Fig. 10-5-a I made this photograph of the North America Nebula 40 years ago on a glass plate. It got broken in a move about 20 years ago. I'm glad I saved the pieces, because now I can repair it digitally.

Example 5: Reassembling an Astronomical Glass Plate

I made the photograph shown in Figure 10-5-a, my first astrophotograph, back in high school in 1966. Back then all serious astrophotography was done on special glass plates that were only about half the thickness of the old pictorial photography glass plates. Twenty years ago my photograph got broken into eight fragments during a move. Now it's time to fix it.

Fortunately, all the breaks in the plate were very clean, so I was able to reassemble the pieces on the platen of the scanner in positions very close to where they should be in the repaired photograph. Unlike the antique glass plate in Example 1, this was an easy scan with no unusu-ally high densities, so I didn't bother masking off the edges of the plate.

My plate recorded a lot of sky glow in the "black" parts of the sky, so I adjusted the levels in the scanner software and the gamma to lighten up the scan (Figure 10-5-b). I also made some modest adjustments to the curves to open up the tones a bit more. None of this was strictly necessary, and a straight 16-bit scan would have been entirely adequate, but it never hurts to improve things early on.

I scanned the plate in 16-bit RGB mode at a resolution of 1200 ppi. In Photoshop, I flipped it left to right and used the Channel Mixer (Figure 10-5-c) to blend all three channels into a monochrome image and converted it to the grayscale file you see in Figure 10-5-d.

My next task was to reassemble all the fragments into as perfect a fit as possible before repairing the cracks. Because of my careful scan, there were almost no gaps between the fragments. The best tool for outlining each fragment as a selection was the Magnetic Lasso tool. Beginning at the lower right corner of the plate, I pinned the Lasso to the start of the edge of the long shard and dragged it along the crack, setting curve points as I went. When I finished selecting this long, thin knife-shaped fragment, shown against the pink mask overlay in Figure 10-5-e, I saved that selection as a mask in a new channel (Mask 1 in Figure 10-5-f).

Next, I used the Magnetic Lasso tool to pick out the horizontal crack that bisected the plate, selecting for the two fragments in the top portion of the plate. I saved that mask in another channel (Mask 2, Figure 10-5-f).

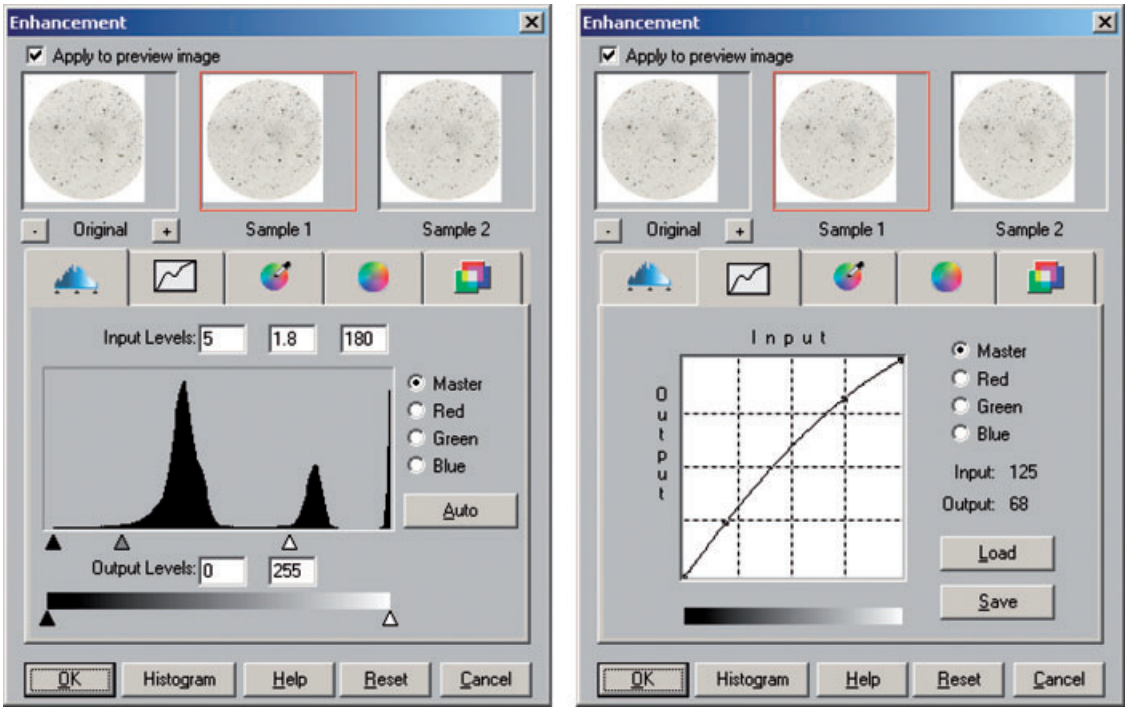

Fig. 10-5-b These are the scanner settings I used to produce Figure 10-5-d. They remove the overall fog and stain from the plate and increase the contrast in the dense parts of the negative, which correspond to the real astronomical details.

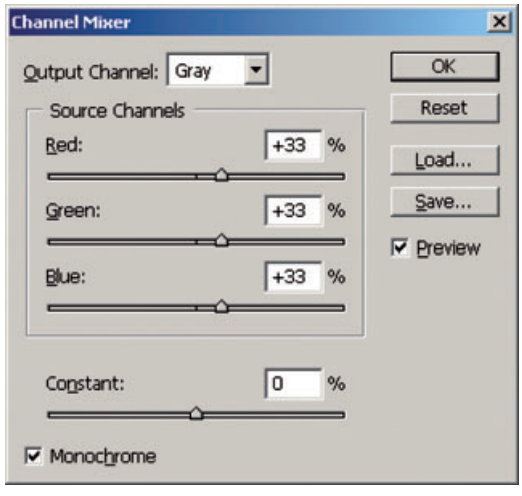

Fig. 10-5-c These Channel Mixer settings combine equal amounts of the RGB components of the scan to produce a grayscale image (Figure 10-5-d). This gives me maximum tonal information with minimum noise for this photograph.

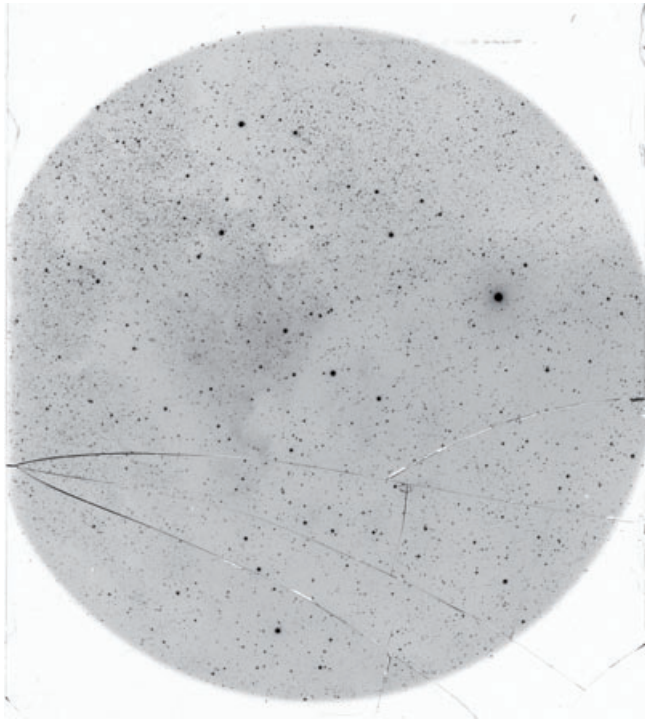

Fig. 10-5-d The adjusted scan of Figure 10-5-a, converted to grayscale. I positioned the shards of glass in approximate alignment on the scanner platen before making the scan. I'm going to have to digitally move them around like pieces of a puzzle to get the alignment perfect.

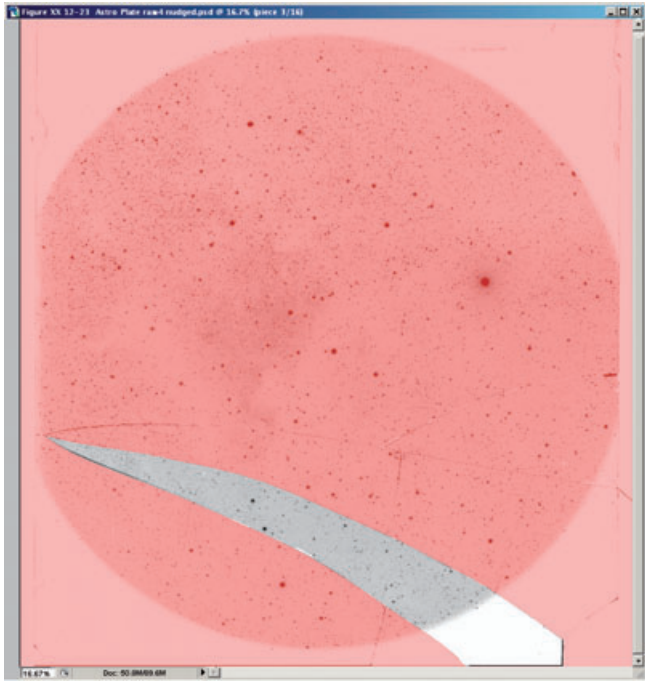

Fig. 10-5-e I use masks to isolate each fragment of the plate, so that I can nudge it into the exactly the right position. I made the mask, shown here as a pink overlay on the photograph, using the Magnetic Lasso tool to trace the boundary of this shard.

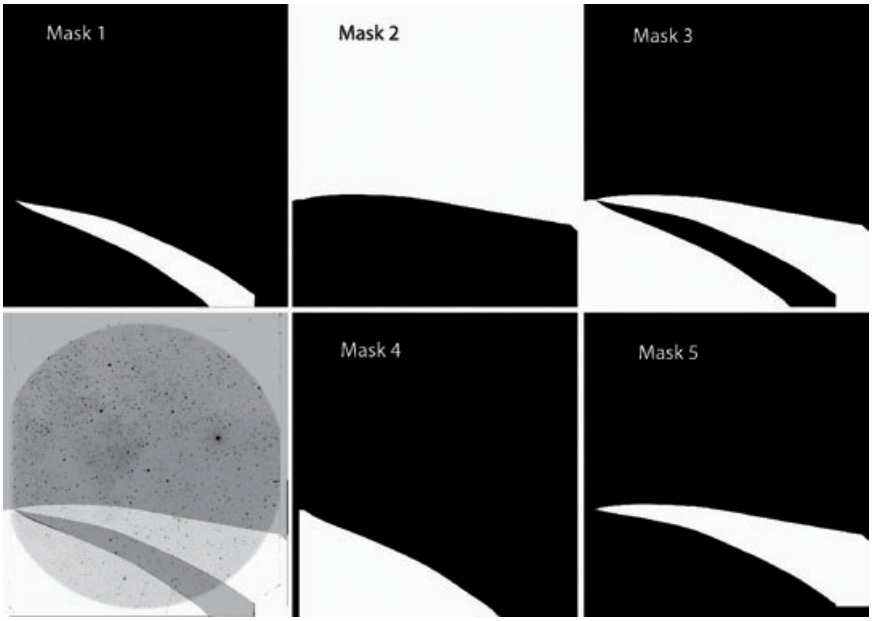

Fig. 10-5-f Mask 1 is the mask I created in Figure 10-5-e. I made Mask 2 by tracing the long horizontal crack with the Magnetic Lasso tool. Inverting Mask 2 and subtracting Mask 1 from it, using the Load Selection dialog, produced Mask 3, shown superimposed on the original photograph at the lower left. It selects two areas of the plate, each of which contains two fragments. I isolated those areas with the Lasso tool and saved them as Masks 4 and 5. I subdivided those masks using the Magnetic Lasso tool to give me four more masks (not pictured) for those individual fragments of the plate.

I can combine masks in a variety of ways, so I can isolate some pieces of the plate without having to retrace their edges by adding and subtract-ing masks. For example, I loaded the first mask and inverted it; that selected everything but the thin knife-shaped shard. Using the Load Selection dialog, I inverted the second mask and added it to the selection I'd already made.

That composite selection I made subtracted out the knife-shaped shard and everything in the top of the plate (Mask 3, Figure 10-5-f). It neatly selected two areas, each containing two fragments, as you can see in Figure 10-5-f, lower left, where I've overlaid this selection on the original scan. Using the regular Lasso tool, I selected each of those areas in turn and saved them as separate masks (Figure 10-5-f, Masks 4 and 5). Now the plate was subdivided into sections containing one or two fragments. I used the Magnetic Lasso tool to select each individual frag-ment out of those masks. I used the large unbroken top half of the plate

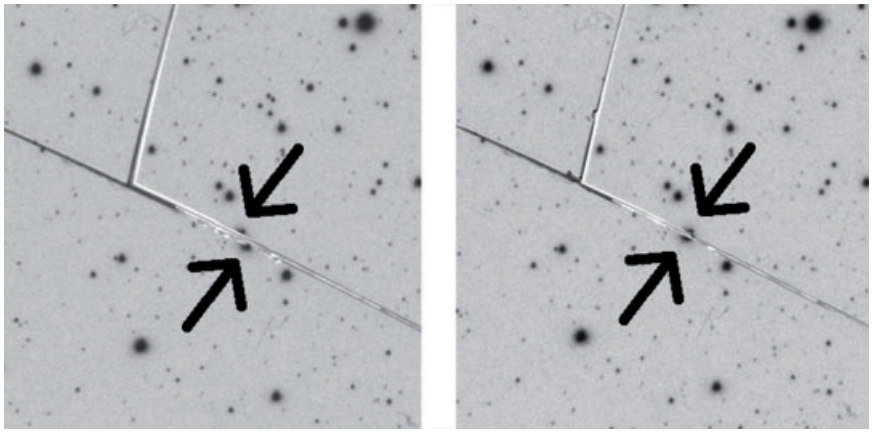

Fig. 10-5-g To find the correct alignment of the pieces of the plate, I looked for star images that straddled a crack and used them to match the two fragments. The arrows here point to the halves of such a star image in the unaligned (left) and aligned (right) images.

as a fixed base, loading the masks that selected the fragments that bordered that half and nudging them into alignment with it. I looked along the cracks for the occasional star image that straddled a crack (Figure 10-5-g). Those images worked like registration marks to let me guide the pieces into pixel-perfect alignment with each other. (*An aside:* If I were trying to preserve this as a scientific record, rather than just a nice picture, I would skip the whole next step of eliminating the cracks because that would erase real stars.)

Having "repaired" the plate, I erased the cracks themselves. The Median filter was ideal for this purpose because there was little or no detail along cracks that needed to be preserved, and the background was very uniform in average density. I set the filter with a wide radius (Figure 10-5-h) to completely obliterate the cracks.

I assigned the Median filter History state to the History Brush and reverted to the history state just before I applied the filter. That undid the global effect of the filter, so that I could use the History Brush to paint over the cracks

I attacked the cracks in two passes. The cracks themselves scanned as dark, but associated with them were clear parts where the emulsion of the plate had broken away. Those areas were all very small and whiter than the image and had no useful information, so I quickly painted them in with a large-radius History Brush set to Darken.

I zoomed in to 100% on the screen image and set the History Brush back to Normal with a radius of 5 pixels and 50% hardness. At that magnifi cation, the cracks were long, shallow arcs for the most part. That permitted me to use shift-clicking to quickly select lengths of the crack and cover them over. I clicked the brush on the crack, moved the brush down the crack a short distance that corresponded to a "straight" segment, and shift-clicked the brush. The brush painted a straight line

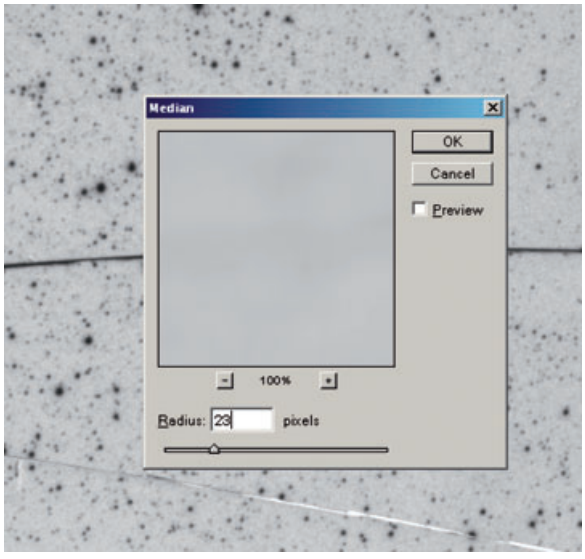

Fig. 10-5-h The Median filter, set to a wide radius, is a good way to erase the cracks. Here I've superimposed the Median filter preview on the corresponding area of the image. Observe how the dark horizontal crack's turned into an almost-invisible faint shadow. Painting in this filter with the History Brush eliminates cracks efficiently.

of Median filtering that nicely obliterated the short segment of the crack. I shift-clicked my way along the crack in short jumps, wiping whole sections with a single mouse-click. This was much faster and more accurate than manually painting along the length of the crack.

While I was at it, I used the Median filter History Brush to wipe out the scratches and dirt specks as well. Once the photograph was clean and crack-free, I cropped it and inverted the tones so that I could start working on it as a positive (Figure 10-5-i).

I used the eyedropper to spot-check the values in the darkest parts of the sky over the field of view. Near the center of the plate the blackest areas had a value of 88; this fell off radially to a value of 78 at the perimeter. I created a Curves adjustment layer to make the blacks darker and to even out the exposure.

First I created the adjustment layer with the curve settings shown in Figure 10-5-j. That layer dropped the values for the blacks by about 60 points. I wanted to darken the blacks at the perimeter about 10 points less than at the center to even out the exposure. That's five-sixths as much of a change at the edges as at the center.

To achieve this I added a radial gradient mask to the layer. I set the foreground color to 100% white, the background color to 85% (five-sixths) white, set the starting point of the gradient at the center of the circular image, and drew a gradient line out to just beyond the edge of the field of view. That produced the mask shown in Figure 10-5-k, which reduced the effect of the layer by just the right amount to give me a uniform exposure over the entire plate (Figure 10-5-l).

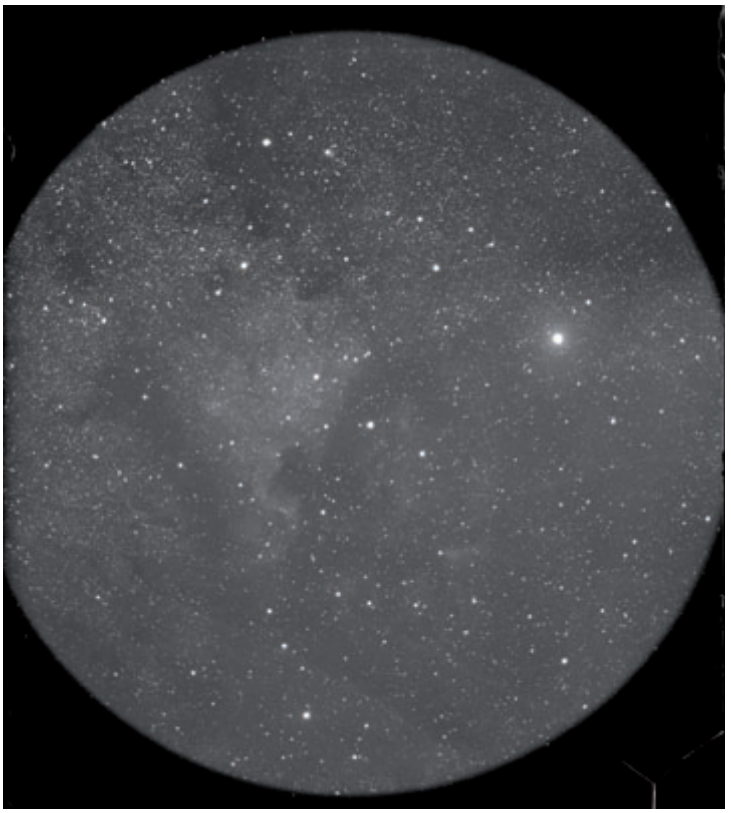

Fig. 10-5-i Here's the plate, repaired, cleaned up, and inverted to make a positive image. Now it's time to improve the tonality and clean up residual artifacts left from the repair job.

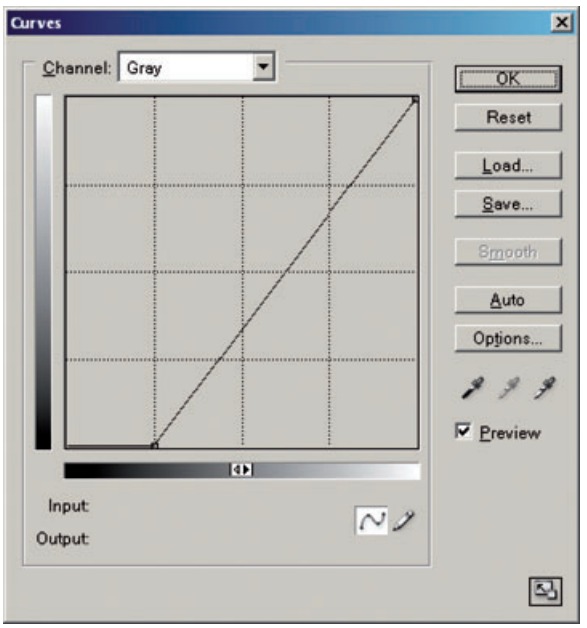

Fig. 10-5-j This Curves adjustment takes the sky background down to a dark charcoal gray in Figure 10-5-l. I used it in conjunction with the mask in Figure 10-5-k to even out the light falloff at the edges of the image.

Fig. 10-5-k This faint circular gradient mask, used in a Curves adjustment layer with the curve from Figure 10-5-j, produces the uniform and good-looking photograph in Figure 10-5-l.

Fig. 10-5-l Here's the photograph corrected with a Curves adjustment layer using the curve from Figure 10-5-j and the mask from Figure 10-5-k.

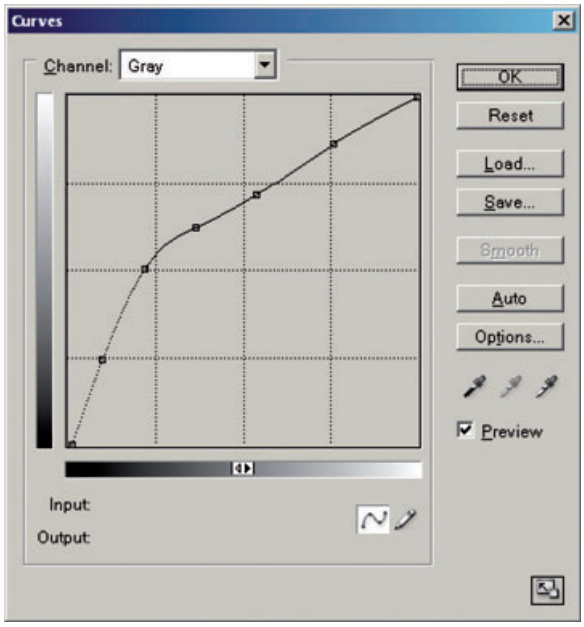

Fig. 10-5-m This Curves adjustment enhances contrast in the shadows, bringing out faint nebulae and detail in Figure 10-5-q.

I added a second Curves adjustment layer (Figure 10-5-m) that made the blacks a little richer and greatly boosted the contrast in the shadows to bring out the faint nebulosity without sacrificing detail in the star images. From an overall pictorial point of view this looks great, but the heavy contrast boost made it clear that more work was needed to blend the erased cracks into the image. Figure 10-5-n shows a particularly bad section that I selected with the Lasso tool for correction.

Image Doctor is very good at dealing with this type of problem. Its Smart Fill function does a better job of synthesizing complicated random-looking textures than the Spot Healing Brush in Photoshop or manual cloning and blending. Image Doctor only works on 8-bit images, though, which is the reason I didn't apply it earlier. I wanted to do as much tonal correction as I could to the photograph before reducing the bit depth from 16 to 8 bits.

After converting the photograph to 8 bits, I applied Image Doctor's Smart Fill to the area I selected (Figure 10-5-o). That produced almost the effect I wanted (Figure 10-5-p), but some areas that should have been filled with faint nebulae were filled with darker sky areas.

I corrected that using the History Brush. I assigned the Smart Fill operation to the brush, and reverted to the previous history state. I set the brush to 100% strength and Lighten and painted over the selected area. That laid down the random star images that Smart Fill had created for me. Then I switched the brush to Normal and 40% strength and

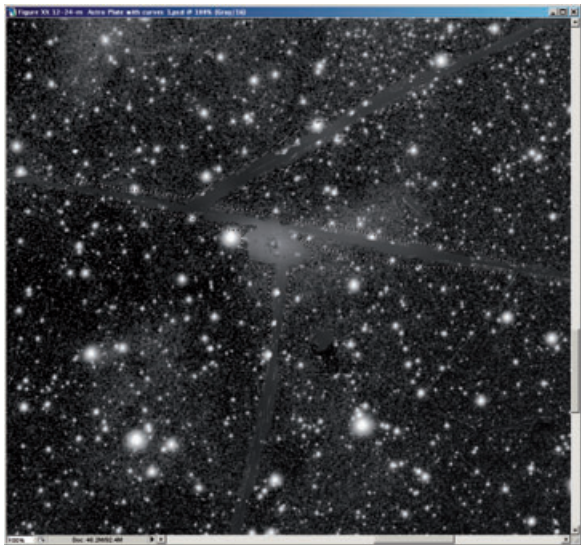

Fig. 10-5-n This screenshot shows an enlargement of the plate where four shards come together and some of the emulsion was flaked off (down and to the right of center in Figure 10-5-d). Here, the Median filter created a blur that has a distinctly different look and texture from the surrounding star field. I selected that region with the Lasso tool for repair by Image Doctor.

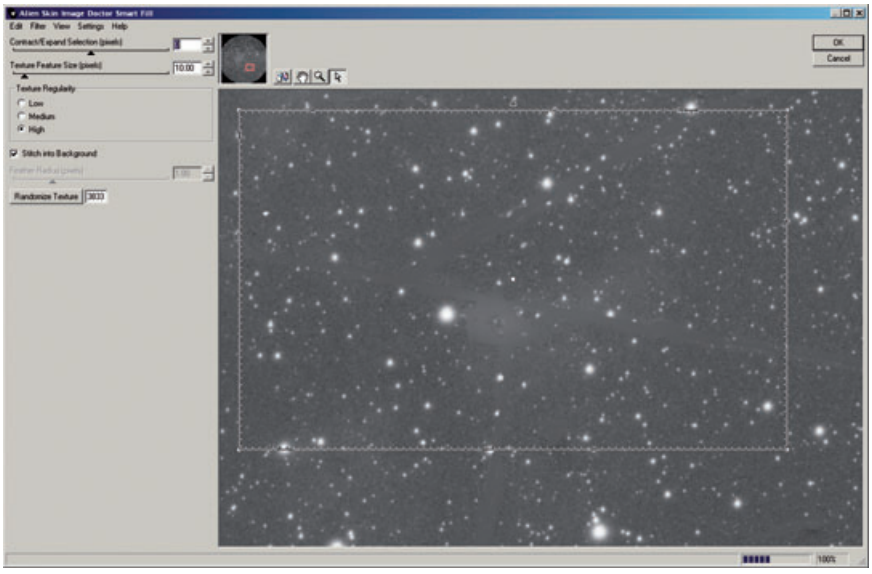

Fig. 10-5-o Image Doctor analyzes the star field inside the rectangular region that bounds the selection in Figure 10-5-n. It synthesizes texture and detail from that information to fill in the selection area (Figure 10-5-p).

started painting in the crack, applying more strokes of the brush to the darker areas and fewer to those where I wanted to retain more of the nebula's glow. That did an almost perfect job (Figure 10-5-q). In this manner I was able to work over all the obvious cracks and blend them almost invisibly into the background. The finished photograph is shown in Figure 10-5-r.

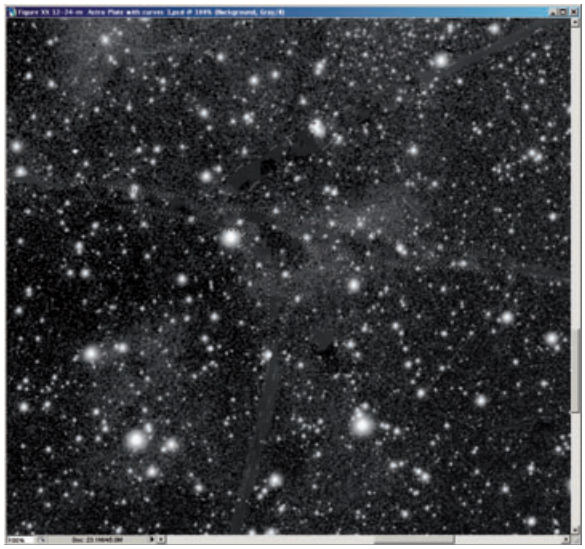

Fig. 10-5-p Here's the repair job that Image Doctor did. I left the dotted selection line on to make it easier to see the repaired region. Note that the stars and nebulae that fill the repaired area are not real. They're inventions of Image Doctor. This kind of repair would not be acceptable if the restoration were meant to have historical or scientifi c value

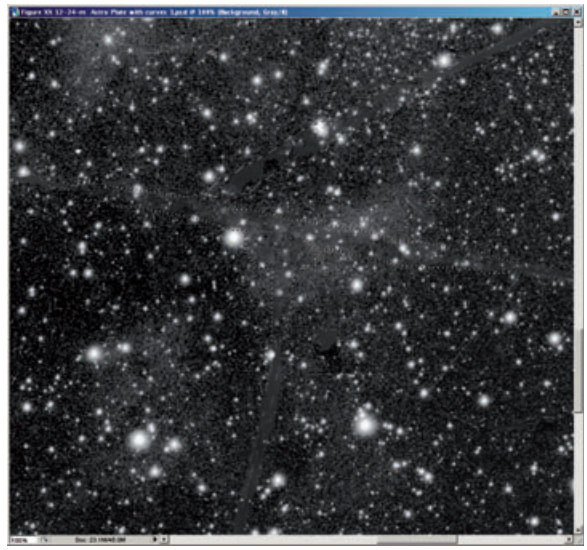

Fig. 10-5-q Image Doctor didn't produce precisely the effect I wanted in Figure 10-5-p, so I assigned that result to the History Brush and reverted to the previous state. I used the Brush in Lighten and Darken modes to paint in Image Doctor's corrections with just the strength needed to make it blend into the surrounding image.

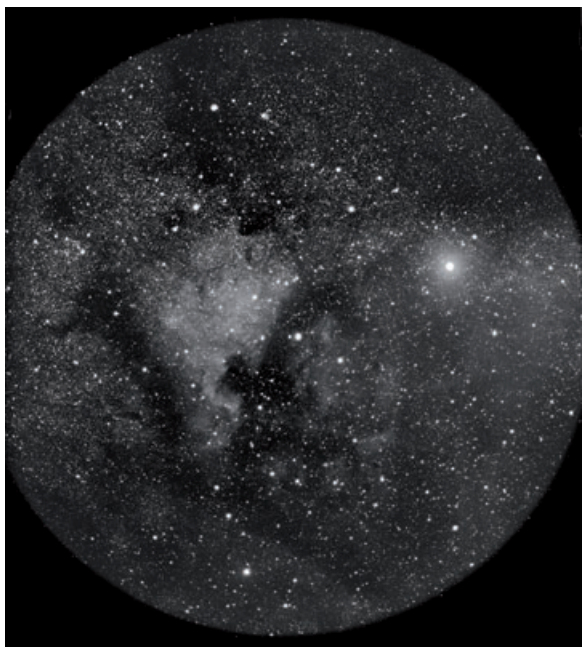

Fig. 10-5-r The finished photograph, after the Curves adjustment from Figure 10-5-m. I not only completely repaired the cracks, but with the assistance of Photoshop's tonal-control tools, I made a photograph that looks better than the original print I had made from the unbroken plate in the darkroom.