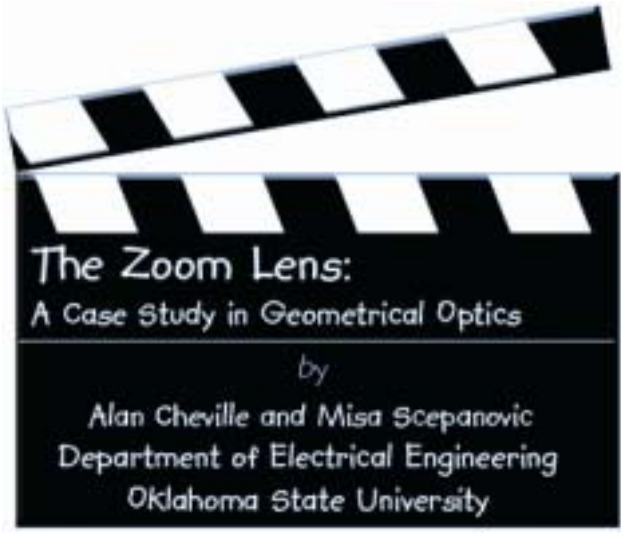


“Cut! Cut, cut, CUT! How many times do we need to film this scene?” exclaimed Pierre LaRue to no one in particular. “Bill, get that camera back on the tracks. Lance, this is a love scene, not slapstick, so you and Edith get it together. We are already two weeks behind schedule. I’m telling you, Stocker is going to make sure none of us ever work in this town again if we don’t get this scene done today.”

“Look, Pierre, nothing against your directing, but we can’t go on like this” exclaimed Lance Smythe, Hollywood heartthrob and one of the most acclaimed actors of the time, while sitting in Pierre’s trailer after the day’s shooting had ended.

“You’re a great director, but the equipment Stocker Freon has you using is pre-war. I know he loves his dollars, but pretty soon someone is going to get hurt on the set. Besides,” Lance added, with a vexed expression on his face, “it’s next to impossible to shoot a serious scene when the camera falls off the dolly or becomes derailed every five minutes.”

“I know, Lance. I’ll have another talk with Stocker tomorrow. Maybe if you come too we can convince him he needs to spring for some new equipment. I just can’t work under these conditions.”

“Yeah, I’ll come along. If this picture turns out to be a dog, my fate is going to be closely tied up with yours. Can we make it in the afternoon? I want to have a talk with a friend of mine in charge of strategic planning over at MGM. They have really been on top of changes there and he might have some good ideas.”

The next afternoon Pierre found himself waiting outside of Stocker Freon’s office at West Coast Film, one of Hollywood’s big movie houses. Stocker, the current head of West Coast, was described by his numerous enemies as an unscrupulous and ruthless businessman. However, during his time at the helm, West Coast had risen from a strictly B movie outfit to one of the big film companies, competing with the likes of MGM for the top stars and scripts.

“Darn it, Lance,” thought Pierre, “you had better show up this time. Stocker is never going to listen to me without the talent making a case....”

Just as Pierre was being ushered in to Stocker’s office, Lance came into the waiting area with a nondescript man in a rumpled grey suit in tow.

“Mister LaRue, Mr. Smythe, Mr. uhh....”

“Mr. Bacchan,” supplied the man in the grey suit.

“Yes, Mr. Bacchan. Mr. Freon will see you now,” said the secretary, a starlet who had starred in several minor movies, as she escorted them in with a long smile for Lance.

Stocker Freon was sitting in a comfy leather chair, calmly smoking a Cuban cigar. “Gentlemen, please pull up a chair. You have come to see me about the delays on the set, yes. Have you decided to take my recommendation to fire the crew and go with non-union labor?”

“No, Stocker. If you try to cut corners that way, this studio will go under in a month. We’re here to ask you to bring the company into the twentieth century. You have a great crew, top caliber actors, and the best director on either side of the Atlantic. The reason we’re behind is the equipment we use belongs in a museum. The cameras are okay but the rest of the stuff was old when Chaplin was the hottest ticket in town.”

“We’ve had this argument before, you and me, Pierre. I’ve had this same argument with every director who has come through here. Equipment costs money, and money is best spent for talent. People pay to see actors and actresses, not some technological mumbo jumbo.”

“He’s right, Mr. Freon,” Lance interjected. “And you are too. People go to see the stars, but the stars aren’t going to work for a studio that has to shoot each scene twelve times because the equipment is falling apart. I was up filming until after ten last night because the dolly that was supposed to do the close-up on the kiss goodbye scene kept derailing. It nearly cut off Edith Pizzarino’s foot! After that she put on heavy boots. Have you ever tried to kiss a woman wearing work boots?”

“Well, what do you propose?” asked Stocker Freon, as the thick cigar smoke filled the richly appointed room. “Money is tight around here, and I don’t like to hear excuses from the people who are losing it for me by running three weeks behind an already generous shooting schedule!”

“Buy our equipment,” said the gentleman who had been sitting silently next to Lance all this time.

“I’m sorry,” said Lance, “this is Mr. Bacchan, an optical engineer with Zoomar. He has been doing some consulting work with MGM, and I think he may be able to help us.”

“MGM, eh? I assume you’re not yet under contract or you wouldn’t be here. I’ll hear what you have to say,” said Stocker.

Mr. Bacchan pulled a peculiar looking device out of his briefcase. “This is the Zoomar A, our newest zoom lens. It is related to some devices we have been developing for the military, but it’s much less expensive. What a zoom lens allows you to do is change the magnification of an image—in other words, make it seem closer or farther away without moving the camera. We have set this demonstration model up so you can look through this end. The real version would be set up to make an image on the film rather than one your eye can see.”

Mr. Bacchan handed the Zoomar A to Pierre. “*Mon Dieu!*” Pierre exclaimed, sliding the handle Mr. Bacchan indicated. “It seems like things are rushing up to meet me!”

“Let me see!” Stocker said, grabbing the device from Pierre. “Hmm, I see what you mean. Why with something like this we could make ants seem the size of dinosaurs! It opens up a whole new realm of special effects!”

“Uh, that is not really possible,” Mr. Bacchan interjected, handing the lens back to Pierre. “The Zoomar A has 3:1 zoom range. To be able to zoom in so an ant would seem as big as a dinosaur, the zoom range or change in magnification would have to be much larger. And, to accomplish that, the ant would get out of focus. The most important thing about this zoom is that it will enable the cameraman to zoom fast when he needs to and you won’t have to invest in new moving dollies.”

“I see what you mean,” Pierre said. “Things go from normal size to about three times normal size. Exactly how much of a range can you achieve with one of these? And can you make the image seem smaller, rather than just bigger?”

“And how much exactly does one of these cost?” asked Stocker.

“Well, the Zoomar A is only a prototype. We would need to decide on the magnification range you needed and how far the image plane would be allowed to move over that range. The 3:1 range is very easy; 10:1 is certainly possible. And it is fairly simple to have the magnification be less than 1 or greater than 1, within limits of course. As far as cost, that depends on the zoom range, and there is the matter of determining the acceptable aberrations of the lens and what size optics we will need. Of course, the film size is important....”

“Enough technical mumbo-jumbo! If it doesn’t have a price tag on the front of it, I don’t care about it!” Stocker exclaimed. “Do you know how much it costs or not?”

“Mr. Freon, it depends on how good a lens you need. If you want to make ants appear the size of dinosaurs, we’re talking a ball park figure of....” Mr. Bacchan wrote a number down on a piece of paper and handed it to Stocker, who immediately turned a sickly shade of green. “However, a simpler system with a smaller zoom range would run more like....” Mr. Bacchan handed over a second piece of paper.

“What I suggest is you contract with us to build a prototype,” Mr. Bacchan continued. “Mr. LaRue here can put it on a camera, see if it will do what you want, and then we can talk real dollars, quantities, and delivery times. The mechanical design is quite expensive and a prototype will allow a final design to be specified before we bring in the mechanical engineers. That represents quite a cost savings.”

“Keep in mind that to back away from a scene you have to have the camera move on rails, which is very expensive. A zoom lens will solve these problems. To put it simply, the cameraman will just have to move a small mechanical part, which will be at the front of the camera, to make the scene appear closer or farther away. It will be faster and more convenient, but the lens will be more expensive. It is an untried technology, but MGM is very interested. I hear that Alfred Hitchcock has been using a similar lens system manufactured by a British firm.”

“This is true,” said Pierre. “Mr. Hitchcock is doing amazing things with his camera work. I have analyzed some of his shots and they are far superior then anything I have seen before, including my own work. He is able to portray human emotions powerfully by zooming in on the actors’ faces. We need to do the same. We must show the anger, fear, sadness, and the happiness of the soldiers, besides all the raw action. Stocker, we need the zoom lens to do this!”

“Ok, Bacchan, you’ve sold me! Make your prototype. Pierre, work out the details, you’re the cameraman here, so work out some specifications. Bacchan, get me a written proposal I can take before the board and we can cut you a check the same day to develop the prototype.”

“It’s a deal,” said Mr. Bacchan.

Mr. Bacchan and Pierre retired to Pierre's smaller, much more cramped office. "You want some coffee?" asked Pierre.

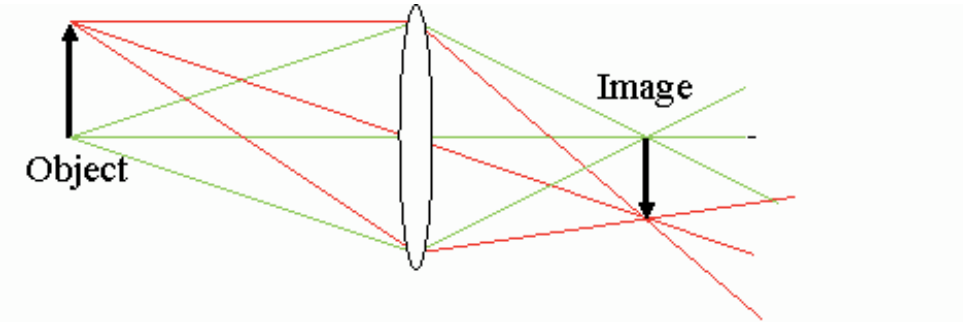
"Only if it's less than three days old."

"That we can handle."

As Pierre poured two cups he asked for details on what exactly the zoom lens was doing. Although he had quite a bit of experience with cameras and lighting, he was only vaguely familiar with the technical details of how lenses worked. Mr. Bacchan launched into a technical explanation, which quickly went deeper than Pierre's knowledge. Stopping Mr. Bacchan often to have a point explained in simpler terms or to reframe a question, Pierre was able to get a basic understanding of how the lens would function.

"A lens can serve many purposes, but here it is a device for creating an *image*. *Image* is a technical term that is used to describe a point in space where all the light rays that hit the lens from some given point on an object (the technical term for what you are looking at) will meet again. When the light rays cross, an image is formed. As far as your eye or film (the detector) is concerned, the object and the image look exactly the same."

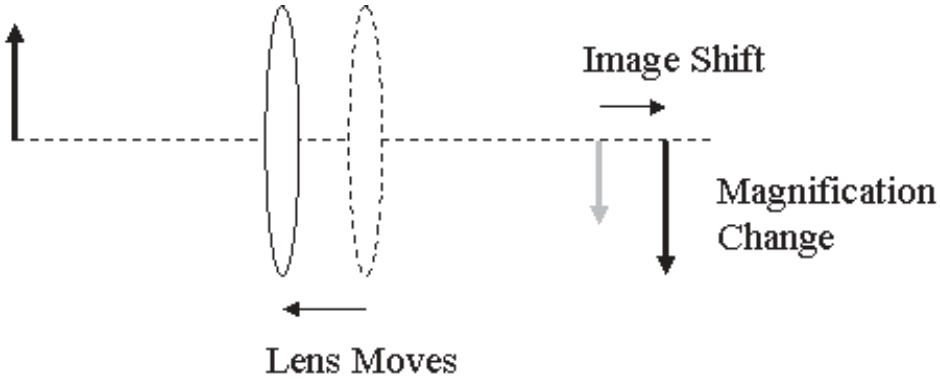
Here Mr. Bacchan took some paper from Pierre's desk and drew a diagram of an object imaged by a lens as he continued with his explanation. "Three light rays come off the tip of the arrow going in different directions. If these hit your eye, you see that part of the object. However, the lens causes the three rays to cross again. As far as your eye is concerned, it looks like the tip of the arrow is at this point. The lens has caused the light to bend so it looks like it comes from a different point."



"However, the image (recreation of the object) and the object itself are not exactly identical. The image can be either bigger or smaller than the object. The ratio of the image size to the object size is technically known as the *magnification*. The magnification can be negative too, which means the image is upside down. The figure I have drawn has a magnification that is less than 1 and negative."

Making another drawing, Mr. Bacchan went on to explain that the place the image is formed depends on the lens used and the distance from the lens to the object. "This means if you move closer to the object (effectively increasing the magnification), you will also need to move the lens. If you don't, the *image plane* (technically the plane orthogonal to this paper in which the image is formed) will move and not fall on the film anymore."

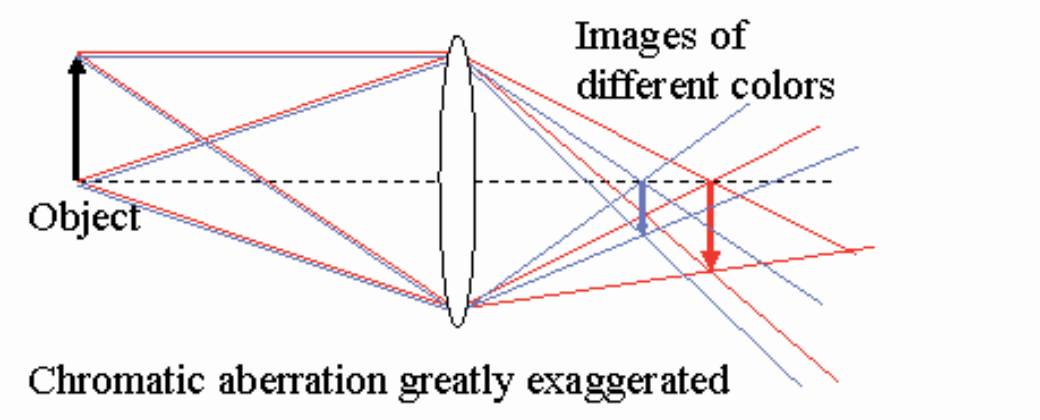
After some thought, Pierre realized that this would mean the camera was out of *focus*. To focus he had to move the lens. Things were beginning to be clearer, especially after Mr. Bacchan explained it with this second figure.



Mr. Bacchan went on to explain that a zoom lens was several lenses arranged so that the magnification or image size could be changed without moving the image plane. In other words, the object could be bigger or smaller without getting out of focus or changing the distance from the camera to the object. To do this, you needed at least three lenses.

Pierre interrupted with a question: "So, the science of optics is just to figure out how to put several lenses together to accomplish this?"

Mr. Bacchan nodded. "Yes, but designing a system to bend light so that an image is formed is only part of the problem. A much more complex issue is that lenses do not bend light perfectly, and so the image that is created is not exactly like the object. How to minimize these effects is a much more difficult problem." Pierre had often seen this in his camera work when taking pictures of lights. The lights sometimes had red or blue borders on the film, which he couldn't see with his eye.



"That is exactly right," Mr. Bacchan said. "The technical term for such imperfections is *aberrations*, and the red or blue fringes you see are a type that is known as *chromatic aberration*."

The figure above is what Mr. Bacchan drew to explain how two images of different color could be in different places. He explained that the lens bent blue light more than red light, so different color images were formed at different places.

"There are many other types of aberrations that can degrade an image in other ways. The hardest part about lens design is minimizing these. So, a really good zoom lens will have more than three lenses. Of course, the lenses that would be purchased would all come with specifications about how large the aberrations were since this is a critical part of the effectiveness of the lens."

"Whew, Mr. Bacchan, I never realized so much went into optics design," exclaimed Pierre.

"Yes, it really is quite complicated, and sometimes more of an art than a science. We rely on designs that have been developed over many years, although with the invention of these new fangled computing machines, like ENIAC, I am hoping the design of optical devices will become more scientific."

After a little more back and forth on the complexity of optical design, Mr. Bacchan and Pierre got down to business. With Pierre's background on zoom lens design issues a little more solid, Mr. Bacchan asked what the next step with this project should be. After all, although the CEO would be paying for the lenses, Pierre was the one who would most directly influence the decision as to whether they would be purchased.

"Well, Mr. Bacchan," Pierre said, "it seems from what you have said that we need to see a prototype of this lens. I really don't have a sense yet of how this will affect my camera work. Why don't you have your teams get back to me with what they think are the best lenses for my application. If these work, the way you are advertising, we will probably buy several hundred a year, although of course Stocker Freon has the final say on that."

Questions for Case Study Discussion:

1. What persons or groups of persons are involved with or will be affected by the decisions made in this story? Include both those who are listed here as well as those who are not listed specifically.
2. What issues are important to the actors and the crew?
3. What issues are important to the CEO?
4. Why would anyone want to use a zoom lens?
5. What is the difference between zoom and focus?
6. Besides the movie industry, where else might zoom lenses be used?
7. Why would you make the input lens of the zoom lens big? What are some advantages and disadvantages?

Assignment:

1. Write down at least three design issues that need to be addressed in making a zoom lens.
2. List several topics you will need to learn more information about before pursuing the design of a zoom lens.

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Case Follow-up: Getting the Proposal Together

Jim Bacchan drove his old Packard to the valley to Zoomar's new headquarters just east of Los Angeles. Walking out of the desert heat into the air-conditioned comfort of the office was always a relief. Why didn't some bright kid in Detroit try to put air conditioning in cars?

His secretary, always very proper, greeted him with the list of calls he missed and the usual question, "Did you sell another system, Jim?"

"Well, Mabel, I think so. That Stocker Freon is a flint-hearted old so and so. Too much time making movies in the Depression when labor was cheaper than film, I guess. Could you round up the guys? We need to put a proposal together a.s.a.p. if we are going to get this contract before the boys over at Hughes get wind of it."

"Sure thing, Mr. B. Meet in the conference room in an hour?"

"Sure, Mabel. And could you go out and get Zack some Lucky Strikes? He always complains that the machines don't sell them, and I'm not in the mood for his griping today."

The conference room filled with smoke and the buzz of muted conversation as the engineers slowly trickled in. Calling the meeting to order, Jim Bacchan outlined the meeting that had taken place earlier in the day at West Coast Films. He finished his summary by stating the importance of this contract. "Look, boys, I know our main business is cameras for aerial reconnaissance and working on light weight systems. But this movie business is potentially important. To survive we need to address more than just the military market. And that includes movie studios, observatories, or any company that uses optical equipment."

"Don't forget the consumer," spoke up Akiro Yogokatsu. "Soon people will want zoom lenses for their cameras!"

This statement was greeted by general laughter. Not many of the other engineers believed there would ever be a market for high technology consumer items.

"Why don't you go back to Japan to build your consumer items, Akiro," laughed Bill Snodgrass.

"Okay, people, let's keep our eye on the ball. I want your design teams to get me a proposal for these systems in two weeks maximum. What items do we need to address in the proposal?" asked Jim.

The discussion was long and heated, but finally the teams agreed on several points that their proposals should address:

- Mathematical modeling of the lens performance, including whatever simulations were necessary.
- A statement of each team's design strategy, including the most important design criteria and how these would be achieved.
- Both optical design (what lenses to use) and mechanical design (how to hold the lenses).
- How to both calculate and measure the performance of the final product.
- Details of the size of the image plane.
- A clear statement of the magnification range of the proposed system.
- A detailed budget to build the prototype.

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