"All the Views Just Sit and Squint"

The "Appearing Point"

Boston, up to the minute weather:: 2:30-2:31pm, sunny, warm. High 393K. 2:31-2:32pm, thickening clouds, snow arriving later that minute High 263K. Outlook for 2:32-2:33pm, showers, but warm and sunny toward the end of the minute.

Turning our world inside-out upside-down and backwards

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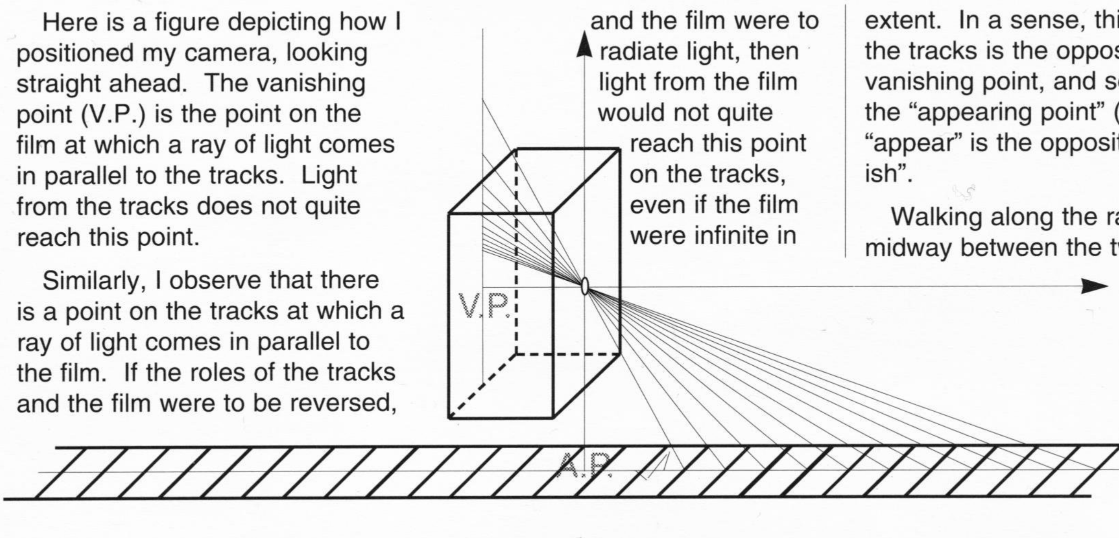
Steve Mann/Massachusetts Institute of Technology

An artist confirms the fact that parallel lines do, in fact, meet, right in the center of this picture, about midway between the artist at the easel (lower left) and the nuclear reactor cooling towers (upper right).

Here is a figure depicting how I positioned my camera, looking straight ahead. The vanishing point (V.P.) is the point on the film at which a ray of light comes in parallel to the tracks. Light from the tracks does not quite reach this point.

Similarly, I observe that there is a point on the tracks at which a ray of light comes in parallel to the film. If the roles of the tracks and the film were to be reversed, and the film were to radiate light, then light from the film would not quite reach this point on the tracks, even if the film were infinite in extent. In a sense, this point on the tracks is the opposite of the vanishing point, and so I call it the "appearing point" (A.P.) since "appear" is the opposite of "vanish".



Walking along the railway line, midway between the two rails, I observe that the railway ties are evenly spaced, with stones between them. There is a periodic pattern of wood-stone-wood-stone, etc.

Each railway tie is imaged on the film (upside-down). Note that the ties are not evenly spaced on the film. Starting from the top of the film (bottom of the picture above), and working our way down the film (up the picture above), we observe that the periodic pattern of wood, stones, wood, stones, and so on, becomes more and more densely concentrated. In the language of electrical engineering, we say that the *spatial frequencies* are increasing as we move toward the center of the image.

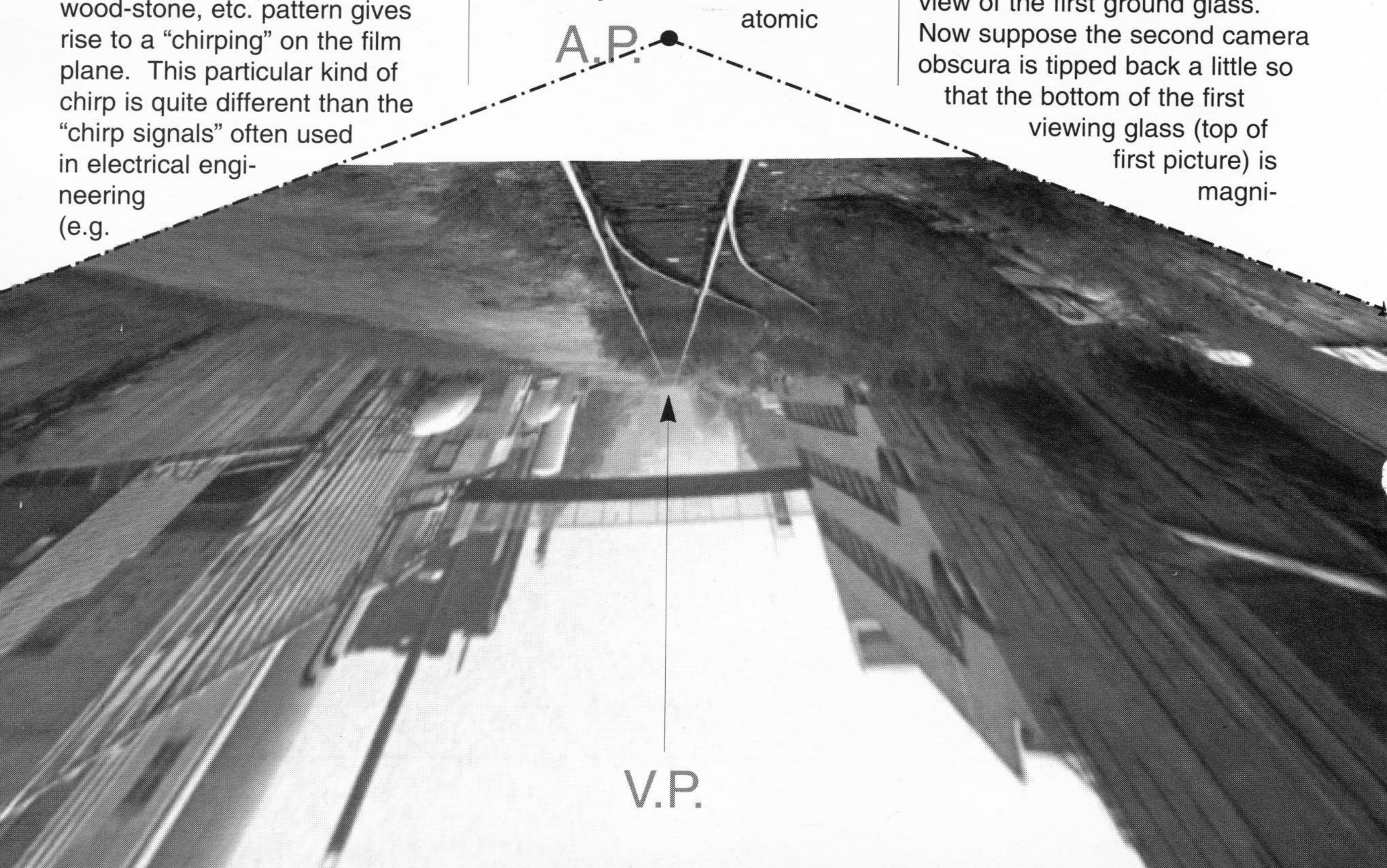
Changing frequency in musical sounds is often described as a "chirp", and is most familar as the sound made by birds. Certain musical instruments also have a *pitch-bend* or *portamento* capability. Even those that do not appear to have it can be made to "chirp" (for example by flexing the neck of a guitar while sounding a note).

In the railway picture, projection of the periodic wood-stone-wood-stone, etc. pattern gives rise to a "chirping" on the film plane. This particular kind of chirp is quite different than the "chirp signals" often used in electrical engineering (e.g. radar), because the spatial frequency (rate at which we cycle through wood-stone, and back to wood again) actually goes to infinity. The point at which the spatial frequecy goes to infinity corresponds exactly to the vanishing point. The vanishing point is a specific location on the picture -- you can place your finger right on that point. Yet it is the image of infinitely distant objects! Infinitely many such infinitely distant objects (e.g. infinitely many railway ties) map to this single point.

If the film were infinitely large in extent (I have shown it extending out beyond the box camera in the figure on the previous page), we would observe that the railway ties would appear bigger and bigger as we moved along the film plane, further and further beyond the boundaries of the camera. We would start to see more and more detail in the wood grain or micro structure of the stones. In the figure above, we have depicted a situation where the appearing point falls between two ties (among the stones). Eventually we would see the atomic structure of a particular stone (neglecting the diffraction and quantization effects of light and the limit of lens quality). The particular atom that we would see in most detail would be that particular atomic particle that is located at exactly the "appearing point".

In summary, the vanishing point is the point of infinite frequency (infinitely many railway ties per millimeter along the image) and the image of the "appearing point" is the point of zero frequency (zero railway ties per millimeter along the image). Of course the image of the appearing point is infinitely far out along the film plane. We will see how we can bring the appearing point to a finite location on this page!

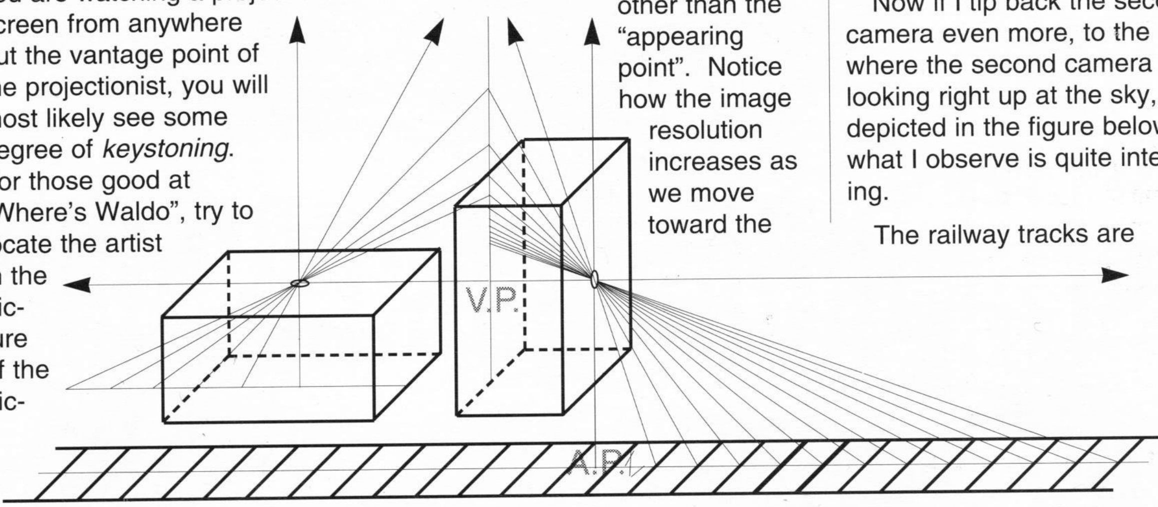
Suppose I take a picture of the picture on the first page. Or, more illustratively, imagine a *camera obscura* placed upon the railway tracks (so that rather than taking the picture you see on the first page, it simply forms the image on a ground viewing glass), and a second camera obscura placed so that it has a view of the first ground glass. Now suppose the second camera obscura is tipped back a little so that the bottom of the first viewing glass (top of first picture) is magni-



fied relative to the top (bottom). I illustrate such a picture (actually generated mathematically, but I prefer to keep in mind the two cameras, one looking at the image of the other).

This "picture of a picture" is pretty big, so I've taken the liberty of letting some of it bleed off the edges of this page.

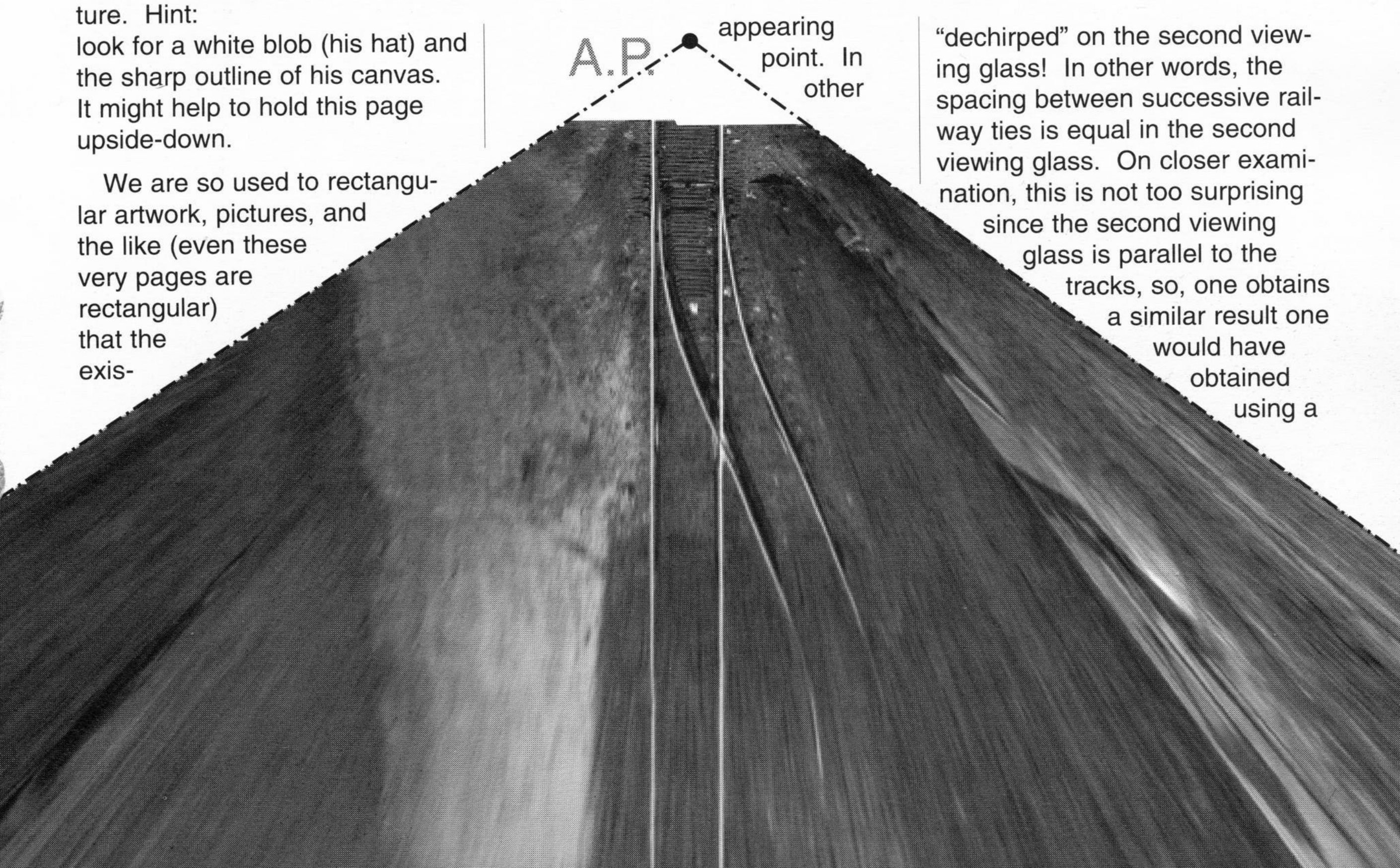
Note also that a picture of a picture has a non-rectangular boundary, similar to the non-rectangular image one typically observes with a haphazardly positioned projector. In fact if you are watching a projection screen from anywhere but the vantage point of the projectionist, you will most likely see some degree of *keystoning*. For those good at "Where's Waldo", try to locate the artist in the picture of the picture. Hint: look for a white blob (his hat) and the sharp outline of his canvas. It might help to hold this page upside-down.



We are so used to rectangular artwork, pictures, and the like (even these very pages are rectangular) that the existence of non-rectangular images can be somewhat disturbing. I am allowing the text of this article to flow around the image, just to emphasize the non-rectangular nature of a picture of a picture. It is time for art to bust out of its rectangular prison cell.

Now if we use the edges of the rectangular picture to define a "new perspective", we observe that this new perspective has its own vanishing point. That is to say, the edges of the new non-rectangular picture meet at a specific point, indicated in this example. This point is none other than the "appearing point". Notice how the image resolution increases as we move toward the appearing point. In other words, as we move along the line from the vanishing point to the appearing point (see picture bottom of previous page), we see more and more detail in the railway ties, and in the stones between them. Now the image ends abruptly, before we reach the appearing point. This termination is due to the finite extent of the film (or viewing glass) in the first camera. Had the viewing glass gone on to infinity, then the resolution would increase without bound toward the appearing point (neglecting again the practical matters).

Now if I tip back the second camera even more, to the point where the second camera is looking right up at the sky, as depicted in the figure below, then what I observe is quite interesting.



The railway tracks are "dechirped" on the second viewing glass! In other words, the spacing between successive railway ties is equal in the second viewing glass. On closer examination, this is not too surprising since the second viewing glass is parallel to the tracks, so, one obtains a similar result one would have obtained using a

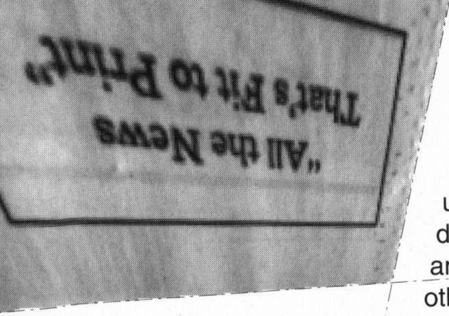
camera in a helicopter, above the tracks, with the viewing glass parallel to the tracks.

What is more interesting, perhaps, is the fact that the vanishing point is now out at infinity. Parallel lines never meet! The vanishing point (which was at a finite location in the original image) is now at infinity, and the appearing point which was at infinity in the original image (e.g. the edges of the original **rectangular** image were parallel so they never met) is now at a finite location in the new image, namely at the point where the edges of this **non-rectangular** image **do** meet.

So far, we have not quite traded the roles of the vanishing and appearing points. Note that the vanishing point was **inside** the original image, right in the center, in fact, which we might as well call the **origin**, or **zero**, for brevity. Thus we have so far seen what happens when we make the **zero** infinite and the infinite finite. We took the origin of the original image and mapped it out to infinity, and took the infinity of the original image and mapped it not to zero but only as far as the edge of the image.

Let us now see what happens when we **exchage** the locations of the vanishing and appearing points.

In other words, let us see what happens when we bring the zero out to infinity and the infinity to zero. We shall use a picture of the front page of the New York Times as a source image. The text on the page provides a clear indication of where the various parts of the picture are "going". There is also an interesting metaphor, for some might say that the NYT brings you "All the News That's Fit to Print", while others would argue that it cannot or will not print everything. When we bring the appearing point inside the image, we, at first glance, appear to have broken the image in half, half of it



being upside down and the other half being backwards. Upon closer analysis, however, we see that it is really only one single picture. Let us follow the path of the edges of the NYT. The left and right edges are clearly visible near the appearing point (center of this page). The top of the newspaper begins near the appearing point and goes off the page, out to infinity, and comes back onto this page at the opposite corner. To see that the top of the page is really one line, observe the colinearity. Projective geometry, afterall, maps straight lines to straight lines, and the 4 edges of the NYT are straight lines afterall.

To really understand what is happening here, we need to break free of the “box camera” that we introduced in the earlier figures. Suppose now that a camera is just a piece of film suspended in space, and a point, called *the center of projection* (COP) which is not on the film.

Light passes through the COP and strikes the film. To make sense of our **new** New York Times, we need to allow for the situation where light may also pass through the film and then strike the COP.

So now that we have explored the technical aspects of the “appearing point”, and, perhaps formulated a language with which to describe the concept, let us now attempt to write some poetry in that language. Let us attempt to use the “appearing point” expressively. Take the NYT. We banish the words “All the News That's Fit to Print” to the corner of this page, for these words, in a sense, are unfit to print, for they deny the very truth they embrace. They look down at the rest of the “News”, knowing full well, that “All the News” requires all the paper in the universe and beyond, hence it is somewhat fitting that this page is infinitely large, though you have before you only 7 by 10 inch portion of it.

Next time you're holding a camera, take a moment and look, not ahead as the camera does, but, look down at your feet. You might be standing right on top of the “appearing point”.