Front and Rear Projection

Take a projector (any projector), turn it on, point it at a screen, focus it, and presto! We see an image. But how does a screen do this? How is it that a front screen can reflect a projected image, but a mirror cannot? How is it that a rear projection screen can display an image, but a pane of glass cannot? Do light rays know which is which? For that matter, what is the difference between **Front and Rear Projection**

The best way to see how a projection screen works is to take one away. Watch: First let's aim a slide projector at a screen and move it just far enough back that its beam fills our image area. When we put a slide into the gate and focus the projection lens, we'll see a good, clear blowup of whatever image occupies that strip of 33mm film. Let's say it's a shot of the swing set in our backyard taken on a nice day last summer.

If we leave the projector on and undisturbed but we decide to whisk away the screen, what happens? The projector doesn't know the screen has vanished, the slide's still in place, and the lens is still focused. At the same plane in space where our screen just was, can there still be an image? Yes, there can.

In setting up our experiment we intentionally did not define whether our screen type was front or rear projection and thus far it hasn't mattered. Now, however, it will be helpful to label our screen as a rear projection device because then, when we remove it, we will be left squinting directly into the very bright beam of light coming out of the projector. (We could have the same uncomfortable experience after removing a front screen, of course, we'd just have to turn around.)

Next, let us imagine that we can put on a pair of extremely dark sunglasses that enable us to look comfortably and without squinting into that bright, bright bulb. With these protective glasses firmly in place, what happens when we move forward just enough so that our eyes are positioned exactly at the plane of the missing screen? Can we see the image? No, but if we look very carefully straight into the projection lens we can see a part of the image, but how big a part? About as much as is covered by the iris of the eye we're using to see the image [See Figure 5].

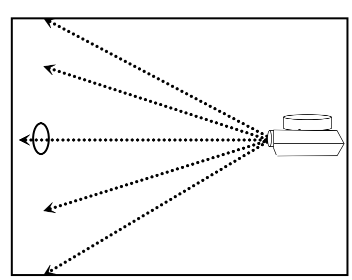

Figure 5

If the place on the image plane where we first put our eye is up at the top, we are going to be able to see a little section of blue sky. (Incidentally, the entire surface of the projection lens will look blue from this vantage paint.) Now, if we move to a lower point on the screen, we can see green (a small patch of lawn). At still another point we can find the red of one of the uprights on the swing set, and so forth.

Alternatively we could accomplish the same thing if we took a little circle of some rear projection screen material (about 5mm in diameter) and, holding it between thumb and forefinger, moved it around the image plane. Anywhere we stopped we would see just that little section of image which our “micro-screen” can capture. Of course we could never see the whole image, the big picture, because neither our eye nor the “micro-screen” is big enough.

Here is a question to ponder. When we reintroduce the full size projection screen into the system and we look from virtually any position in front of it, how is it that we can see the complete image displayed clearly across the entire screen without even having to move our heads?

Without the screen we can only make out one very small area of the focus plane at a time and then only if we put our eye at exactly the right distance away. With the screen we can see the whole image clearly from a huge variety of viewing distances and angles. How does a screen do that?

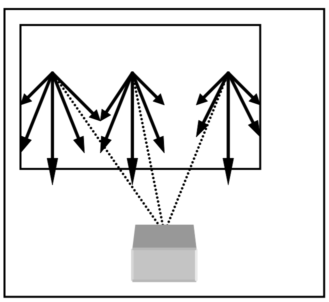

Figure 6

The answer is that screens scatter light. Front projection or rear projection, it doesn’t matter. All screens disperse projected light rays incident to their surfaces. Reflection or transmission isn’t enough. Mirrors reflect; panes of glass transmit. But neither disperses. Figures 6 and 7 represent, respectively, a front and rear projection screen. The dotted arrows coming from the projector are to indicate idealized light rays. When one of these rays hits a screen it gets broken up into a bunch of smaller rays, each of which splinters off in a different direction.

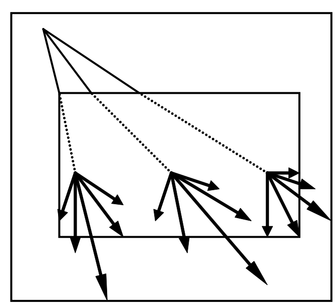

Figure 7

As you can see, some of the scattered rays get redirected at angles that diverge considerably from the original incident angle. Hence you no longer have to be positioned exactly in front of an incoming light ray to see it. By breaking up each incident light ray into a smear of smaller, less intense rays, the energy of the original ray is distributed across a much broader field-of-view. Without a screen our field-of-view was effectively 0^{o}. That is, we could see nothing of an individual ray unless we positioned ourselves precisely in front of it.

With a screen the field-of-view can easily be enlarged to 60^{o} or more. This is how, for instance, we can see information in the upper left-hand corner of a screen when we are positioned in front of the lower right.
True, if a screen is permitted to have an on-axis gain that’s too high, the scattering will be minimal and an opposing corner will appear murky and dim. When that happens, of course, we perceive the center of the screen as excessively bright and call it a hotspot.

Fundamentally, then, front and rear projection screens are operationally alike. They both disperse the projection beam directed at them so that some portion of

each and every
incoming light ray is scattered across the screen's total field-of-view.

With this underlying similarity established for both types of projection screens, what about differences? Is one better than the other? Should we prefer a screen that is reflective over a screen that transmits? Or vice versa?

The single greatest difference between front and rear projection screens is that when you use a rear projection screen it is easy to ensure that the only light aimed at the audience comes from the projector.

A front projection screen will indiscriminately reflect all light incident to its surface with equal efficiency. Thus light from the projector can be diluted by light from other sources (room lights or windows, for example).

All competing light sources in a rear projection system travel in directions essentially opposite to the projection beam. And since a rear screen is transmissive in both directions, only a small fraction of whatever light that strikes its front surface is reflected. The major portion passes harmlessly through the screen to be absorbed by the booth behind it.

That same booth, of course, comprises the great drawback to rear projection. By definition rear projection has to have space behind the screen for the one or more projection devices that are to be aimed at it. And, needless to say, the bigger the screen, the bigger the booth area.

Improved projection lenses with shorter focal lengths and clever mirror systems now exist to decrease the amount of space necessary for a rear projection booth, but its existence remains unavoidable and its size non-trivial.

With front projection, of course, the architecture can remain unaltered. Since the audience and projector are on the same side of the screen, the room size will always accommodate both. This convenience, by itself, is enough to explain the statistical preponderance of front projection screens over rear.

That actuality aside, however, the very highest quality displays are invariably rear projected. Particularly when the projection source is some form of video rear screen technology that includes a range of optical coatings, tools and lenses which singly or in combination can display outstandingly fine imagery, often under extremely challenging conditions.

Front projection screens are also available in numerous configurations but all of them to a greater or lesser extent are constrained by their sensitivity to extraneous light sources and their utility, therefore, is generally confined to darkened interiors.

Despite these seemingly clear distinctions, picking out the right projection screen for a particular application can be a daunting task. Even after deciding whether you want front or rear, the choices don't immediately get easier. Da-Lite currently offers front projection screens in nine different models and provides rear projection screens in eleven different models. To make things even more complicated, some of the latter come in two different substrates; glass or acrylic.

To help navigate through this possibly bewildering array of screen alternatives, Da-Lite has published a pair of guidance manuals that both define and distinguish appropriate applications for each model.

A part of the company's Presentation Media Application Series, the first of these 24-page handbooks is entitled Selecting Front Projection Screens for Today's Presentation Applications. The second is dedicated to selecting rear projection screens.

Note: The material used in this paper is taken from the Da-Lite educational series *Angles of View, Vol. 1*

For additional questions and information you may contact your local Ford Audio-Video sales representative or call 800-654-6744. We are available to visit your Church to analyze your needs and make recommendations to help you with training, sound mixing, and special programs.

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