The Carbon-Gum Process

A Creation

By

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Preface

A hundred years ago color pigments in a raw or reduced state were applied to tint or color the surfaces of carbon prints. But these tints were not impervious to moisture. By mixing the pigments with a colloid/bichromate solution the colors can be applied wholly or selectively to the carbon print surface. Through exposure to light the color is made insoluble.

At the turn of the 20th Century, photographer Paul Anderson began doing a similar process in conjunction with platinum prints. I have chosen to affix gum-bichromated tints to carbon because I prefer the richer blacks inherent in the carbon process. Moreover, since I found no evidence that it has been done previously, the combined processes offered the challenge to try something new.*

* While serving an internship in the Division of Photographic History at the Smithsonian's National Museum of History and Technology, 1976-77, I had the opportunity to learn and view most of the photographic processes which have been done in the United States to about 1975. I am most grateful to David Haberstich for his assistance and advice on this project.
Chapter I

History of the Carbon and Gum-Bichromate Processes

An Englishman, Mungo Ponton, noted in 1839 that when paper was soaked in chromium compounds and dried, it was then sensitive to light. Edmund Becquerel observed in 1840 that sizing in the paper increased the sensitivity of the chromium compound. He attributed this reaction to the presence of organic substances in the sizing. ¹ Twelve years later William Talbot discovered that when bichromate and gelatine are mixed and exposed to light the gelatine is rendered insoluble. ²

Alphonse Poitevin experimented further with a bichromate and gelatine. In 1855 he found that if a colored substance is mixed with the gelatine, sensitized with potassium bichromate, and then exposed through a negative to light, the unaffected parts will be washed away, while those areas exposed to light are made insoluble. His discoveries form the foundation of the carbon and gum-bichromate processes. ³

Poitevin's results, however, were less than satisfactory since most of his middle tones were washed out. Abbé Laborde attributed the tonal loss to the fact that of the two surfaces, the outer and the inner, only the former received the action of light. Therefore, the half tones are lost during the washing cycle, ⁴ resulting at best in a high contrast image.

Several others experimented with the Poitevin findings, but offered no solutions which were sufficient for general use until 1864 when Sir Joseph W. Swan patented the carbon tissue. Swan coated a sheet of paper with a mixture of gelatin and carbon pigment, and sensitized it with a coating of potassium bichromate. When dry he exposed the sensitized carbon tissue beneath a negative and transferred ⁵ it before development to another support, and then soaked it in warm water. Once soft the carbon tissue backing was stripped off leaving the pigment gelatin on a new support. The image on this
support was developed from the back in warm water. After a rinse-wash in cold water it was hung to dry.  

This is the first practical process of pigmented printing in which the pigment is incorporated with a bichromated colloid before exposure, and which yields all the details present in the negative. Although some variations have been added, today the carbon process is unchanged in its basic form.

At one time a variety of colors could be placed in a single image. This, however, is no longer true of the carbon process. In the 1950's the Autotype Company, Ltd. of London ceased manufacturing over thirty carbon tissue tints. Now the choice of available tints is limited to brown, blue-green and a few blacks, and they are only available through Gallery 614 in Ft. Wayne, Indiana. The only other possibility is for one to coat the carbon pigment onto the paper surface. Water color pigments which are used with gum-bichromate are readily available and one is only limited by his imagination as to the obtainable blends.

The gum-bichromate process is essentially Poitevin's carbon process. In the 1890's it was revived through the efforts of Rouille-Ladèvéeze, Robert Demachy and other French pictorialists. They were able to improve the richness, depth and contrast latitude of the process by multiple printing their images.

The gum-bichromate process, then, is founded (as the carbon process) on the reaction created by light bichromated colloids. The pigment merely adds color. The gum process remains essentially unchanged from the 1890's.
Chapter II

Introduction

Both processes have their advantages and disadvantages. Since carbon and gum-bichromate are both composed of colloids\textsuperscript{10} and pigments, and are sensitized with chromium compounds, they are compatible. Because they are non-silver processes, they have the added advantage of being permanent. That is, the images will not fade in the presence of light (provided, of course, permanent colors are used),\textsuperscript{11} and extremes in temperature or climate "have no detrimental effect."\textsuperscript{12}

The principal advantage of the gum-bichromate process is that through multiple printing one can build up a variety of colors on a single surface. Similarly one can obtain a longer tonal scale than with any other medium by recoating and reprinting the same image the desired number of times.\textsuperscript{13}

On a single printing the gum cannot produce a full tonal scale as can the carbon print. Primarily this is because there is no transfer involved in the gum process where the print is developed from the front. Both of these factors result in the middle tones dropping out or in losing either the shadows or the highlights.\textsuperscript{14} Thus, this would result in the same difficulties Poitevin incurred in 1855.

Because carbon printing is a transfer process, and the print is developed from the back, a single printing will produce all of the tones which exist in the negative.\textsuperscript{15} In addition, some control exists in the dilution of the potassium bichromate.\textsuperscript{16}

Multiple printing in the carbon process requires an elaborate registration system, simply because there is no visible image on the carbon tissue after it is exposed under the negative. With gum printing, however, one merely places the negative back over the recoated image. When a gum print
is recoated with opaque gum pigment, accurate registration can be troublesome. However, with the foregoing process registration will be an easier procedure since most of the gum pigments used will be translucent over the black carbon foundation print permitting enough of its black areas to show through for proper registration. To counter any unforeseen difficulties a simple registration system was devised and is described in Appendix A.

The objective of the thesis, then, is to produce first a full tone carbon print to serve as my foundation (or base) print. Then I will build upon this base print by applying a choice of gum-bichromated pigments to either the entire or part of the composition, and re-expose it under the same or selected negatives. In this manner I may either build a variety of colors, or do any other combination which may appear feasible. I plan to do four varied compositions:

1. A series of three prints illustrating the gum process, the carbon process, and the carbon-gum process.

2. A monochrome carbon-gum print produced by placing a carbon image on a gum pigmented surface.

3. Density overlays in which the surface of a carbon image will be selectively colored with one or more layers of gum pigment and the exposure controlled by using varying density negatives and positives.

4. Selective opaquing is similar to no. 3 above except that the exposure of the gum coloring will be accomplished by using a water color opaque to block out areas of the film not to be exposed.

5. Multiple image: A gum image of various colors will be composed first, and then a carbon image compatible with the composition will be placed within it.
Chapter III
"The Gum Bichromate Process" (See Plate I Left)

The gum bichromate process has been enjoyed by those who use it primarily for its esthetic, soft, mellow quality, and the versatility of the medium itself; e.g., the medium is not limited to photography but can derive its images by other means such as objects themselves exposed directly on the sensitized surface; one can also work the surface directly with a brush, scraper, and with other means.

Although any good grade of sized drawing paper is acceptable for gum printing, 100% rag watercolor paper is preferable for repeated printings because it is more dimensionally stable. It is less subject to shrinkage and it does not break up with repeated wettings.

Watercolor paper is usually sized by the manufacturer, but an extra coat of sizing would be in order to provide a good hard surface to assure that the gum bichromate solutions do not sink into the paper surface. Sizing is also useful in multiple printing in that each layer can be "fixed" or protected from abrasions. Information on sizing is supplied the reader in Appendix B.

The best chemicals for preparing a sensitized surface are raw chemicals. Ready made or industrially manufactured products often have other additives for fillers to give weight or bulk.

The colloid is prepared by placing some gum arabic in a cheesecloth bag and suspending it in a jar of distilled water for a few days. The bag is then withdrawn and a few drops of carbolic acid, formaldehyde or thymol are added to prevent spoilage. The ratio of gum arabic powder to water is 1:3.

The sensitizer is prepared by mixing one dry ounce of potassium bichromate (powder) to ten ounces of distilled water and allowing it to stand
for several days until the water is fully saturated with the chemical. Then pour off the solution, saving the residue at the bottom for future use. A sensitizer can be made quickly by adding the potassium bichromate to hot distilled water ($100^\circ$).

It is important to use distilled water wherever possible and practicable, especially in mixing chemicals, because most tap water usually contains other chemicals which may later cause deterioration to the image. Both the gum and the sensitizer will keep well in brown glass bottles which can be acquired from any pharmacy.

To prepare a gum bichromate solution mix one part of gum with two parts bichromate and add some watercolor pigment. It is usually best to mix the watercolor pigment (the tube type is held to be the better$^{21}$) to the desired tint and then add and mix the gum solution next, and the sensitizer last. The chemicals mix easier this way.$^{22}$ As the heavier substances, especially the pigment, settle easily to the bottom of the mixing vessel, the mixture should be stirred just prior to each application.

The solution should be prepared for the type of coating desired, e.g., thin, medium, thick. An example of a thin coating consists of one inch of pigment from a tube added to 15cc of gum solution and 30cc of bichromate solution. For a thicker mixture increase the solutions in geometric proportions. That is, for a medium coating simply double the amount for a light coating, and for a heavy coating double the medium amount.$^{23}$ These are suggestions leaving the best solutions to be determined by the individual.

It is easiest to coat the paper by tacking it to a board with stick pins.$^{24}$ Using a camel's hair brush quickly apply the solution. Begin in the center and work out criss-crossing until the page is covered. Then to obtain an even surface start at one end of the paper and draw the brush in quick, smooth, light strokes across the surface until it becomes tacky. It is
important to coat rapidly so as to prevent the solution from sinking into the surface or drying and becoming too thick to provide a smooth coating.\textsuperscript{25} Moreover, the brush stroke should follow the line of composition, e.g., vertical or horizontal. After the coating has been applied it should be placed in a dark room or box to dry. When coating the paper tungsten light of up to 25 watts may be used. However, once dry, the paper is sensitive to all except yellow or amber light.

Because the colloid and bichromate solution is not as sensitive as the silver bromide process, it is necessary to place an enlarged negative in contact with the sensitized paper and expose it to a light source which emits ultra-violet rays.\textsuperscript{26} Exposure time must be determined by "trial and error." The length of time is dependent on the density of the negative, the thickness of the solution coated on the paper, and the distance of the light source from the easel. If a secure registration has been obtained, the print density can be checked periodically. With experience and good note making correct exposure can be determined at a glance.

Development of the image is accomplished by placing the exposed print face down in a tray of water with a temperature between 60-\textdegree{}F.\textsuperscript{27} Before placing the print to soak it should be drawn slowly through the water face up a few times to flatten it out.

The print will develop out in about one half hour. If it is developed sooner, then it is underexposed. Conversely, if it is still dark it is usually overexposed. In the latter case the print may either be left to soak longer, or exposed to a gentle stream of warm water passing evenly over the print. A small soft brush\textsuperscript{28} can be used to clear highlights while the print is still wet, but care should be used since the emulsion is soft and delicate.

Once the image is complete, the print should be placed in a tray containing a 1\% solution of sodium bisulphite for a minute to remove any
remaining bichromate. Next wash the print a few minutes in cold (60-65° F.)
water; then drain and lay it face up on a horizontal screen to dry.
Chapter IV

"The Carbon Process" (See Plate I Right)

The carbon process has been revered by its users for its deliverance of depth and rich tonal range sometimes beyond that seen on the negative. Similar to the gum bichromate process, carbon printing is a contact process, and so a negative of desired size is necessary. Since the carbon sheets can be purchased in their best state, e.g., manufacturally coated, there is no need to prepare the surface. They, however, must be sensitized with potassium bichromate before use. It is well to do this latter step just prior to usage.

The dilution of bichromate controls the contrast. Chambers suggests that "One ounce of bichromate to each pint of distilled hot water will give approximately a 5% bath—a convenient standard for dilution as required." Moreover, the season of the year affects the contrast, and the mixture should be adjusted accordingly. Exposure time must be regulated to mixture, e.g., the higher the dilution (of water), the longer the exposure, but the contrast will be lower.

To sensitize a carbon tissue (which should be cut slightly larger than the negative) first submerge it in a tray of cold water, 60° F., for approximately one minute or until it flattens. Next place it pigment side up, in a tray of potassium bichromate which is also 60° F. As soon as it is placed in the tray, gently wipe the pigment surface free of air bubbles with a piece of clean cotton. Then agitate the tray for about two minutes, while being careful that the tissue is always below the solution surface. The two minutes completed, slowly pull the tissue from the bichromate bath; place it pigment side down on a clean sheet of plate glass and squeegee off the excess sensitizer. Carefully peel the tissue from the glass and place it pigment side up on a drying screen in a cool dark dry room or closet. Once
dry the tissue is sensitive to light and should only be handled in yellow or amber light. Drying time is usually from 4-8 hours. A speedier method of drying is made possible through the use of a spirit sensitizer. However, the means described above is usually preferable and simpler.

After the sensitized tissue has dried, place it and the negative together in a contact printing frame. The negative should be of greater density and contrast than one used for normal bromide printing. To prevent image reversal, make sure the emulsion side is facing the light. In addition the negative should have a one inch opaque margin, which can be provided by cutting a mask. Be sure to work in amber or yellow light, as the carbon tissue is very sensitive to light when it is dry.

The light source for making exposures can be either natural sunlight or artificial light, which emits some light in the ultra-violet spectrum (360-400 A.), i.e., photoflood, sun lamp or quartz lighting. Caution should be exercised when using these artificial light sources. They emit much heat and could cause the glass over the contact to break. One preventive measure is to not place the lamp closer than three feet from the contact printer. Another is to direct the air from a small electric fan over the contact frame. Exposure must be determined through trial and error. A step wedge is most useful here. Up to this point the process has been similar to the gum bichromate process. That is, a negative has been placed in contact with a sheet of paper covered with colloid pigment sensitized with potassium bichromate, and exposed to an ultra-violet light source for a period of time to form a latent image upon its surface that will be developed out in a tray of water. If we were, at this point, to place the carbon tissue in a tray of water, it would develop out and resemble a gum print. Yet this is not what occurs; instead, this is where the two processes begin to differ.
This latent image on the carbon tissue must be transferred to another support. The insoluble portions (which now rest on the upper portion of the exposed carbon tissue) will be transferred (or placed) on the transfer paper surface, while the soluble (or lower) portions of the carbon tissue image will now rest atop the transfer paper surface and be easily washed out in the forthcoming hot water development process. Thus development will take place from the back of the image down to the top which now rests firmly at the bottom supported by the transfer paper.

Once the tissue has been exposed, it is then placed in contact with the final support paper, which should be larger than the carbon tissue. The transfer paper should have been soaking in a tray of cold water from 15-25 minutes prior to this step. Before the exposed tissue is actually brought into contact with the support paper, it should be submerged in the same tray of water as the transfer paper and wiped lightly with a camel’s hair brush to dislodge any clinging air bubbles. The same should be done for the support paper. Now, with the tissue and transfer paper still submerged, the tissue should be slid beneath the support paper. Quickly lift the sandwich from the water and place it on a clean sheet of plate glass (tissue back up) and squeegeed together. Remove any excess water from the edges and back with a clean sponge. Next cover the sandwich with a sheet of wax paper and place the combination between two sheets of clean photographic blotter. Then place this package between two pieces of 16 X 20 X \(\frac{1}{4}\) plate glass for twenty minutes.

At the end of the twenty minutes place the tissue-support paper sandwich into a three inch deep tray of hot water (100\(^\circ\) F.). Within a minute or so pigment from the tissue will begin to ooze out from the edges of the sandwich. This is the signal to slowly peel the two papers apart. Be sure that this is
done beneath the surface of the water. Keeping the final support paper totally submerged, agitate the water by gently rocking the tray first left to right and then top to bottom. Once all of the excess pigment has been separated from the print surface, quickly pull the print from the hot water and immediately place it face down in a waiting tray of cold water (60°F). After a minute remove the print quickly to another tray containing a 5% solution of chrome alum. Allow it to remain here 3-5 minutes to remove the bichromate stain, then place it in a tray of gently running water with a temperature of about 60°F. The print should be kept face down during all of these cold water rinse steps, which will help prevent surface air bubbles.

The print having been washed approximately ten minutes, lay it out on a drying screen. The print may also be dried by suspending it from two clothes pins, with its bottom weighted with two additional pins. This latter drying process results in a flatter print.
Chapter V
"The Carbon-Gum Process"

1. Comparison Prints

Three prints from the same negative will be produced to illustrate the ability of each process and the combined processes: e.g., one carbon print, one gum bichromate print, and combined process (carbon-gum) print. A step wedge will be used with the separate carbon and gum prints to illustrate the variance in their tonal scales produced on a single printing. These prints will be made on white paper to better illustrate the black and white tonal range of each process.

In making the first two prints, e.g., the carbon and the gum bichromate, procedures were similar to those given in the chapters on gum and carbon printing. The combining of the two processes was accomplished by first making a carbon print and then coating the dried carbon print with a water color gum bichromate solution. When dry it was exposed and developed.

While making the gum overlay portion of the carbon-gum print, I found it necessary to make a reversal negative (or what is more properly termed a positive image). First, however, it was necessary to determine just which areas were to be exposed. In the instance of the first print of the bridge, to have used the original negative when exposing the gum overlay would have caused the dark mass surrounding the bridge to become blue. The area desired to be blue was the sky which was dark on the original negative. With a positive film image, the sky area would be clear permitting the blue gum pigment to be burned in, while holding back the passage of light to the surrounding dark mass.
The above and all foregoing exposures were made with a 500 watt photoflood bulb set in a reflector, and placed at a height of 21 inches above the printing frame. I incurred no problem with glass breakage from the heat of the lamp. Exposure times were for a minimum of one half hour, and lasted as long as 1½ hours for denser negatives used with thick gum bichromate coatings.

2. Monochrome

The simplest carbon-gum print can produce a monochrome effect instead of a multicolor one.

A layer of pigmented gum bichromate solution was coated onto the surface of water color paper. When dry it was exposed for 3 minutes and soaked in cool water (70-75°) 20 minutes and rinsed.* Upon drying a carbon image was transferred to the paper surface.

This process is useful for producing carbon-gum prints with a single color, thus extending the colors presently available in carbon tissues (e.g., black, brown, blue and green). By using a color gum close to the color of the carbon tissue one can shift the appearance of the color range from, say, a white to black to a sepia to black. At the same time the richness of tone will be enhanced. (See Plate III.)

3. Density Overlays

Two prints in carbon will be made from full tone Super XX negatives taken from color transparencies. Kodalith negatives and positives of varying densities will be made from the Super XX film. Once the carbon print is dry,

* A more thorough explanation of this procedure is discussed forward in part 3, "Density Overlays".
the surface will be recoated with a layer of gum bichromate pigment, then the least dense Kodalith positive or negative placed in register with the carbon image, exposed and developed. This process will be repeated, each time using a different color pigment and a denser negative or positive.

The purpose is to build up an array of colors overlaid on a black and white carbon print. The foundation print will be made on white rag paper tinted with a gum bichromate pigment, which will provide a background color.

One sheet of white vellum, ninety pound watercolor paper was coated with a light solution of blue tinted gum bichromate, dried, and then exposed. An exposure of a few minutes was all that was necessary to set the color on the surface. Once developed out in 70° water and dried, a soft light blue covering lay on the surface upon which I could place a carbon image foundation. The blue background had been predetermined along with other tentative colors that were to be used in the composition.

Being satisfied with the color, a dozen similar surfaces were prepared. In doing these surfaces I found that the surface tone could be lightened by either development or wiping. In the latter situation, after development, the surface was wiped lightly with a soft brush or cotton until the desired tone was achieved. The surface must be kept continually wet, and pressure on the soft surface had to be kept constant to prevent blotching. The temperature of the water was also used as a means for lightening the surface tone. By soaking the print in warm water (75-80° F.) more pigment will separate from the surface. If left too long the entire surface would clear. But by periodically checking the print about every five minutes after the first twenty minutes of development, the print can be pulled at the moment of satisfaction and hardened in a cold water bath of about 60°.

In the first image (Plate IV) several full-toned carbon foundation images were placed on the above surfaces and processed normally.
For the grassy area of the composition a mixture of pigments was chosen: cadmium yellow pale and sepia were mixed to produce a rich yellow brown. This color was mixed with the gum and the sensitizer was added. The solution was then coated on only in the grassy area (e.g., not the sky or house). Better highlights were desirable in the field grass. To accomplish this effect a positive film image of greater contrast was placed in registration with the carbon image. The higher contrast film image gave strong exposure to some areas while providing little to others. This resulted in the effect of greater contrast than would have been achieved with an average tonal range film overlay.

The exposure time was about forty-five minutes. After developing it out in cold water for about one half hour, the exposed area was carefully cleared with a soft brush; then the highlights were lightened to the desired amount.

For the roof area of the shed burnt umber was chosen, and complementing touches of the same color were placed in some of the grassy area. To intensify the highlights of the roof edges, a negative film image of greater contrast than original was used. Once exposed and processed the highlights were brushed out with the usual care.

The front of the house was not coated with gum pigment at all so as to allow the carbon surfaces to provide a color in itself. In making the second image (Plate V) several carbon images were placed on the blue gum pigmented paper. I decided to tint only the brick surrounding the window. I needed only one positive film image for this second part. A somber color, raw umber, which would not compete with the blue and black interior, was selected for the brick area.
4. Selective Opaquing

Using a full tone negative a carbon print will be produced on white rag paper which has been colored with a gum bichromate pigment. Pre-selected areas on the carbon print will be brushed in with different colors of gum bichromate. Areas of the negative not to be re-exposed will be blocked out with an opaquing medium. Then the negative will be placed in register with the print, exposed, and processed. This procedure will be repeated until the desired effect is achieved.

Similar to the prior procedure the surfaces of one dozen sheets of white watercolor paper were prepared and processed with a solid color. This time indigo was used as the base or background color. Then a carbon image was transferred to each sheet.

For the foreground a coat of Indian red gum bichromate solution was placed only in the field area. In applying the solution to the carbon print it was difficult to obtain an even coat and at the same time avoid coating certain areas, in this instance the tree trunk and lower brush. To prevent this area from being burned in, the corresponding clear area on the film was blocked out with a water color opaquing medium.

After the first print, I determined that a negative of greater contrast would provide more snap to the composition. While making a series of varying density negatives, I decided that some positives may also be useful.

Selecting a contrastier negative, it was blocked out and used for a new exposure. This time more to satisfaction, and so the remainder of the carbon images were coated and processed. Then the same area was recoated with a cadmium yellow pale and raw sienna mixture. To prevent the red furrows from being re-exposed with this new color, I now found use for one of those positive images I had made earlier. Selecting a contrasty one the lower trunk
and brush were opaqued out. The positive film image was then place in registration with the carbon-gum image, exposed and processed.

The grayness of the carbon image blended well with the indigo of the sky, yielding a feeling of the ensuing storm, and so was left as is.

5. Multiple Image

First a base gum bichromate print will be made of a color field which has been previously placed on white rag paper. Then selected areas of the print will be brushed in with color gum bichromate. Prior to exposure, unwanted areas of the negative will be blocked out either by opaquing or Kodalith film whichever is most convenient. After this has been exposed and processed, the procedure will again be repeated to satisfaction. Then a new image, which will balance within the composition, will be superimposed in carbon.

In this final stage of the carbon-gum process, a different order of procedure was followed. The multi-colored gum surface was first built up and then a carbon image was superimposed upon the surface of the gum composition. About 18 sheets of water color paper were coated with a pale yellow gum bichromate solution. Once dry, the sheets of coated paper were exposed, developed out and dried. The tone was sufficient with normal development and brushing out the surface was unnecessary. The surfaces were re-coated with a thick solution of burnt sienna gum bichromate.

After the coating had dried, a high contrast negative, which had been made from a color slide, was placed in contact with each coated paper and exposed. It was predetermined that a high contrast negative would provide more crispness to the image than a normal negative. To substantiate this one exposure was made with a normal negative which yielded a rather flat image.
When doing multiple images, especially for one new at it, it is advisable to begin with a run of at least three times as many copies as will be needed for final prints. In this way there will be material still available for use in the event of mistakes or accidents. There were several in this stage alone, with most occurring in bad color selections and some with improper registration in the third and fourth steps. There was also difficulty encountered with carbon overlay.

Once the initial gum foundation image had been laid down as a first run, I began the next color step by recoating and exposing only one sheet at a time until the desired color was obtained. When once color is being placed upon another there is an effect on the hue of each color, so it is best to predetermine this before an entire run is made. It is also a good idea to check registration for correctness at this time, especially when different negatives are to be employed.

In the next step gum bichromate pigment was applied to only that portion of the print being considered for a different color—in this case the top half of the circle. Before placing the negative in contact with the print for exposure, areas not be re-exposed were opaqued. Once this step of the print proved satisfactory the remaining prints were processed in a similar fashion.

Then for the next and following steps the processes were carried out similar to above: changing color, blocking out more undesired areas, judging its appearance when dry, and if satisfactory, processing the remainder of the prints.

The final step involved superimposing a carbon image onto the multi-gum image. The proper registration of the carbon image was predetermined by first placing the image to be superimposed on a sheet of film the same size as all previous negatives and blocking out all extraneous areas with opaque. The image was then checked against the foundation image to be sure it would place
in the precise area. Next a piece of carbon tissue the same size as the negative was cut. A small corner of it was snipped off to mark correct directional placement during the transfer process.

In reversing the order of the use of the two processes (i.e., carbon on gum), I had to consider some difficulties that I would possibly encounter.

1. Would the carbon image, in fact, adhere to the gum-bichromate surface? In theory the latter resembles a sized surface, but would it be smooth and even enough to hold the carbon image? Doing proved that it would.

2. Would the color ground show through the transparent highlights of the carbon image, and if so how would I react? Of course it did show through the transparent areas of the carbon image. At first I would have liked to have seen the superimposed image in pure black and white sitting on the surface. However, once I observed the image as a blend of black, gray and burnt sienna, I enjoyed the latter effect more because the image had become a part of the composition instead of merely a juxtaposed one. That is, it moves from within the composition and above its surface like an image plane hologram!

3. Would the surrounding area of the gum print be blocked up from the carbon tissue which extended out beyond the superimposed image? During development of the carbon image the excess carbon separated from the gum surface more readily and clearer than it had in any of the preceding prints. It appears that the gum acts as an excellent sizing material.

4. Would the gum image itself remain intact after being exposed to the hot water (over 100°) necessary for development of the carbon image? The gum image proved to be impervious to the hot water.
Chapter VI
Conclusion

From my experiences with the carbon-gum process I find that building up colors on a carbon image yields a print of sharper quality as in Plate IV. When the procedure is reversed, as in Plate VII, it is difficult to prevent distortion and blurring with repeated printings in the same area of the gum image. However, superimposing a carbon image onto a gum image provides a dimensionality seen only in tri-color carbro prints.

I was particularly satisfied with the monochrome carbon-gum print, Plate III. This procedure is especially useful when one desires to give only an additional tint to the color of the carbon pigment.

Two points I found most important to making quality carbon images are to use a freshly sensitized carbon tissue, e.g., within 24 hours; and that the gradual lowering of the development water from $100^\circ$ to just a few degrees above room temperature prevents the formation of air bubbles on the image surface.

Two major advantages in photo-sensitizing the pigment to the carbon image over hand coloring it: The watercolor is set permanently by the light exposure, and fine detailed areas can be colored in without the spill-over or unevenness which may occur from hand coloring.

Although time consuming and tedious, the Carbon-Gum process is relatively simple to perform, and supplies are readily available at low cost. It requires only one major chemical: the sensitizer. Thus, if one has the servitude and patience for building an imaginative composition, then it is an excellent process which offers versatility and creative possibilities.
Appendix A

Film Image Registration

I found the simplest means for obtaining proper registration is to place the film image in contact with the sensitized paper and draw a pencil line around the lower right and left corners. Next place these in a thin matte board frame which covers a $\frac{1}{2}$ inch border on each side of the film image. Then cover this combination with a sheet of $\frac{1}{4}$ inch plate glass and expose. After the image has been processed and dried the registration should be checked before recoating the prints for the next stage. In this way the print can be checked for shrinkage and correct registration.

To make registration easier, the negative should be larger than the image -- at least $\frac{1}{2}$ inch on each side. This border will be masked off with the matte. The printing paper should be larger than the negative so that the image does not fray along its edges.

The fact that the matte board causes a slight separation in the contact between the film and the glass does affect the sharpness of a gum print image.
Appendix B

Sizing the Paper

A sizing bath may be made by dissolving 30 grams of gelatin in 300cc hot (50° C. or so) distilled water. Next dissolve 3 grams potassium chrom alum in 300 cc warm (75°) distilled water. Then combine the two solutions. The mixture should be applied while it is still hot. Using a small sponge, rub the solution well in a circular motion into the pores of the paper. Porous papers may need a second coating after the first has dried. Thinner papers have a tendency to buckle when the sizing is being applied. A way to prevent this is to tack all four corners down on a smooth flat board with stick pins. Finally, the sized paper will dry better and more quickly if it is hung up by one corner.
Appendix C

Kodalith Positives and Negatives

To make varying density-contrast positives and negatives Kodalith Type 3 ortho film was used. This film can be worked with in red light of about 25 watts maximum, and it develops and dries quickly. Although it is an ultra high contrast film, it will yield a normal tonal range if developed in high concentrate developers such as Rodinal or HC 110, which can be diluted for variable contrast development. The more the developer is diluted with water, the lower will be the contrast; whereas with less water being added the contrast will be higher. The density of the film is controlled by the amount of exposure.

The original negative used for making the carbon base print was placed in a contact print frame with a sheet of Kodalith film and exposed. This was repeated with six separate sheets of film, but varying the exposure times, e.g., 1/2", 1", 2", 4", 6", 8". Then all were developed for the same amount of time (about two minutes) in Rodinal developer with a dilution of 1:20 (1:100 being a normal dilution). These images were positives varying in density and contrast from about normal to very high contrast.

To produce a similar series of negatives, one of the above positives with a normal tonal range was placed in contact with six separate sheets of Kodalith film and processed as above, yielding the same results except in a negative image.
Appendix D

Eliminating Air Bubbles

There was some difficulty with air bubbles. The best method I have found to eliminate these after all of the excess carbon has cleared from the transfer image is to add more water while gradually lowering the temperature to coincide with that of the room (or about 70°), and then quickly pouring it off. This also acts as a rinsing procedure.

Before pouring the water off, a 5% chrome alum bath was added to the rinse water when it had reached a clear stage. The print was then allowed to soak for about five minutes. This bath clears any excess bichromate remaining in the print (see carbon instructions above). Then the rinsing procedure was continued for another ten minutes.

Rinsing was accomplished by placing a small hose emitting a smooth stream of water into the tray. As the tray filled up, the top water was slowly poured off until the water just covered the surface of the print; then the tray was filled up again, and so on until the end of the ten minutes.

It is imperative that the print remain below the surface of the water until the final rinse is complete, lest contact with the air cause surface bubbles. Some stainless steel weights, such as dinner knives, will help in holding the print down. However, even then the print will attempt to push its way to the surface, so a watchful eye is important.

Often a light layer of excess carbon remains on the edges of the print. Most of this can be cleared during the rinse cycle, but before the chrome alum bath is added. (The chrome alum acts as a hardener.) This can be done when the rinse water is still at the warm stage (80-85 degrees), by running a stream of water over these areas with the print still submerged. Be careful not to run the stream into the still fragile carbon image. I noticed that
this excess carbon cleared more rapidly and easily when the transfer was produced with a freshly sensitized carbon tissue.
Appendix E

Spotting

The carbon image may be spotted with either a watercolor pigment or Spot Tone®. The former is usually better as it will blend more uniformly with the density of the carbon surface. One should first practice on a rejected carbon print before launching into perfecting a finished print.

The gum pigment should only be spotted with a water color pigment which matches the area to be repaired. Again experimentation is a must, and is better done on a rejected print. It is best to reproduce the exact desired color and check its application (when dry) before applying it to the final print.
Footnotes


4. "In the sensitive film, however thin it may be, two distinctive surfaces must be recognized, an outer and an inner which is in contact with the paper. The action of light commences on the outer surface. In washing, therefore, the half tones lose their hold on the paper and are washed away." Neblette, p. 490.

5. "Transfer is necessary because the insoluble pigment which has been formed by the action of light is upon the surface of the tissue while the insoluble pigment which must be washed away in order to reveal the image lies beneath the image. It is, therefore, necessary to transfer the pigment so that the soluble pigment will be on top where it can be washed away without affecting the pigment forming an image." Ibid., p. 499.


7. Jones, p. 78.


10. The only practical difference in the chemistry is that in the carbon the colloid is gelatin and the gum colloid is gum arabic.


13. Neblette states that the shadows are "superior to all other printing mediums with the exception of photogravure and possibly the oil process." Neblette, p. 511.

14. When a gum print is made so that detail is available in the shadow and highlights, the print is usually flat in appearance. On the other hand, if the gum print is exposed whereby there will be rich detail in the highlights, the shadows will block up. Conversely, if the shadows are exposed for good detail, the highlights will wash out. It is possible to derive a full tone gum print from a limited tone negative of about five zones, but not from one of a full tonal scale—approximately ten zones. A full tone gum
print can only be produced from a full-tone negative vis-a-vis multiple printing of the negative from two to five times. This entails recoating, properly registering and re-exposing the negative each time. Encyclopedia of Photography, Greystone Press, New York, pp. 1677-8 (also refer to footnote #4 above).

15. Neblette, p. 493 (see also footnote #5 above).

16. A normal solution is 40-50 gr. to 1000 cc water. By adding more p. b. the contrast is reduced and by adding less the contrast is increased. Chambers, p. 629.

17. Demachy & Maskell, p. 18.

18. Ibid., pp. 15-16.

19. Ibid., p. 18.


22. Demachy & Maskell, p. 24. I found that a punch glass with a concave bottom was useful for breaking up the water color. Using the rounded end of a large watercolor brush handle, it is easy to achieve a mortar and pestle effect. In fact, a small mortar and pestle would probably be the most ideal.

23. Encyclopedia of Photography, p. 1678. A thin coating is useful to create a longer tonal range through multiple printing. A medium to thick coating will usually yield a satisfactory image with one printing but it may be a bit contrasty.


25. Ibid.

26. Encyclopedia of Photography, p. 1678. The light source may include photo flood bulb, sun lamp, quartz light, or indirect sunlight.

27. I found that warmer water develops and loosens the surface more rapidly. Temperatures below 60° do not soften the image quite as much and so provide more control over development. Warmer water may be used to loosen difficult highlights, while the denser areas will be held firm as a result of the cold water bath.

28. Having a variety of brushes at hand is advisable. Small oil paint brushes from soft to hard bristle are very useful for cleaning up stubborn highlights. Refer also to footnote 48.

29. Chambers suggests a negative of greater density and contrast than a normal negative, p. 630. I found that a negative comparable to one exposed for use in a diffusion enlarger to be sufficient.


32. Ibid. Chambers states that "a 4% bath is about correct for normally dense negatives, but a weaker bath may be advantageously employed for weak negatives." And for the converse Jones suggests that "if a lower contrast is desired, then a dilution of 6 to 7 percent should be used." Jones, p. 80. The latter would, of course, apply to achieving a somewhat near normal contrast carbon image with a high contrast negative.

33. For a normal or average negative contrast in the winter use a 5% solution; in the spring and fall a 4% solution; and in the summer a 3% solution. Ibid., p. 80. The reason for this is the humidity.

34. Chambers further points out that the printing time is affected by sensitizer dilution. "For instance, pigment paper sensitized in a 1% solution requires about three times more exposure than a piece treated in a 4% solution and printed from the same negative." Chambers, p. 629.

35. Jones, p. 80. It seems that air bubbles are the most tedious contention of the carbon process, so every opportunity to prevent them during each step of the process is imperative; otherwise, the dried print will be covered with large specks. A method for reducing these specks to a minimum is discussed in Appendix D.

36. Ibid., p. 81. Instead of being immersed the carbon tissue is wiped with a solution of one part sensitizer mixed with one part denatured alcohol. To coat the surface a spirit sensitizer solution is made by mixing one part of stock sensitizer solution with one part denatured alcohol. Then the mixture is wiped on the surface of the carbon tissue with a flannel cloth, cotton balls or a soft brush. It should be applied in even strokes over the entire surface 2 or 3 times, then hung to dry. Drying time is only 1/2 hour. The difficulty is preventing streaks while coating.

37. Refer to footnote 29.

38. Better contact was achieved in the carbon process, by placing the mask outside (on top of) the glass of the contact printing frame.

39. Jones, p. 107. I did not find the fan necessary with my light source: a 500 watt photoflood bulb placed in a reflector. Exposures of up to ten minutes, with the lamp as close as 21 inches, were made without excessive heat on the glass. However, the use of a fan has been suggested for sun and quartz lighting.


41. Jones, p. 107. For transfer paper I preferred d'Arches hot press, velum surface, 90 lb. water color paper. This paper is also 100% rag content, and it does not break up with continued wettings.

42. Ibid.

43. Ibid. Jones suggests using newspaper, which I decided to avoid primarily because it contains a good deal of acid which could be transfused
through the back of the print and eventually deteriorate the image itself. Acid in newspaper can be readily determined by odor, or observing the yellowing of it caused by exposure to sunlight for about a week.

44. Neblette points out that trays at least three inches deep should be used so that there is sufficient room to work beneath the surface of the water without the papers coming into contact with room air until the right moment. Neblette, p. 503.

45. Chambers suggests that if the pigment is stubborn to separate from highlight areas, it can be helped along with a stream of water slightly hotter than the development water. Chambers, p. 630. This is a delicate procedure: the stream of water should be maintained at the "gentle" level and used cautiously.

46. See Appendix D, "Preventing Air Bubbles."

47. This is done by simply placing the negative in contact with a fresh sheet of film and exposing it to light. The new image will be a reversed or positive one. Also refer to Appendix C.

48. Working with a camel's hair brush, apply the gum pigment to the desired areas. In smaller areas, a small, flat water color brush may be preferable. Be sure to immediately wipe any overflow pigment from the surface with a viscose sponge; use warm water. The sponge should be rinsed in warm water immediately after use, lest the pigment harden into it. The latter also applies to cleaning brushes.

49. Refer to footnote 27.

50. Refer to footnote 28.

51. The above reference sources on gum printing, in general, recommend building up an image contrast by a series of thin coatings and re-exposures. I have found that a thick coating exposed through a rich, contrasty negative will yield a good image on a single printing. The solution is to overexpose the print and oversoak the print in cold water (below 60°) for about one hour. The exposure provides a good hard surface, while the cold water development loosens only the highlights and some of the middle tones. Thus, when the print is cleared with a soft to medium brush only the highlights loosen, leaving some middle tones and all of the dense areas. The result is a "snappy" print on a single printing. Of course it does not have the tonal latitude produced by a carbon image, but the contrast gives the impression of it being such.
Bibliography


The carbon-gum process: a