INSTRUCTIONS
THE MOD II HOLOGRAPHY SYSTEM

Introduction

Since the 1968 introduction of Gaertner Scientific Corporation's then uniquely different Rectangular Optical/Instrument Bench, Holography, in theory and practice, has grown to considerable sophistication. A good fundamental holographic system allows improvements to be made thereby providing for both the introduction of techniques and understanding to the newly initiated while simultaneously forming the basis for the more advanced users to move ahead with their work.

With this approach in mind, Gaertner has introduced larger benches, flat benches, x-y-z stages, segmented beamsplitters, precision plate holders, modular interferometers, and many other modular components. The design objective has been to allow users of "old" systems to update to improved systems without the loss of value of equipment already owned.

The new MOD II system is just such a development. Owners of any of the "R" series systems or components will find it economically feasible to move up to the MOD II, (R132, R232 or R332) because they can use most of what is already owned and merely purchase a few extra components. This booklet tells the detailed story of the "MOD II", and how to put it to work.

To our friends who do not have any "R" equipment, this information may be of interest anyway and we are happy to provide this copy to you. If we can help with your needs, we'll be pleased to hear from you.

THE MOD II HOLOGRAPHY SYSTEM
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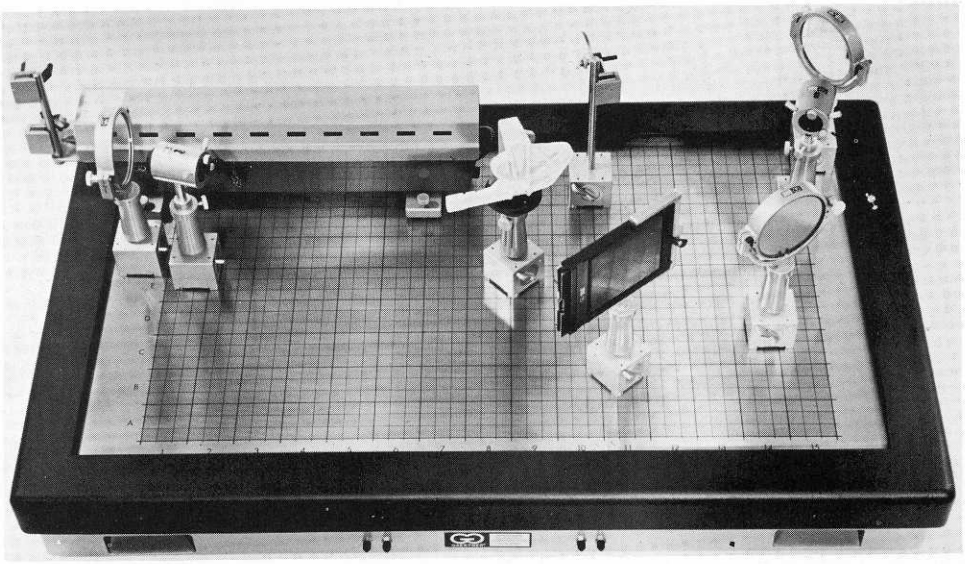


FIG. 1

R132 MOD II Holography System

SECTION I – The R132 System Components

The theory of Holography is covered sufficiently in other literature and therefore is not repeated here. In fundamental form, the Gaertner-Jeong Manual (provided free with all Gaertner systems and otherwise available at a very nominal price) will prove adequate for understanding elementary holographic theory. It also provides information on setting up a basic Gaertner system.

This MOD II brochure will provide information on newer setups which are more flexible and which produce higher quality, brighter holograms without increasing laser power. In essence, use of the R132 system setup will provide much greater flexibility and allow the user to produce high quality holograms over a very broad range of objects.

Components

The R132 system is comprised of the following components. All are available from Gaertner.

Item Description	Gaertner Catalog No.	Quantity
Laser	R290	1
Mounting Bars (for Laser)	R290B	1
Beam Deflector	R258	1
Mirrors	R255L	3
Spatial Filter	R250	1
Spatial Filter	R250-2	1
Variable Segmented Beamsplitter	R261	1
Specimen Table	R270L	1
Plateholder	R275	1
Rectangular Bench	R110*	1

*There are several Gaertner designs available but the basic standard is R110, a flat bed, 60 x 106 cm work surface with air suspension. Information on others is available on request. All work equally well in this system. The R232 system uses a bench with rails and scales and the R332 uses a two meter long flat bed. Otherwise, the R132, R232 and R332 are identical.

Note: There are a few accessory items available and recommended such as the R252 Shutter/Diaphragm which while not essential to this high performance system will be found helpful in maximizing results. Appropriate reference is made to them in the text.

Laser: The R290 laser is a conventional He-Ne type producing single-mode TEMoo continuous energy in the 2mW range (nominal) and at 632.8 nm. While any good quality single mode laser of sufficient power will do the job, the R290 was specially selected for this system. The built in power supply makes the unit's placement entirely optional anywhere on the bench – the only wire is the one going to the AC outlet (120V., 50 – 60Hz.). It weighs just 11.5 pounds, is rugged and highly reliable and consumes 75 watts of power. Mounting Bars are provided for increased stability and adjustment.

Beam Deflector: The R258 consists of two first surface mirrors held on a vertical rod by magnetic mounts, permitting vertical adjustment and rotation in azimuth and elevation. A bracket attaches the unit securely to the front panel of the R290 laser. The rod can also mount to a magnetic base (R280M) for placement elsewhere in the system. This deflector allows the user to direct the beam anywhere it is needed – high or low, on axis or off.

Mirrors: The three R255L mirrors are 100 mm diameter first surface units, each mounted in a yoke attached to a 13 mm rod which in turn, mounts in a support tube on a magnetic base, for secure placement. Vertical, azimuth and elevation adjustments can be made.

Spatial Filters: The two spatial filters, R250 and R250-2 are each mounted on a rod, support tube and magnetic base. The R250 utilizes a 10 x objective with a 25μ pinhole. The R250-2 has a 20x objective with 12.5 μ pinhole. (Other objectives and pinholes are available and interchangeable). These filters "clean" the laser beam by eliminating scatter caused by dirt, dust or minor optical imperfections of components in the system. A threaded adapter is incorporated to allow the spatial filter to be mounted directly to the laser itself should this be desired. A simple spring loaded shutter and cable release are included for convenience in the R250 unit only. See Figure 3.

Variable Segmented Beamsplitter: The R261 is a circular glass disc 86 mm in diameter with nine numbered segments of 2cm^2 optical aperture. Each segment is uniformly hard coated providing reflectivity at a 45^o angle in steps of 10% from 0 to 80%. The disc is rotable and is magnetically coupled to a rod which in turn mounts to a magnetic base. It provides elevation, azimuth and vertical adjustment. The primary purpose of the R261 is to allow direct and easy changes in beam ratio which will be further explained in the appropriate section of this booklet.

Specimen Table: The R270L is an elevating table and stand to support the object of which a hologram is to be made. It too is mounted by rod and support tube on a magnetic base.

Plateholder: The R275 is a modified 4" x 5" plateholder for holding the holographic plates and is also mounted on a rod, support tube and magnetic base.

Rectangular Bench: The rectangular bench concept is hardly new but Gaertner was first to present a commercial version

of it with several unique features including inexpensive anti-vibration suspension, a choice of flat bed or rails and "on-off" magnetic supports. Whether yours is a "rail" type or "flat bed" type is less important than having one with vibration damping air suspension. This simple, low cost feature is available for either the one or two meter models. Air valves are located conveniently on one long side so that air pressure may be used in a controlled manner, not only for damping action, but also for leveling the table once it is loaded with the optical components of your system. (Older models may be equipped in the field with a simple and inexpensive hose and valve kit to make it equally convenient to adjust air pressures. Contact Gaertner for kit ordering information – R210K).

The more familiar you become with your R132 components, the easier you will find it to accomplish your objective of producing holograms quickly and with high quality.

SECTION II System Layout and Alignment of Components

1. Set the bench on any reasonably solid table in a room which can be darkened. Lift off the black outer frame of the bench and remove shipping screws from bench sides. Make certain that bench bed is "floating" on air suspension tubes. Replace frame. Note: Valves for adjusting air are located on one of the long sides of the bench. Be sure this side remains accessible. When bench is carrying full load of laser and all components, floating should be checked and air adjusted for a level bed. Clean bed (use paste wax if necessary).

2. CAUTION – unpack components carefully. Avoid fingerprinting mirrors and lenses. Place all components except the two spatial filters on bench approximating the layout shown in Figures 1 and 2. Lock magnetic bases with levers. Note that laser faces away from system and the beam deflector is used to bring beam back. This arrangement provides more room for components on the bench. Deflector rod should be vertical and all four laser feet should rest in same plane. Use leveling screws as necessary to level laser.

3. DO NOT TURN ON LASER until you get to step 6. While the power of the R290 is nominally about 2 mW, do not look directly into its beam (or for that matter into any laser beam). Equally important, do not look into any mirror-like reflection of the beam. Nothing is served or gained by so doing and as of this writing no known standards exist in determining what comprises dangerous level laser radiation. Therefore, it is simply good procedure to keep either the direct beam or its reflection from entering the eye of oneself or others who may be present.

4. Adjust the height of all of the components (except laser and specimen table) so that the center of the apertures are approximately 8-1/2" above the bench.

5. Position the plateholder so that it is perpendicular to an imaginary line drawn from where the face of the object will be to the plateholder. Place object of which hologram is to be made on table, adjust the height of the center of the object to the height of the center of the plateholder aperture.

6. Plug in laser to 120 v., 50 – 60 Hz. outlet and turn it on. Swivel bottom beam deflector mirror so that it receives the beam. While keeping the beam approximately centered, tilt the mirror to direct beam vertical to top mirror.

7. Repeat procedure with top mirror to direct beam (object beam) horizontally through center of segment "O" on the Variable Beamsplitter to the approximate center of mirror M-2. The plane of the Beamsplitter disc should be vertical and at an angle to the incident laser beam such that the reflected beam will be directed to mirror M-1. The surface on which the reflecting segments are deposited should be toward the Beam Deflector. Align M-2 to direct beam to center of mirror M-3. Be certain that the segmented disc faces the proper way. (Fig. 1).

8. Using mirror M-3, direct beam to illuminate object as desired.

9. Rotate Variable Segmented Beamsplitter to position 8. The laser beam is now mostly reflected toward mirror M-1 (reference beam). Adjust the position of the mirror to have the laser beam strike its approximate center.

10. Align M-1 by rotation to direct the beam to the center of the plateholder.

11. Recheck all alignments and make any minor adjustments that are necessary.

Spatial Filters

12. Place spatial filter R250-2 (SF1 in Fig. 2) next to mirror M-1 as shown in Fig. 2. Be certain that it is oriented as in Figure 2. Remove pinhole (held magnetically) by pulling straight out (to aid in filter alignment). Pinhole is the black knurled piece at the end of filter which is away from mirror.

13. Position the spatial filter so that the laser beam passes through it. Since the beam is now being spread by the filter unit, it is best to place a white sheet of paper 4" to 6" from the filter and allow spread laser beam to project onto paper. The projected pattern will appear similar to that shown in Figure 4A, that is, essentially circular. Re-position filter as needed to get this pattern; the more circular, the better. Also position filter so the spread of the beam covers the complete plateholder aperture.

14. Rotate "focusing screw", see Figure 3, clockwise to move objective lens to its back position and replace pinhole assembly.

15. Using the two "pinhole centering screws", approximately center the pinhole, adjusting until a pattern similar to that in Figure 4B is obtained.

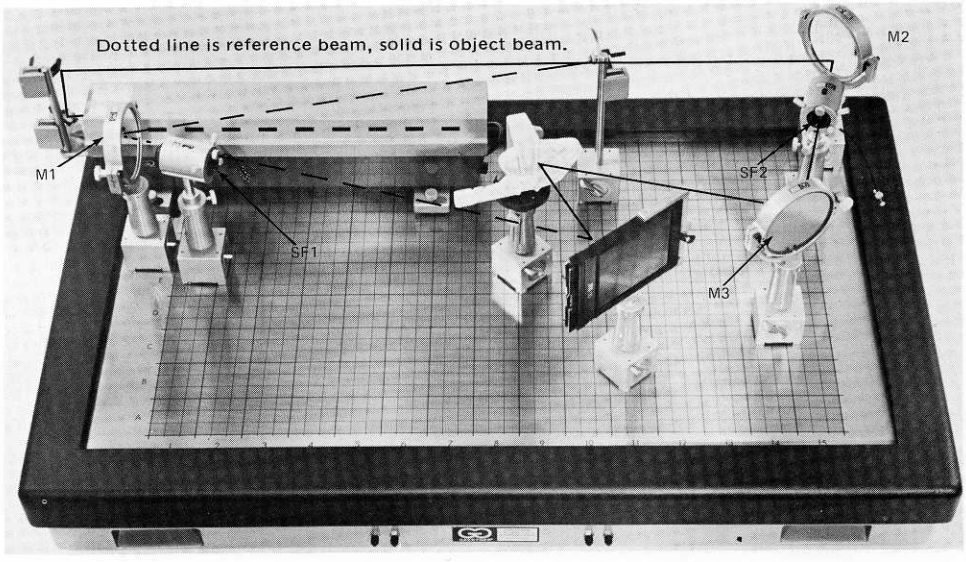


FIG. 2

Suggested arrangement for making transmission holograms on R132 MOD II.

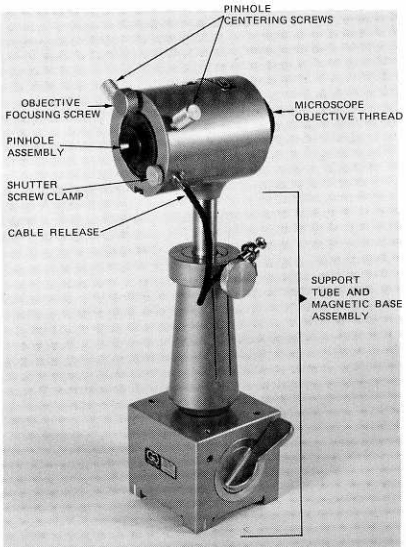


FIG. 3 SPATIAL FILTER ASSEMBLY R-250

16. Rotate the "focusing screw" counter-clockwise and observe the projected pattern. If the pattern begins to move off center, distorting the circular pattern, see Figure 4C, re-center pinhole using the "pinhole centering screws" and resume rotating the focusing screw. If the alignment is good, the projected beam will increase in size, remain circular and the rings shown in Figure 4B will disappear. At the point where they disappear, Figure 4D, the spatial filter alignment is complete.

17. Set Beamsplitter to "O" and repeat steps 11 to 16 for Spatial Filter R250 (SF2 in Fig. 2). Position it according to Figure 1 adjacent to mirror M-2 so that it is about the same optical path distance from the object as the other filter was from the plateholder and it illuminates the object.

18. The system is now in complete alignment. Some minor adjustments may have to be made to accommodate for different sizes of objects or for experimenting with "home-style" techniques. If you wish to use the R-252 Shutter/Diaphragm as a means of controlling film exposure and eliminating any stray beams (secondary beams) from the laser, it is insertable in the system between the beam deflector and the Variable Segmented Beamsplitter. It has its own magnetic base.

SECTION III Recording a Transmission Hologram

Be sure all elements are locked. If the alignment procedure was followed, the beam from Spatial Filter R250-2 will illuminate the Plateholder aperture and the beam from Spatial Filter R250 will illuminate the object.

These two beams should not interact with each other except at the plateholder which "sees" the reference beam and the reflections of the object beam coming from the object. To assure that this occurs correctly (thereby adding greatly to the system efficiency), add a cardboard baffle as shown in Figure 5. This baffle prevents any of the reference beam from striking mirror M-3 and filter R250. It also serves to block out reflections from the laser, deflector and beamsplitter. If baffle is made a dull black it will be best. If preferred, order R254, a black metal baffle which is more durable and properly shaped for this application.

Choice of Objects – While many different objects will work well, there are some guidelines that might be followed to achieve best results. It is recommended that experimentation be saved until the system is used as described to obtain one or two quality holograms. To do this, stay with suitable subject material. Here then, are points to consider:

1. Dark objects have little reflectivity and are difficult to use.
2. Highly polished, shiny surfaces are often too reflective and unless they can be toned down, might cause the loss of some areas in the hologram. This can be compensated for somewhat by diffusing the object beam with a ground glass placed between M-3 (Fig. 2) and the object.
3. If objects permit it, a spray of white paint or frost will yield good results. A wet, fine sandblast can also be used if the object permits.
4. Sometimes a "difficult" object need only be positioned differently on the table to achieve excellent results.
5. What you see approximately 8" from the plateholder's aperture will be approximately what you will record so guide yourself accordingly.
6. All of the foregoing invites experimentation and the system is highly flexible so such work is encouraged. The experimentation should include variations in such things as beam ratio, exposure time, object position, and even overall system layout. More will be said on these and other items as appropriate in this and subsequent sections.

Adjusting Beam Ratio – Convention provides that the Beam Ratio is the ratio of the intensity of the reference beam to the object beam. The ratio is adjustable by simply rotating the Segmented Beamsplitter. As a starting point, a ratio of approximately 6:1 is recommended. This is achieved with a setting of "3" on the Variable Segmented Beamsplitter, for an object of "normal" reflectivity. A light meter with a low sensitivity scale reading about .014 ft-c (0.1507 lux), may be used to verify the ratio if desired. To do this, alternately block off each beam and measure the other beam at the plane of the plateholder with the meter pointed directly at the incident light. The shutter in the R250 Spatial Filter is spring loaded and operated with a cable release. Its normal position is open. To close it, push the plunger. To lock it closed, push plunger and tighten side knob next to plunger. The 250-2 has no operable shutter.

Plate or Film Selection and Plateholder Loading – The recommended films or plates for use in holography are those identified as emulsions 649F (Kodak) or 10E75 (Agfa). Use "halation backed" plates for transmission holograms (and "non-halation backed" for reflection holograms). They and their specifications are directly available from the respective manufacturers. Eastman Kodak Co., Rochester, N. Y. 14670 and Agfa-Gevaert, Teterboro, N. J. 07608.

These emulsions are high resolution spectrographic types with good contrast and are sensitive to 632.8 nm. The manufacturer can provide complete details on specifications and availability. (Note: The wavelength sensitivity was selected to match the R290 Laser, also 632.8 nm, so if any other laser is used, it will be necessary to check its characteristics against other available emulsions and seek to obtain a corresponding match.) Both emulsions may be handled with a dark green safelight. Follow manufacturer's recommendations.

FIG. 4A

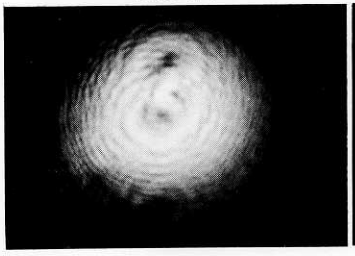
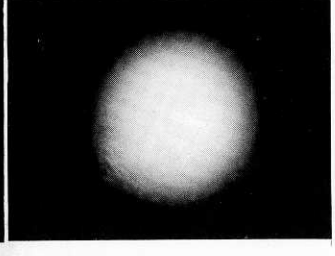


FIG. 4B

FIG. 4C

FIG. 4D



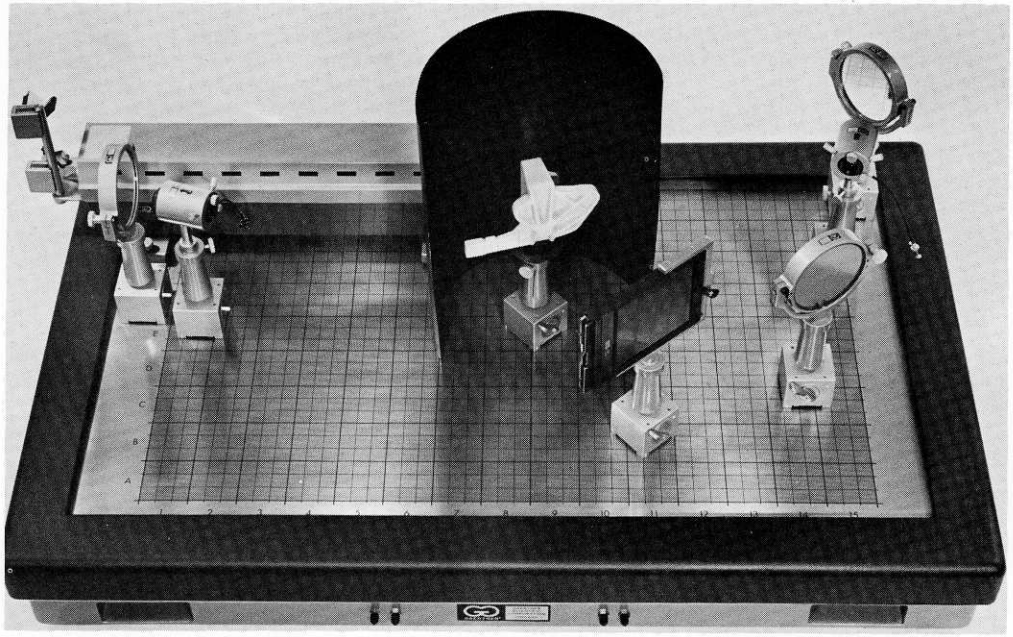


FIG. 5

R132 MOD II Holography System with baffle to shield out reflections.

The Plateholder R275 is a modification of a conventional type unit. Although it is originally intended to hold two films or plates, one on each side, for holographic applications, use only the side which has a leaf type spring in contact with the frame. To load the holder, do the following:

1. Turn off lights (or use dark green safelight).
2. Remove dark slide from leaf-spring side of holder by pulling on handle. Move leaf-spring and open wooden end flap. Set both pieces down.
3. Open plate package. Generally, the two outer plates are placed emulsion side in and the two inner plates back to back with emulsion side out. Instructions accompanying plates will clearly indicate packaging and emulsion sides.
4. Plates must be loaded in frame with emulsion side "out", that is, the emulsion side will be directly beneath the dark slide when it is slid back into holder.
5. Holding plate by its edges with emulsion side facing the palm of hand, lay plate in holder, fold down wooden flap and swing leaf-spring back to hold flap closed.
6. Replace dark slide making certain it slides all the way into the slot in the wooden end flap. Be certain the dark slide on the opposite side is in place. Lock both shields to prevent accidents.

Film Loading – If film is used rather than plates, it will be necessary to sandwich the film between two pieces of 3/64" thick, 4" x 5" glass plates (not furnished) to keep film flat and permit frame loading as described in steps 1-7 of the preceding directions. Film is more difficult to handle but does have the advantage of being less costly and it is possible to use sizes smaller than 4" x 5". Film is usually edge notched so that when the notch is in the lower right side the emulsion is up. Check manufacturers information sheet to be certain.

7. Put plateholder back on its stand in system with loaded side (spring clip) facing object. Tighten clamp screw.

Exposure – Remember, vibration-free exposures must be made to record a hologram. Avoid bumping or otherwise moving the bed or components during exposure. Be sure all components are locked in place. Follow these steps:

1. Check Spatial Filter SF2 to make sure the shutter is open.
2. Turn on laser and block beam with cardboard placed ahead of Variable Beamsplitter, or if R252 Shutter/Diaphragm is used, set for "BULB" and make sure it's closed.
3. Darken room except for dark green safelight.
4. Remove dark slide from plateholder. Wait 30 seconds to stabilize system.
5. Make exposure by carefully operating cable release on Shutter/Diaphragm or if using a cardboard to block beam, lift cardboard clear of beam. Exposure times vary with emulsions, subject matter, laser used and other factors. If, for example, the Agfa emulsion is used, with an average object and the R290 Laser, try an 8-10 second exposure.
6. Close shutter (or replace cardboard) to end exposure.
7. Replace dark slide in holder – make certain it is pushed in all the way.

Plate Processing – While film processing techniques are constantly changing and improving, the method described below works very well and is recommended at least as a starting point.

The basic items needed are:

Kodak D-19 developer, Kodak Fixer, Kodak Chromium Intensifier (A), three trays (8x10 or larger), small squeegee, paper towels, a clean bucket capable of holding a gallon of water or a temperature controlled running water wash tray, a timer and a dark green safe light. NOTE: Careless handling can spoil holograms during processing. If extra care is exercised, the results will always compensate for the effort. Inbetween each of the steps, move the plate from solution to solution as rapidly as possible since allowing the wet emulsion to make more than brief contact with air may distort the emulsion. Slide plate into each solution from the end in one quick continuous motion so that the emulsion is instantly and totally flooded with solution – avoid splashing that might cause bubbles to form on the surface of the emulsion. If for any reason it is necessary to "hold" between steps, put plate in the water bath until you can again proceed but do not 'hold' bleach.

Mixing Chemicals – Follow the mixing directions provided with the chemicals. All solutions should be between 68°F and 72°F before processing. The developer temperature is most critical. Fill trays to a little more than half full. Store excess developer in a dark brown or opaque bottle. Do not reuse developer from tray. The fixer may be reused, as well as the Chromium Intensifier which is used as a bleach. Only part (A) of the intensifier is used, part (B) may be discarded without mixing.

Developing – In dark room, with dark green safelight, remove plate from holder and with emulsion side up, slide into developer. Rock tray gently and continuously for 5 minutes. Remove and rinse in wash (water) bath for ten seconds or so.

Fixing – After washing, slide plate into fixer, emulsion side up. Rock gently for about 15 seconds then allow plate to remain in fixer for 4 or 5 minutes – occasionally rock tray during this time. Lights may now be turned on and the remaining steps done in regular room lighting conditions. Rinse plate in bucket of water (or in temperature controlled running water) for 5 minutes.

Bleaching – Use a Chromium Intensifier (A) solution only. Slide plate into bleach and watch carefully. The black emulsion will start to turn yellow in patches. Agitate continuously. When the entire black area is yellow, remove immediately and wash. Do not over-bleach. (If plate does not clear completely in one minute, it was probably overexposed). Wash with constant agitation in temperature controlled running water for 30 minutes.

Drying – (A little care at this point can make or break a good hologram. Keep in mind that the trick is to remove all excess water immediately without damaging or "shifting" the soft emulsion. Speed and a light touch will suffice). As soon as you remove the plate from the wash, shake off excess water and place on two or three thicknesses of paper towelling, emulsion side up.

Dry your hands and with a clean dry squeegee make two light strokes across the plate. Between strokes, touch the squeegee to the towelling to dry the edge. Don't press hard on the plate as too much pressure may shift the emulsion. Turn plate 90° and repeat squeegee operation. The surface should be clear of water drops and streaks at this point.

To finish up, allow plate to air dry in as dust-free an area as can be had. This will harden the emulsion and make the hologram quite stable and durable.

Film Processing – While flexible film is somewhat more difficult to handle in tray development, it does have the advantage that mishandling cannot break it. Follow all steps given for plate processing up to the drying step. For drying film, use a small clip on one corner and shake off excess water and wave in air or use a good quality commercial spray dry.

SECTION IV Viewing Holograms

A transmission hologram, as was made with procedures outlined in Section III, is viewed by sighting through the plate while the emulsion side faces the laser illumination source i.e. source on one side facing emulsion and viewer on the other side viewing through hologram toward light source. The source may be the R290 Laser beam spread by passing through a beam expander (the spatial filter is a beam expander.). The hologram is most easily viewed by simply placing it back in the plate holder in the same position as was used when it was first produced. It may also be viewed using any laser with a beam expander and holding hologram with emulsion side facing into beam. When viewing it this way, maximum brightness and correct size will be achieved when the distance from the spatial filter to the plate is the same as it was in the system and if the plate angle to object is approximated in the position used for viewing. It will quickly become apparent how best to view and show this work to others. Use only one beam.

SECTION V Reflection, White-Light, Multi-plex and Other Holograms

Details of theory and practice for other variations of the "standard" transmission type are beyond the scope of this booklet. However, many reference sources are available should they be needed, and the R132 will be very flexible in adapting to these others. Also refer to the Gaertner-Jeong manual.

SECTION VI Double Exposure Holography

Refer to the Gaertner-Jeong manual Section VI, page 23. In the double exposure type of hologram, the object is first holographed for 1/2 the normal exposure time. Then the exposure is repeated without moving any components whatever. If the object had a slight displacement (as for example, an item being brought from a no-load to a loaded condition between exposures) the double exposed hologram will have "captured" any resultant deformation of the object. When developed the hologram will show the object and super-imposed on its image will be interference lines at all places of displacement.

It is important to realize that we are talking of changes of relatively low magnitude. Major changes will wipe out the double exposed image completely.

SECTION VII Miscellaneous

References – A number of references are given in the Gaertner-Jeong Manual on page 30. In a field as exciting as holography it becomes impossible to keep any reference list adequately updated. The usual trade publications should be followed.

New Products – New products are regularly introduced by our company. While we attempt to desseminate this information in news releases or advertisements, many of our customers miss getting the information that they are entitled to. We try to maintain an active communication link with our customers but admit to only limited success. If you will check with us anytime you are planning something new or different, we will be happy to suggest available equipment to help you with your work. We also make custom equipment and invite your inquiry should there be nothing commercially available along the lines of what you need.

Liability – Gaertner Scientific Corporation, its employees and representatives have no liabilities, express or implied, for anything other than repair or replacement of equipment found to contain defective parts or workmanship and then only within the limits set forth in our standard warranty which is stated in its entirety on the Instrument Registration and Warranty card which accompanies each complete system or is otherwise available on request.

Note: References to the Gaertner-Jeong Manual apply to first edition copies.

Real Time Holography – Send for bulletin 156-71L which describes the new Gaertner Liquid Plateholder R274.

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