Way Bill and CLEARLY MARK:

   U.S. CUSTOMS CLEARANCE TO ISSUE TIB BOND, PRIOR TO DEPARTING THE U.S.

   AND ALSO:

   AIRPORT CUSTOMS CLEARANCE FOR CANADIAN CUSTOMS CONTACT: PEACE BRIDGE BROKERAGE LTD.

2. Air Way Bills must be identically marked as above.

3. Air Mail two extra copies of Canadian Customs invoice, the original Air Way Bill and you commercial invoice or purchase order to PRA the day the shipment leaves.

SHIPPING INSTRUCTIONS CONTINUED

WHEN SHIPPING BY MAIL OR PARCEL POST:

1. Canadian Customs invoice, in quadruplicate, must be mailed direct to:

   PRA INTERNATIONAL INC.
   45 MEG DRIVE
   LONDON, ONTARIO
   CANADA N6E 2V2 Phone No.: (519) 686-2950

2. Mail two extra copies of the Canadian Customs Invoice, and your commercial invoice or purchase order to PRA, on date of shipment.

   PLEASE NOTE: If goods are not registered with U.S. Customs as leaving the U.S. to be going to Canada for repair or replacement, there will be lengthy delays, and it may be necessary for additional charges to be incurred for proper Customs clearance.

   PRA is entitled to refuse to accept any returns that do not have proper Customs documentation, once the customer has been advised of proper procedure regarding returns.

If any questions arise concerning the foregoing procedure, please contact:

PRA INTERNATIONAL INC.
45 MEG DRIVE
LONDON, ONTARIO
CANADA N6E 2V2

Phone No.: (519) 686-2950 Attention: Traffic Department