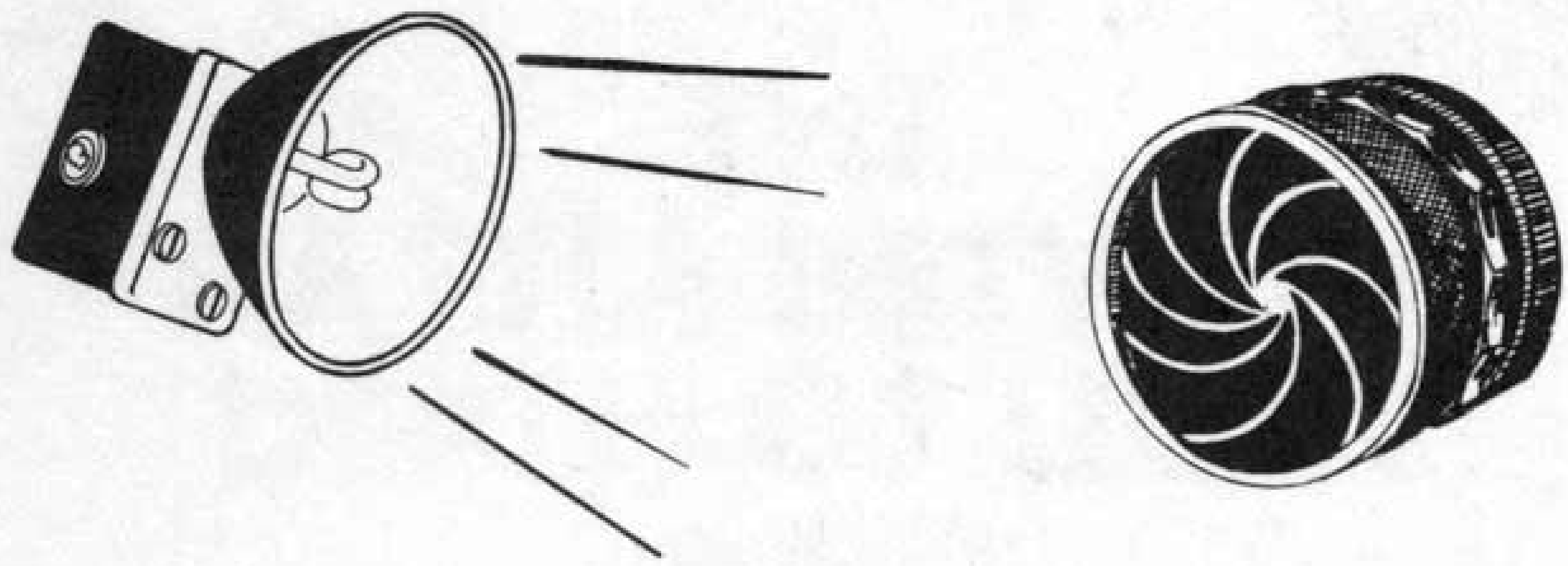


THE BATTLE BETWEEN DEPTH OF LIGHT AND DEPTH OF FIELD

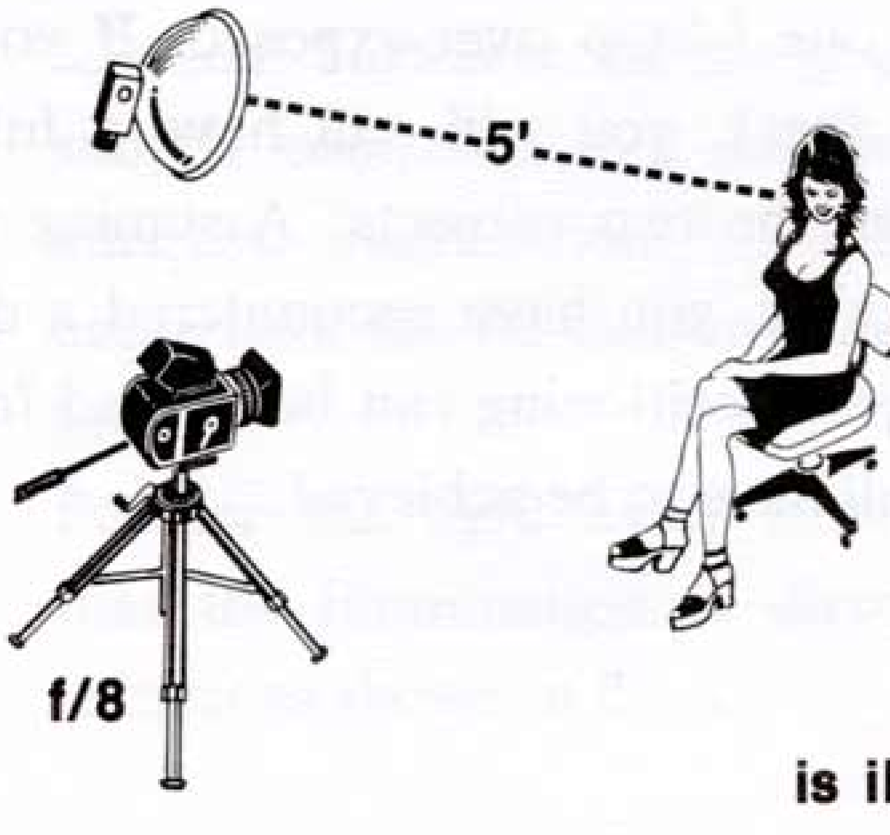
(THE INVERSE SQUARE LAW)

WHAT IS THE INVERSE SQUARE LAW?

"Light falls off as the square of the distance." This statement is the Inverse Square Law, but you may ask, what does this have to do with *inverse?* The word *inverse* is not even mentioned in the above statement! The answer is that the remaining amount of light (illuminating the subject) is equal to the inverse square of the distance from the light to the subject. In other words, if you place a light source five feet from the subject, the amount of light that remains to illuminate the subject equals the inverse square of five feet, or $1/(5)^2$. This is 1/25 of the amount of light at the source.

Let's assume that the correct f/stop for a particular flash unit and film speed in this situation is f/8 (see fig. 1).

Fig. 1

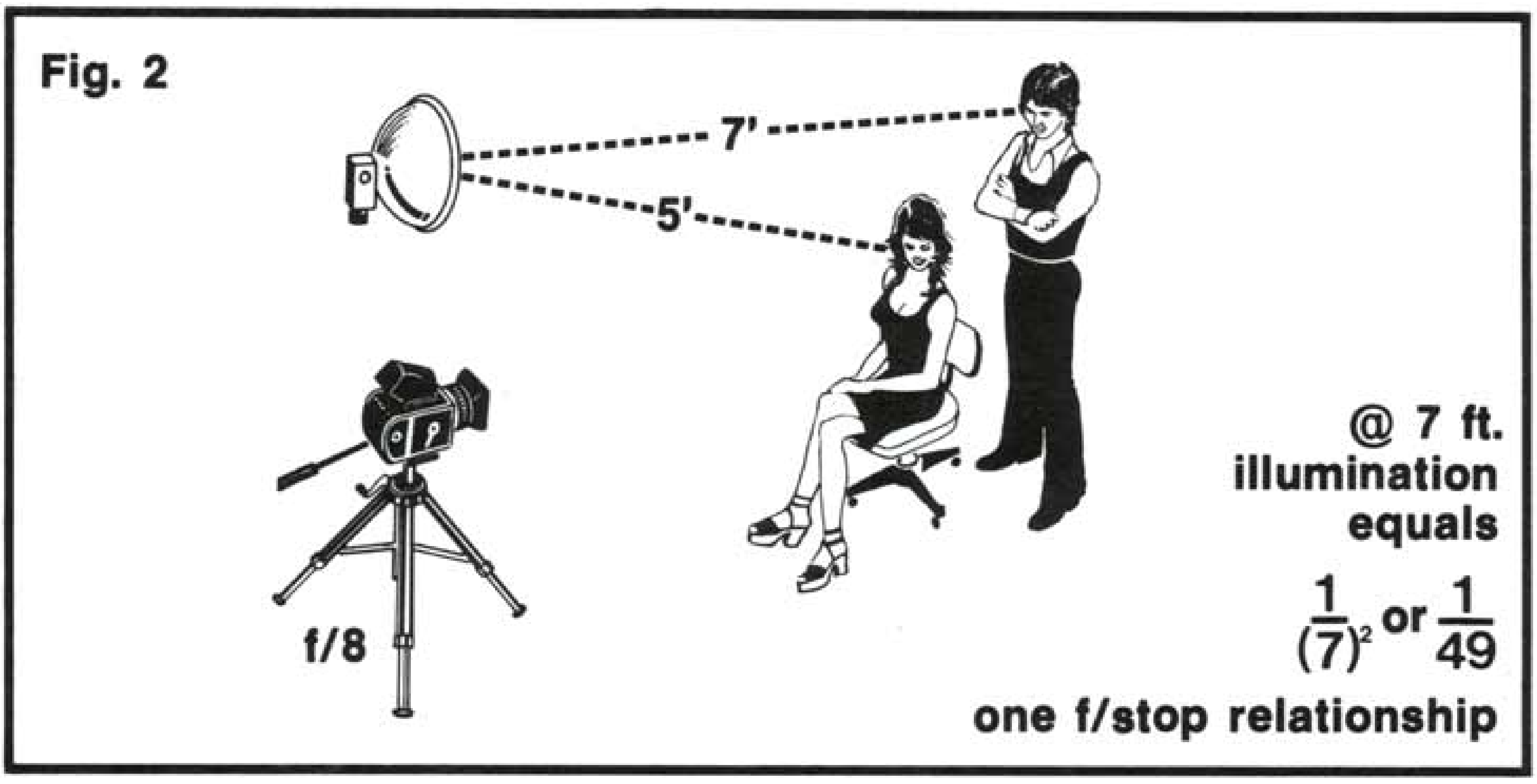


$\frac{1}{(5)^2} = \frac{1}{25}$

of total light is illuminating the subject

Now, let's say that you are photographing two subjects and the second subject is at seven feet from the same light source. How much of the original light is illuminating the second subject? See fig. 2.

Fig. 2



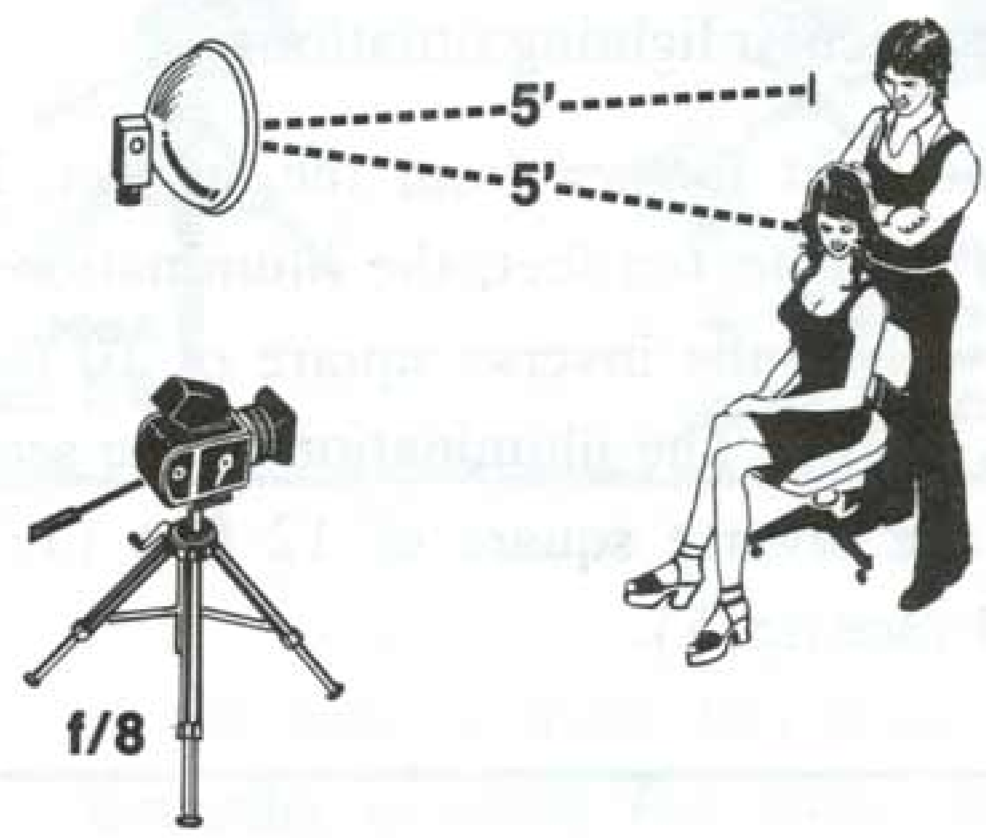
It would be the inverse square of seven feet or $1/(7)^2$. This is 1/49 of the light at the source. Since 1/25 illumination is approximately twice as much as 1/49 illumination, the illumination at our second subject is approximately one-half, or one f/stop less than at the first subject. Therefore, if you correctly expose the first subject (at our hypothetical f/8), the second subject will be one f/stop under-exposed. If you correctly expose for the second subject (f/5.6), the first subject will be one f/stop over-exposed. If you expose for the middle area (at six feet), you will still have a full one f/stop exposure latitude between the two subjects. Assuming that this one f/stop latitude is undesirable, you have encountered a depth of light problem. Either the subject positioning can be altered for less depth, or better depth of light will have to be achieved.

HOW CAN DEPTH OF LIGHT BE EXTENDED?

There are several ways to obtain greater depth of light:

1. Reposition the subjects or the light so that the distance from the light to the subjects is closer to the same footage as illustrated in fig. 3.

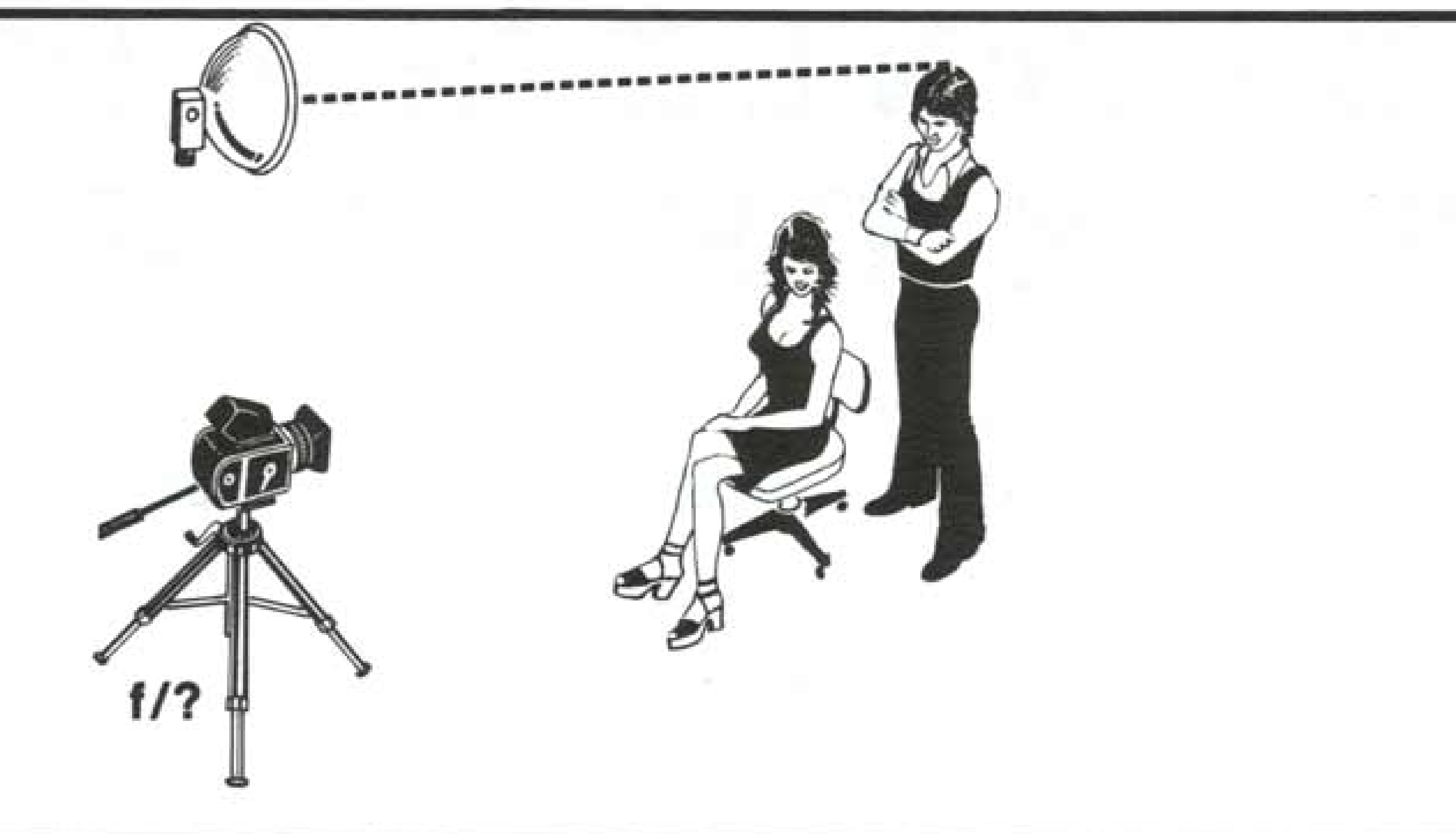
Fig. 3



For candid work, this is perhaps the easiest and best solution. However, in many cases, the most desirable subject composition is sacrificed in order to provide adequate illumination. Also, moving the subject could cause undesirable shadows for proper subject illumination.

2. Feather the light away from the nearest subject so that the illumination is directed toward the farthest subject as shown in fig. 4.

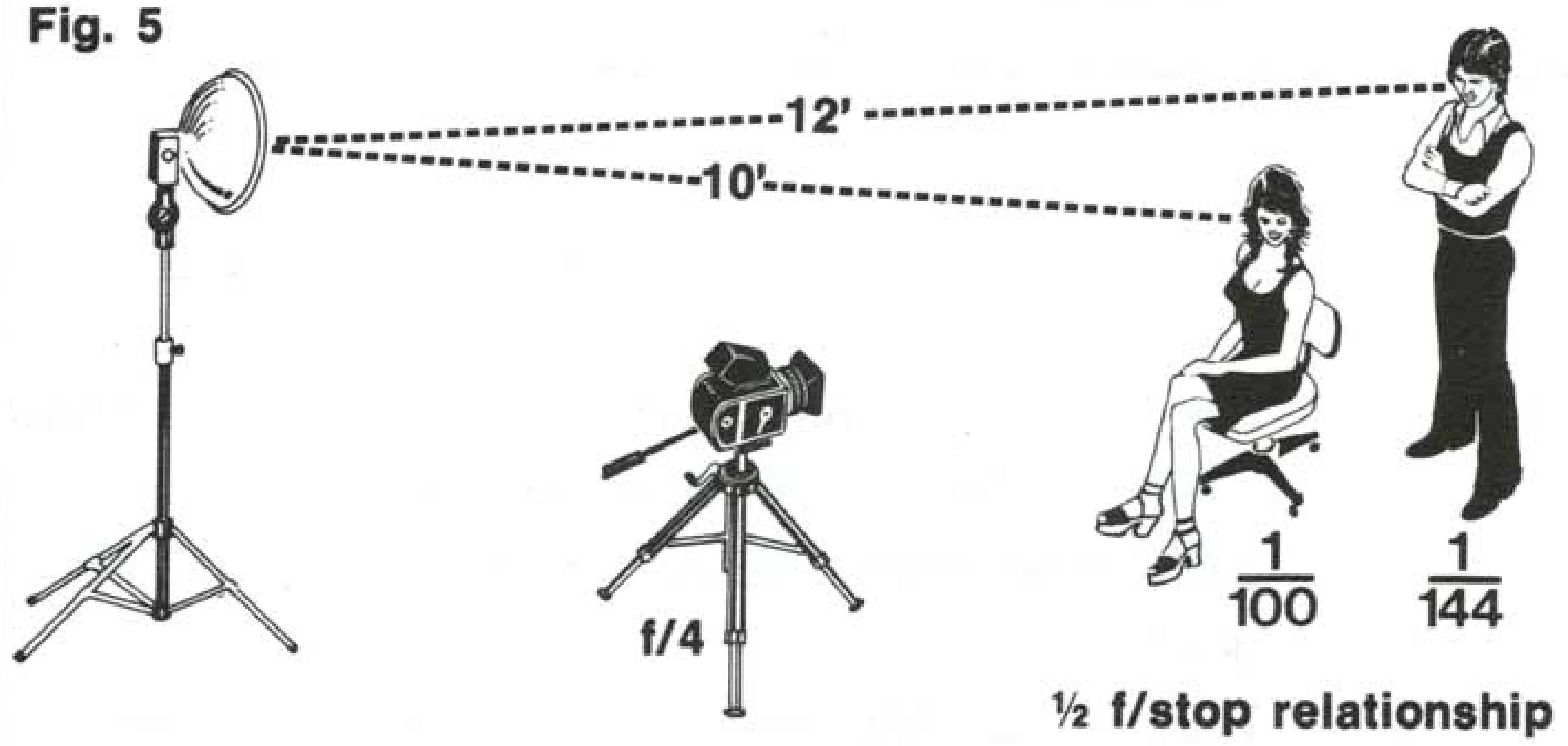
Fig. 4



This can be a good solution if its application is practical in your particular lighting situation.

3. Move the light farther from the subject. If we move the light back to ten feet, the illumination on the first subject will be the inverse square of 10 feet ($1/10^2$), which is 1/100. The illumination at the second subject will be the inverse square of 12 feet ($1/12^2$) which is 1/144 (see fig. 5).

Fig. 5

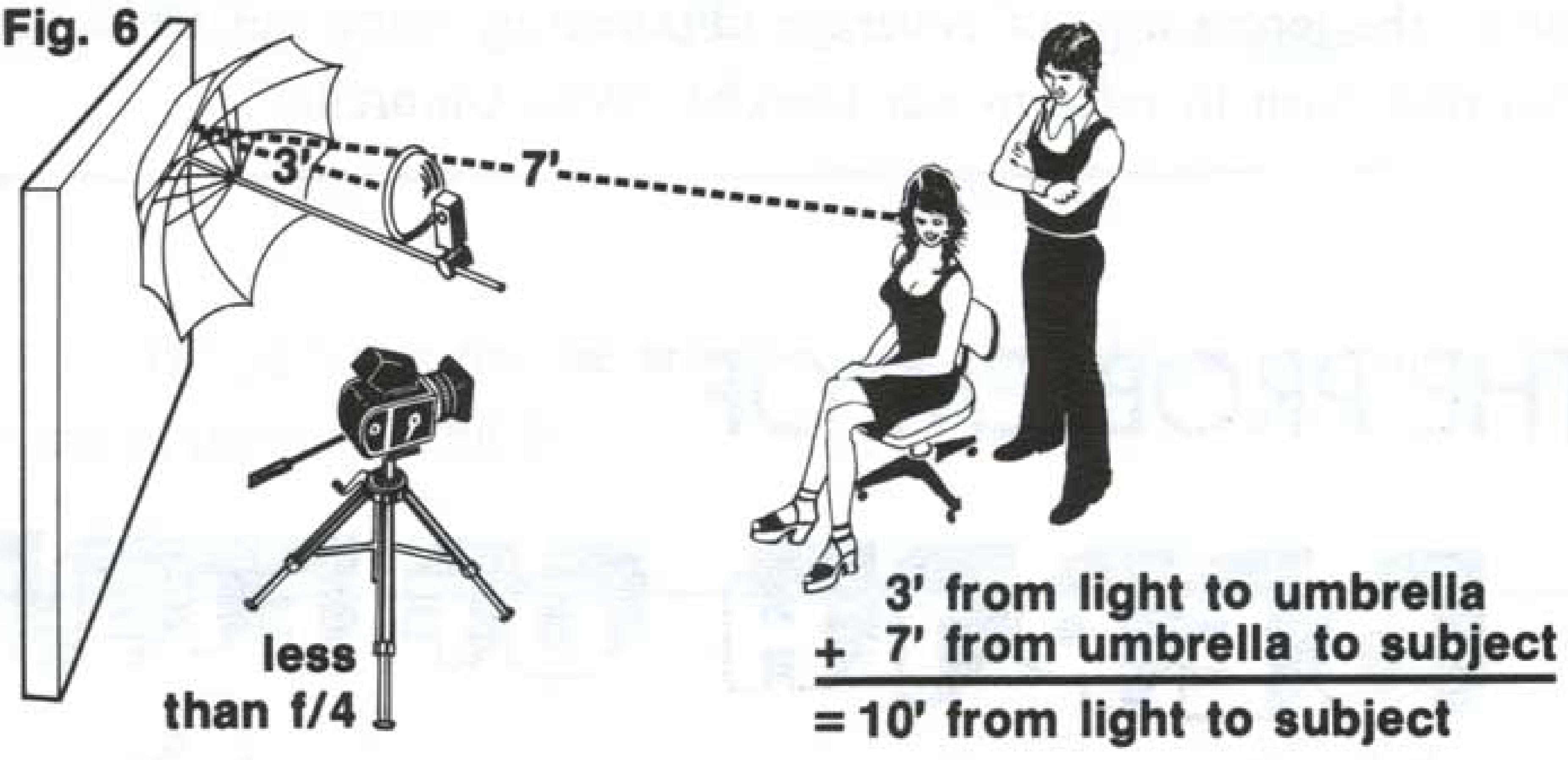


If the illumination at the second subject were 1/200, it would be 1 f/stop less than at the first subject. However, 1/144 is about ½ f/stop less than at the first subject. Therefore, we have extended the depth of light.

BUT — what if the shooting space was not large enough to enable us to move the light back as far as 10 feet? See solution number 4.

4. Bounce the light into an umbrella or bounce flat as shown in fig. 6.

Fig. 6



If the light is three feet from the umbrella and the umbrella is seven feet from the subject, the light is 3+7, or 10, feet from the subject. Therefore, the same depth of light is achieved as placing the light at ten feet from the subject. In this situation the umbrella could be called a "wall extender" because it enables the light to be ten feet from the subject with only seven feet of working space.

5. Use an additional light to help illuminate the second subject. This can be a good solution. It requires your skill in light placement and technique so that the effect of additional light will not be detrimental to the overall lighting of the photograph.

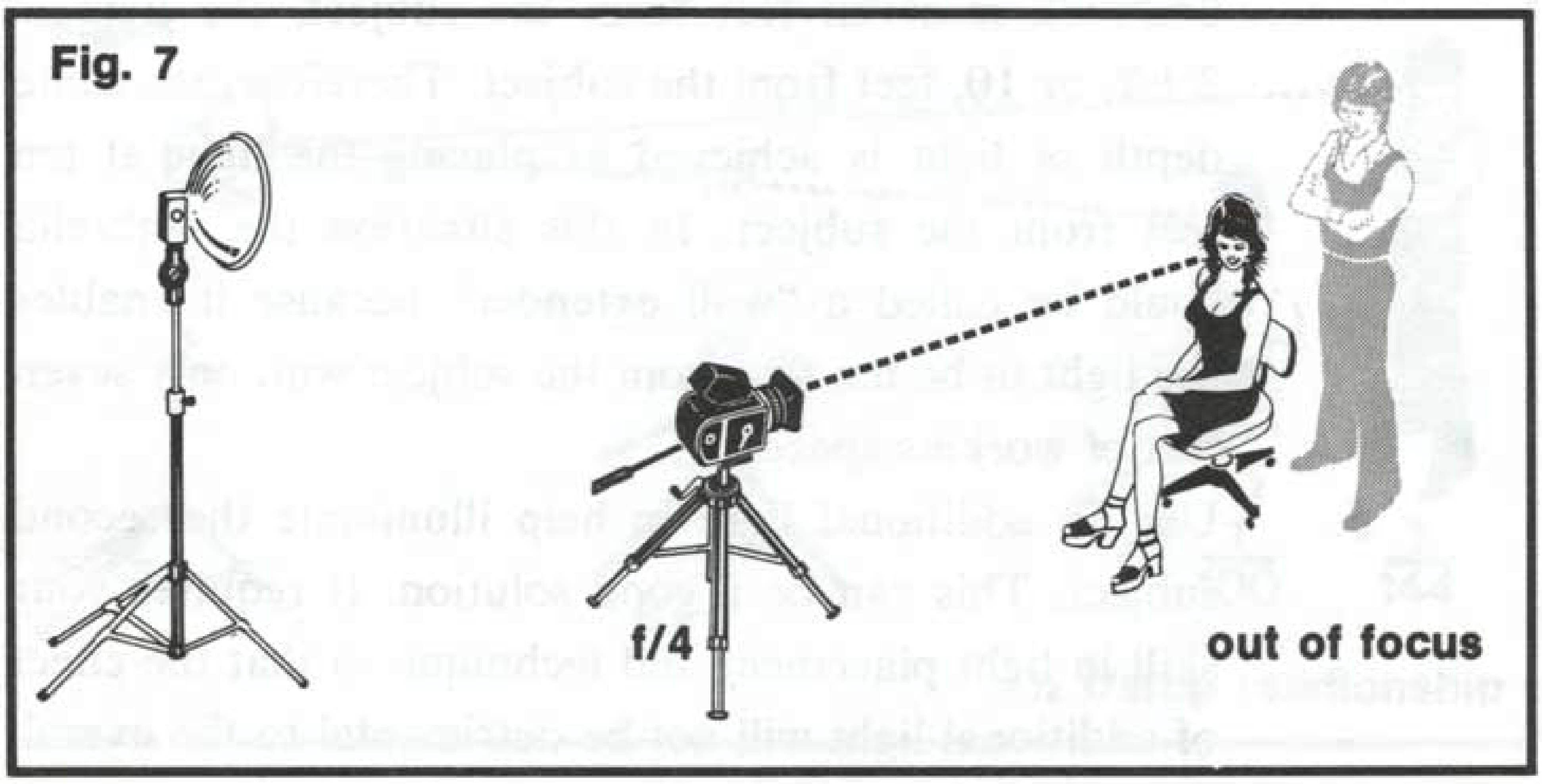
In actual practice, you may use a combination of these suggestions to achieve the desired results. But, there is one potential problem that has not been mentioned thus far — when the solution to extending depth of light results in less illumination on the subjects (as in solutions 2, 3, 4 and possibly 5), our hypothetical f/8 aperture setting can no longer be used. This can result in a depth of field (sharpness) problem. The extent of this problem depends basically upon the focal length of the lens and the subject-to-camera distance.

Doubling the light-to-subject distance will result in an exposure loss of 2 f/stops. Therefore, in solution number 3, we must use f/4 rather than f/8. In solution number 4 we will lose more than 2 f/stops because of the losses in the umbrella or bounce flat and also due to the larger area of coverage obtained by using this technique. You may wish to refer to our booklet "Why Umbrella."

THE PROBLEM OF DEPTH OF FIELD

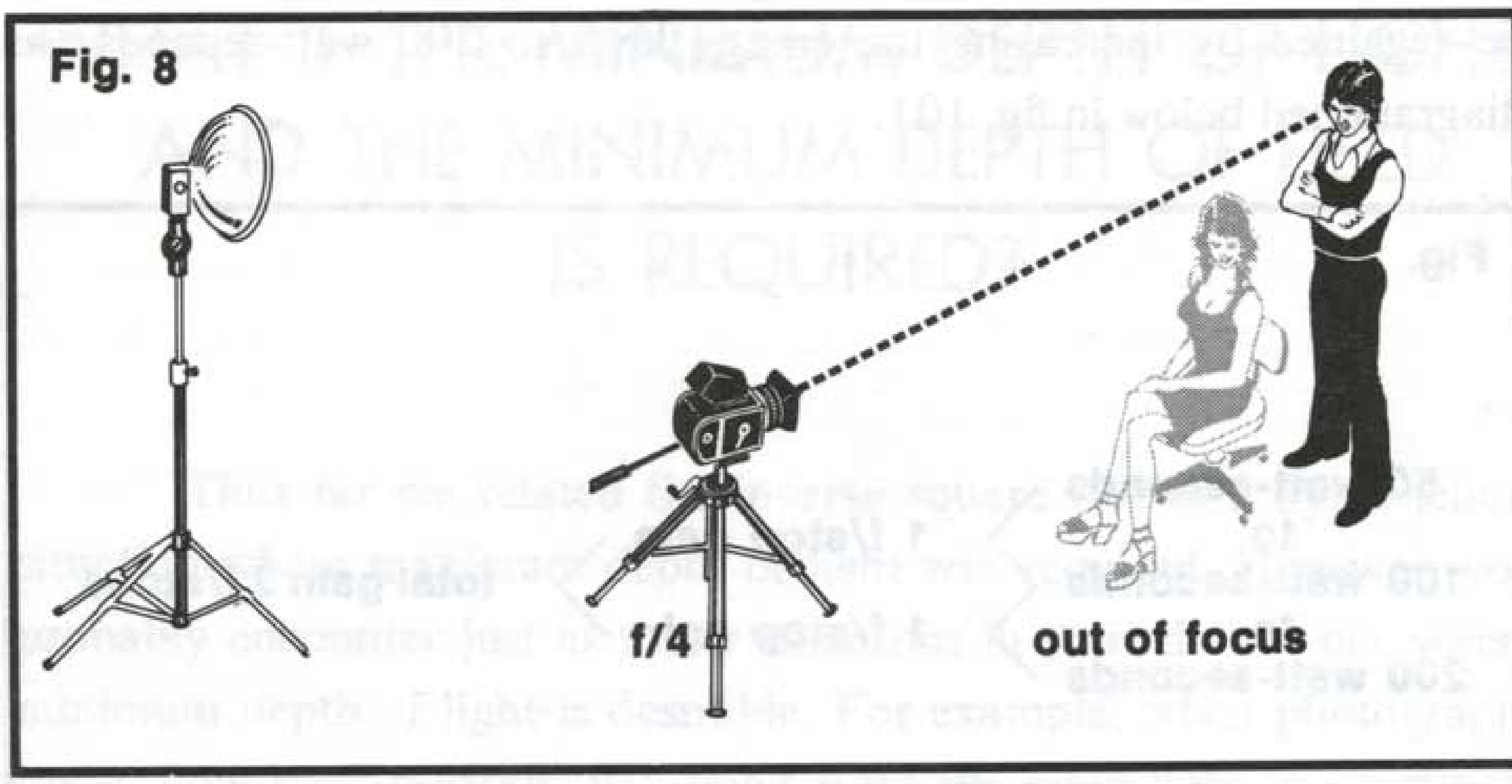
If you focus on the first subject, the second subject may be out of focus as illustrated in fig. 7.

Fig. 7



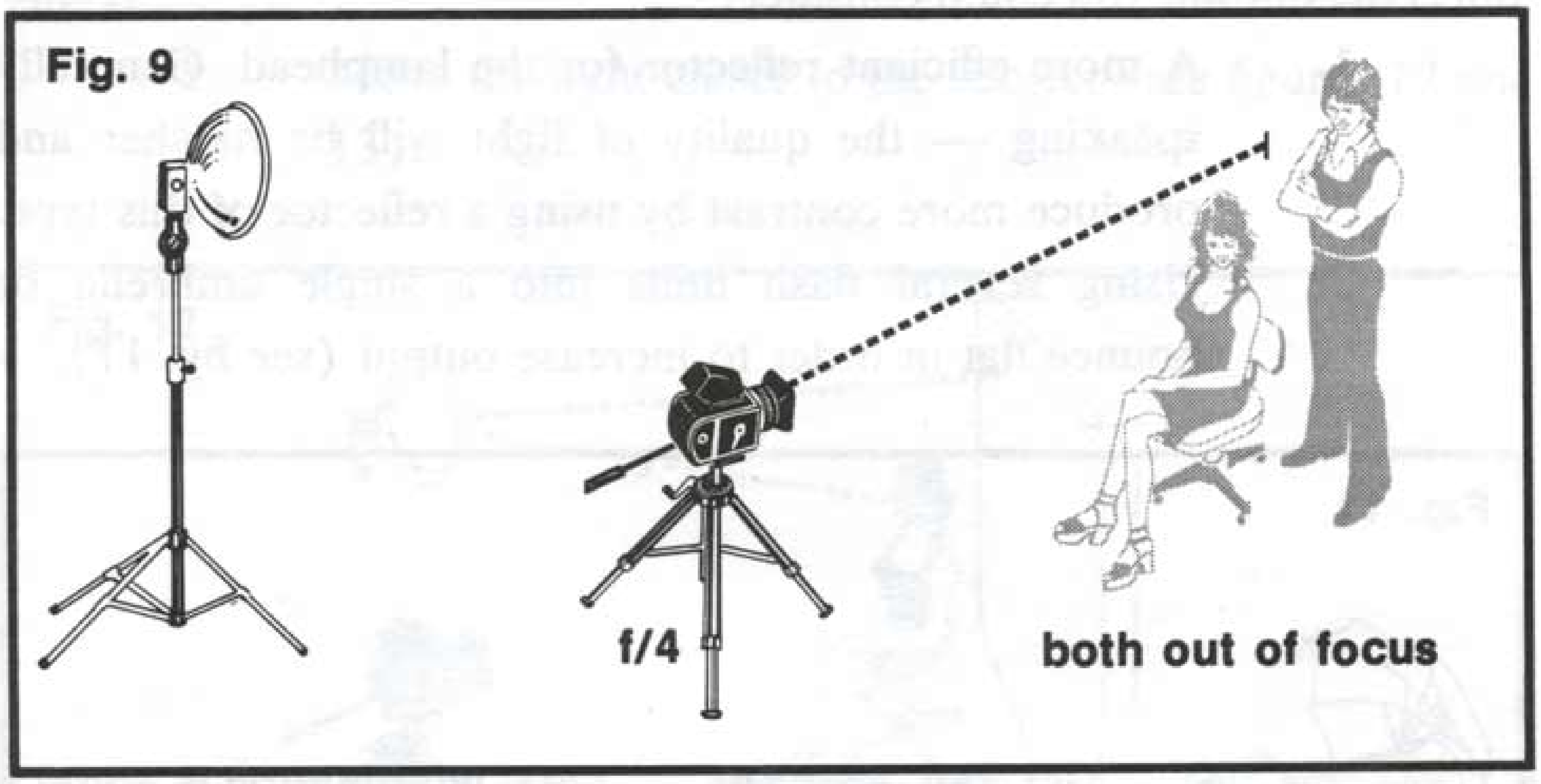
If you focus on the second subject, the first subject may be out of focus (see fig. 8).

Fig. 8



If you focus for the area between the subjects they may both be out of focus as in fig. 9.

Fig. 9



The smaller the lens opening, the greater the depth of field. Therefore, the basic objective, aside from reposing the subjects, is to again stop down to f/8 (or perhaps smaller). Assuming that we do not wish to use a film with faster emulsion speed, we simply need more light at the subject. Four times as much light will be required to regain the 2 f/stop loss in order to use f/8 again.

Doubling the watt-second level of your flash unit will produce one f/stop more light with a given lamphead. Therefore, if you are using your flash unit at 50 watt-seconds, the 2 f/stop increase could be regained by increasing the energy level to 200 watt-seconds (as diagrammed below in fig. 10).

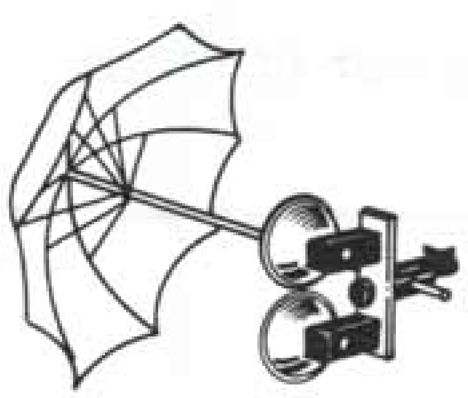
Fig. 10

50 watt-seconds to 100 watt-seconds	1 f/stop gain	total gain 2 f/stops
100 watt-seconds to 200 watt-seconds	1 f/stop gain	

If your flash unit does not have the capacity to produce four times the output, you could consider:

1. A more efficient reflector for the lamphead. Generally speaking — the quality of light will be harsher and produce more contrast by using a reflector of this type.
2. Using several flash units into a single umbrella or bounce flat in order to increase output (see fig. 11).

Fig. 11



100 watt-seconds
100 watt-seconds
Total illumination is equal to a single 200 watt-second light source into umbrella

3. Using one or more of the techniques described on pages 6 thru 8.

You may end up in a compromise or in acquiring additional equipment, but at least you understand the problem and its possible solutions.

WHAT IF THE MINIMUM DEPTH OF LIGHT AND THE MINIMUM DEPTH OF FIELD IS REQUIRED?

Thus far we related the inverse square law to a hypothetical situation where maximum depth of light was required. However, you probably encounter just as many situations in your daily work where minimum depth of light is desirable. For example, when photographing a "low key" portrait, you don't want the main light to illuminate the background, nor do you necessarily want the background to be in focus. You probably don't even want very much depth of light and depth of field on the subject. Assuming that you are using a suitable background for "low key" work, there are several ways to create this effect:

1. Move the light closer to the subject (see figures 12 and 13).

Fig. 12

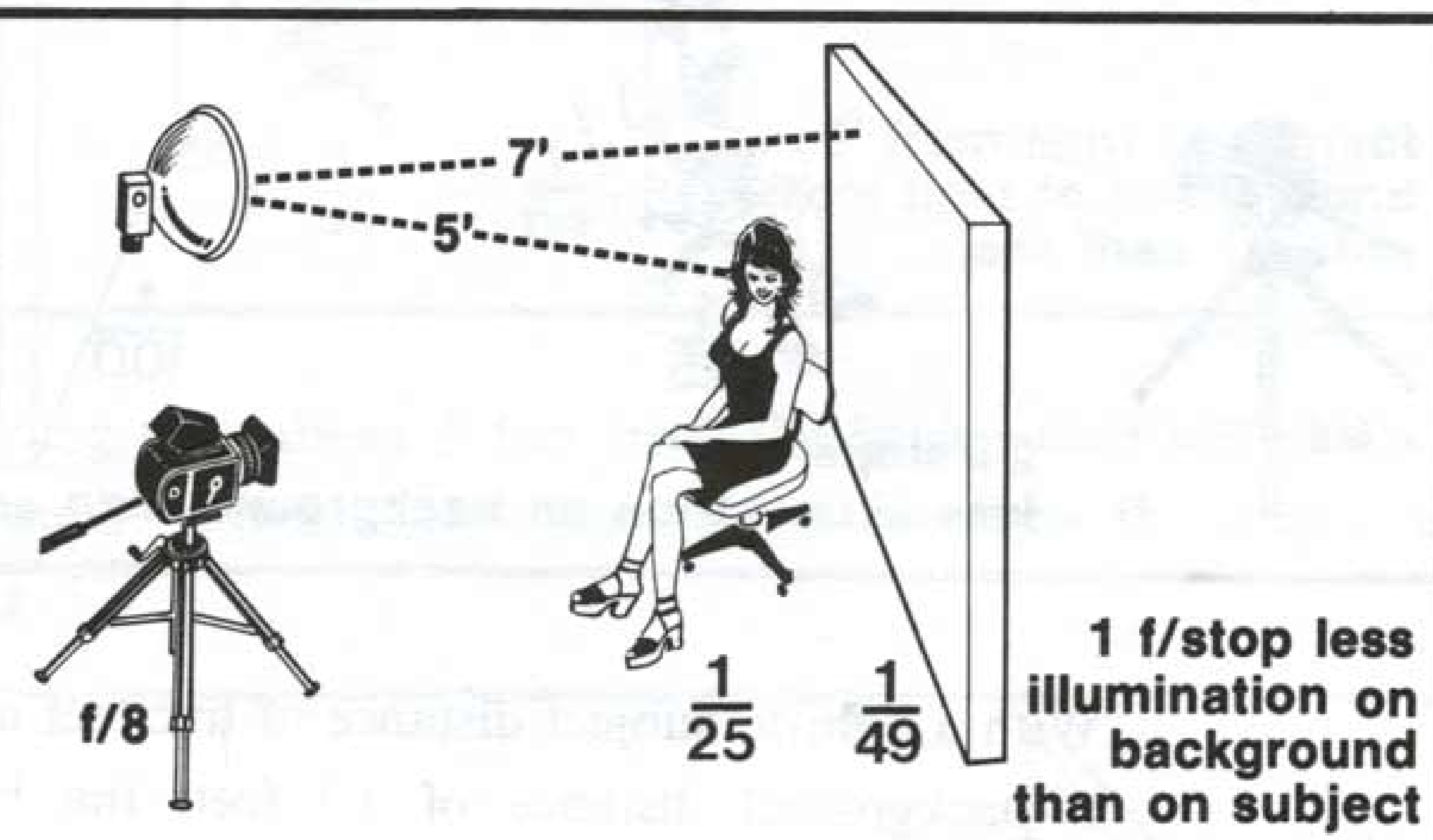
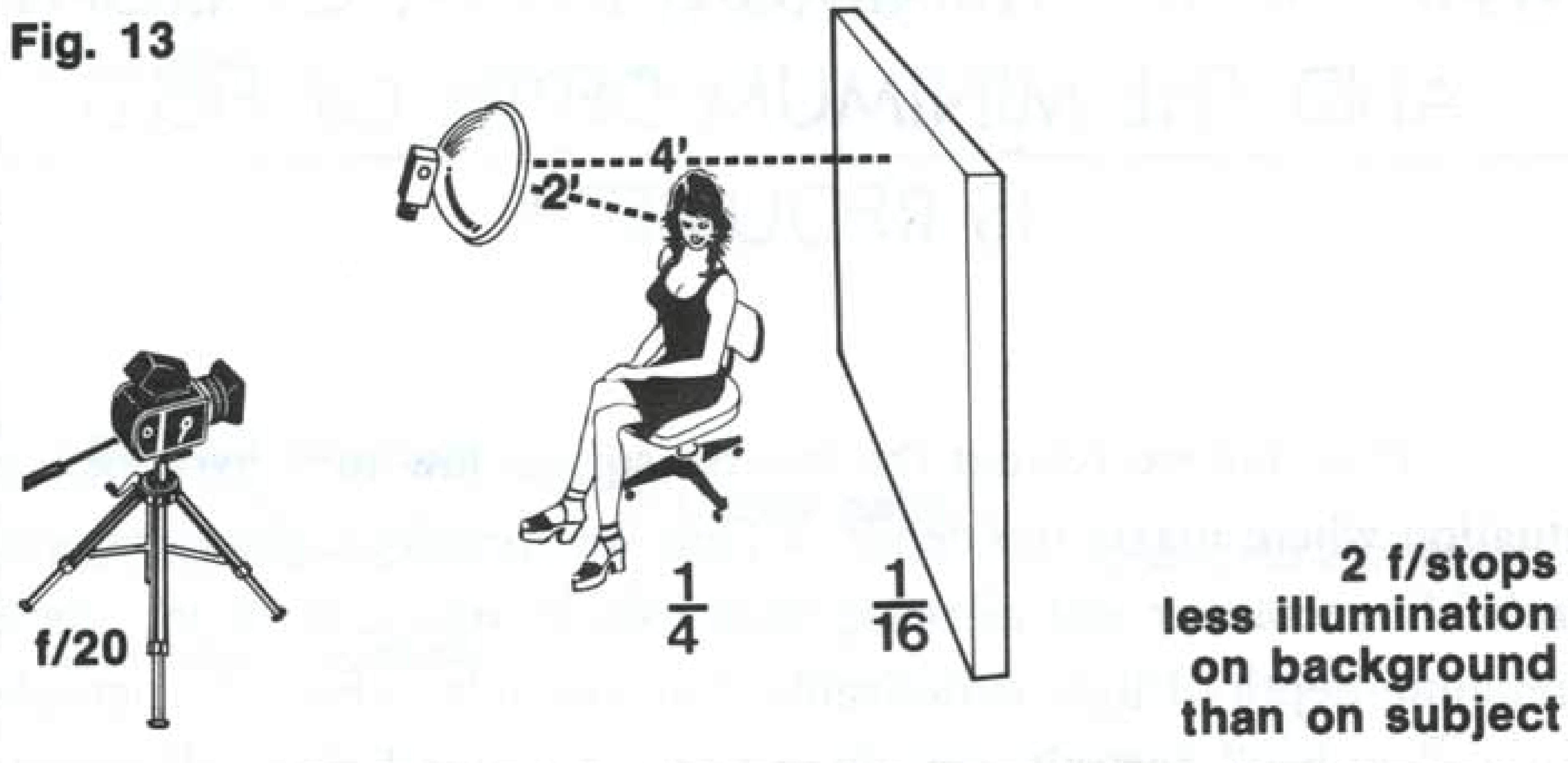


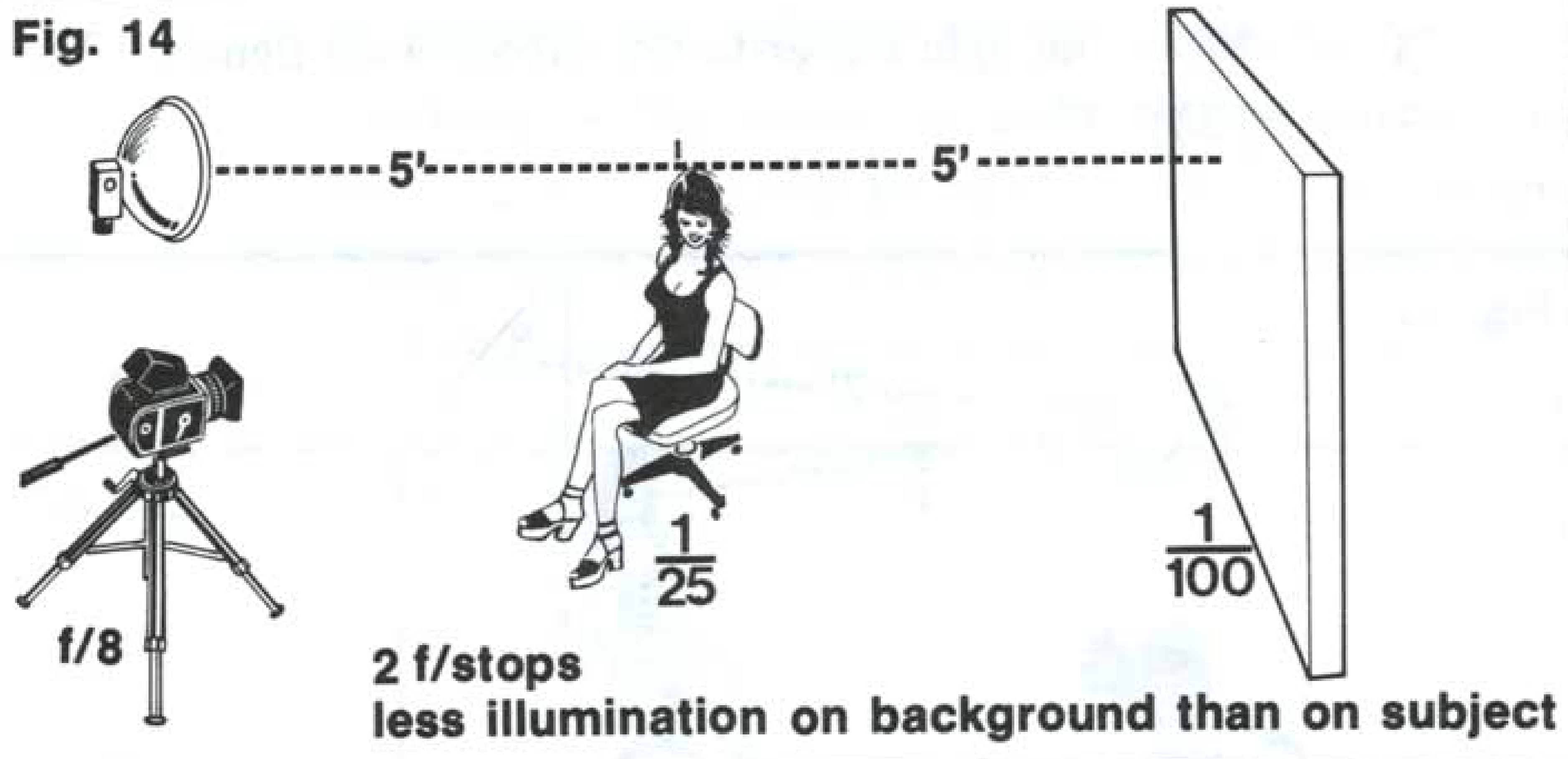
Fig. 13 illustrates that background will become darker due to the ratio of subject illumination to background illumination as governed by the inverse square law.

Fig. 13



2. Move the subject farther from the background as in fig. 14.

Fig. 14

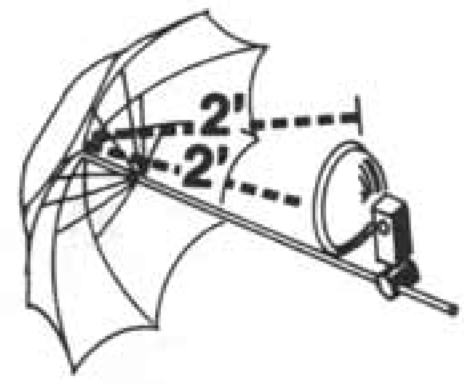


With a light-to-subject distance of five feet and a light-to-background distance of 10 feet, the background will receive 2 f/stops less illumination than the subject.

You will probably use a combination of both these techniques to achieve the desired effect.

When using an umbrella light as the main source in "low key" photography, you must move the subject farther from the background than normal because the light-to-subject distance cannot be as short due to the distance lost between the light to umbrella and back to the light (see fig. 15).

Fig. 15

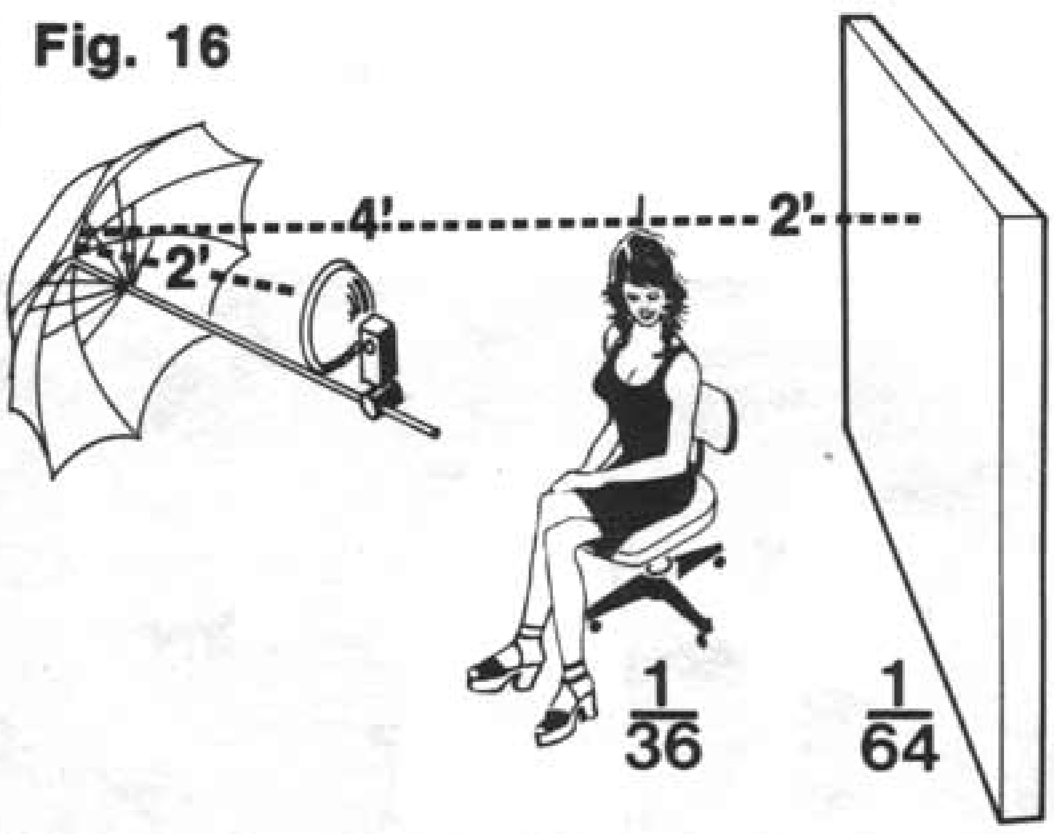


4' total distance at light source

With the light 2 feet from the umbrella, you cannot place the subject closer than about 4 feet from the light. Actually 6 feet is perhaps a minimum distance because you must move the umbrella/ light far enough from the subject to keep it out of the field of view.

With the background 2 feet from the subject, the illumination at the background is not even 1 f/stop less than at the subject (refer to fig. 16).

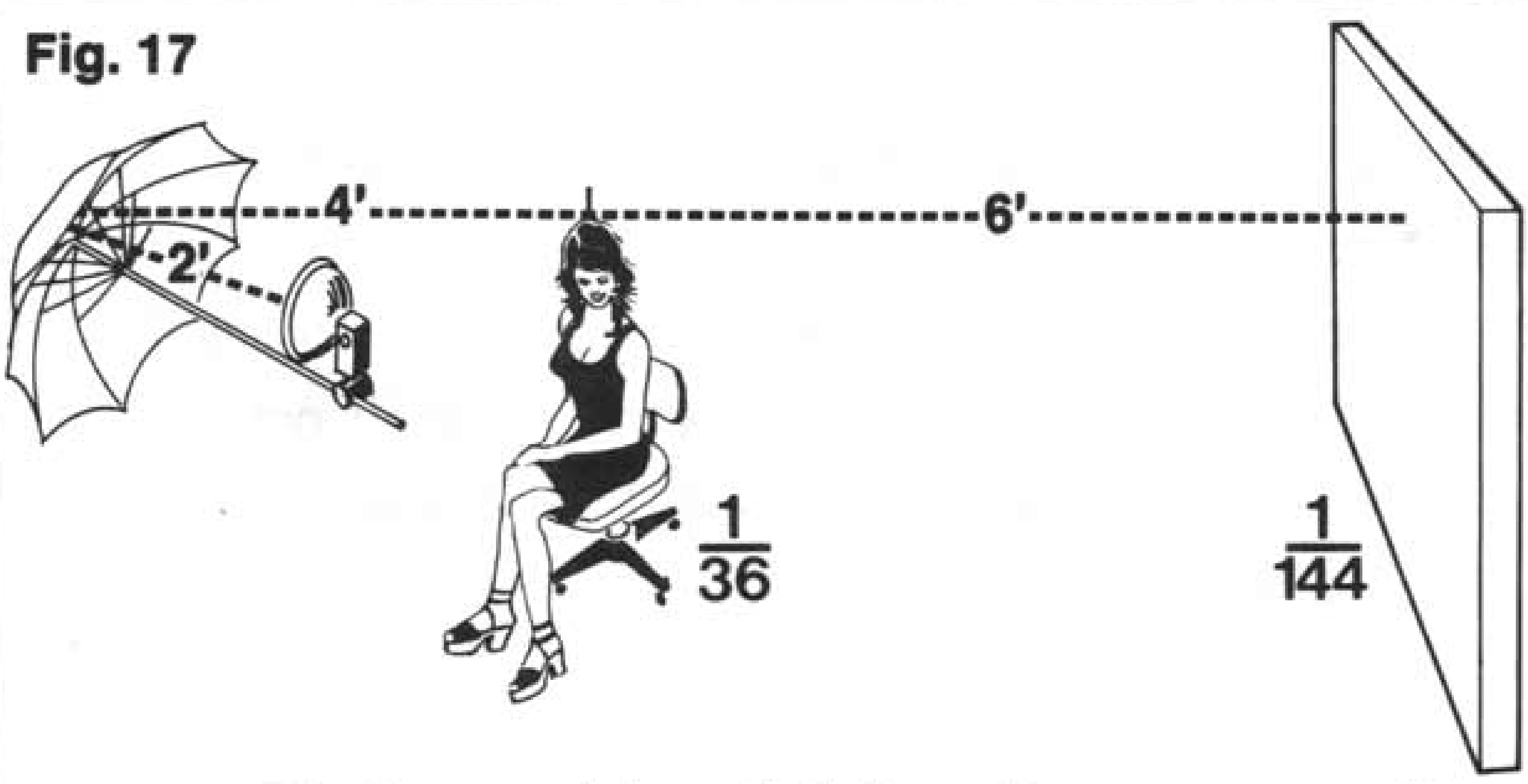
Fig. 16



6' from light to subject
8' from light to background
less than 1 f/stop

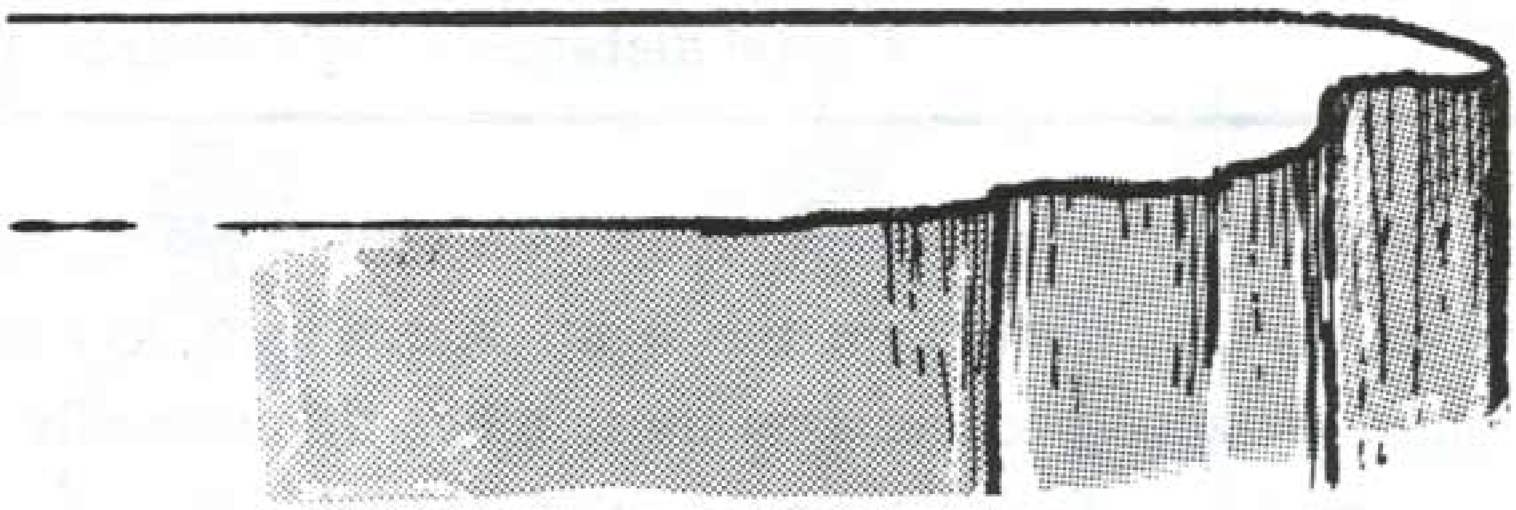
Moving the subject 5 feet from the background will provide the background with 2 f/stops less illumination than the subject as shown in fig. 17.

Fig. 17



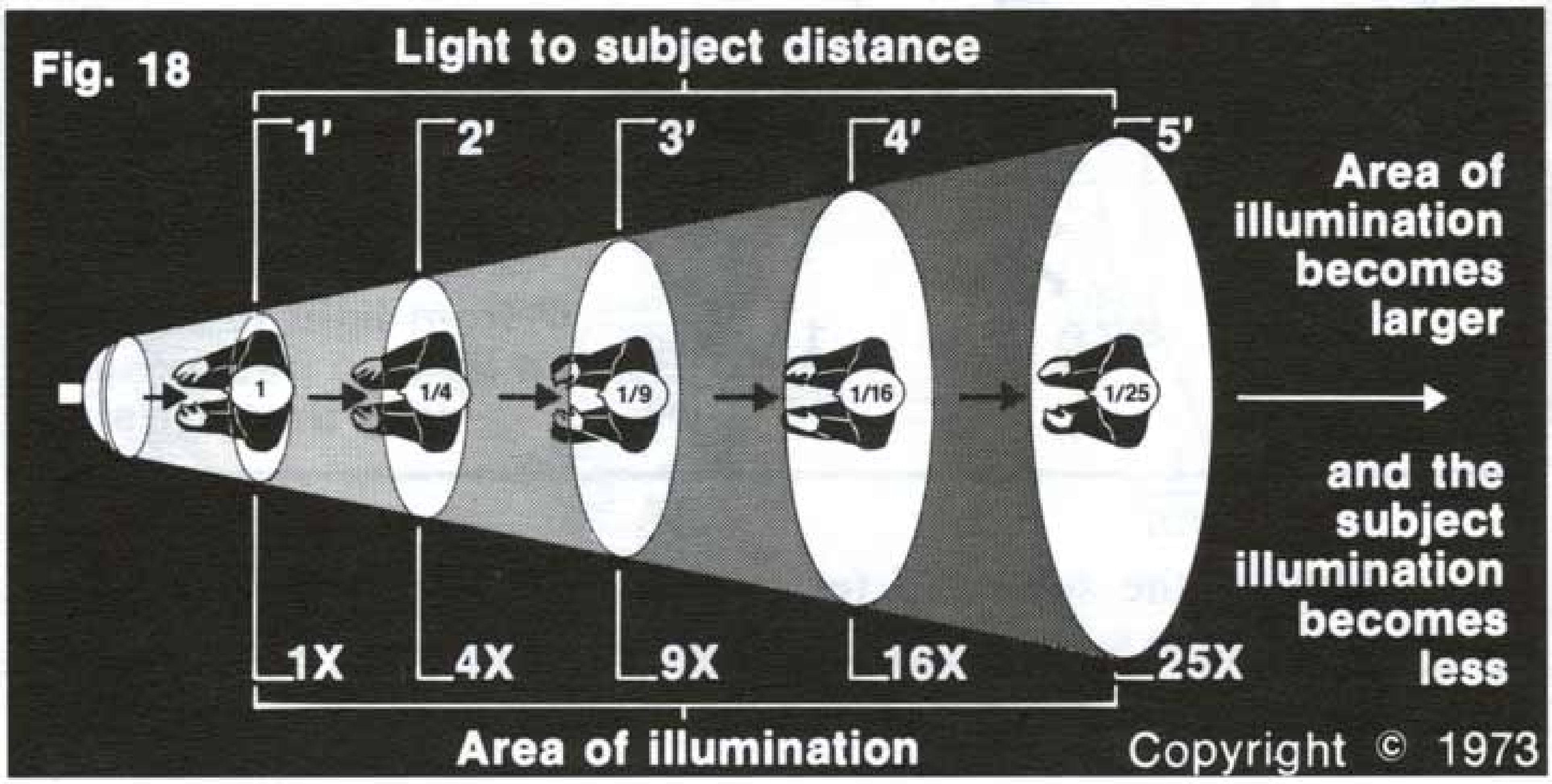
Background has 2 f/stops less exposure than subject

WHAT HAPPENS TO THE LIGHT THAT FALLS OFF?



Actually, light doesn't really "fall off" (decrease in intensity), it simply spreads out to illuminate a larger area as it moves farther from the source. Fig. 18 illustrates this.

Fig. 18



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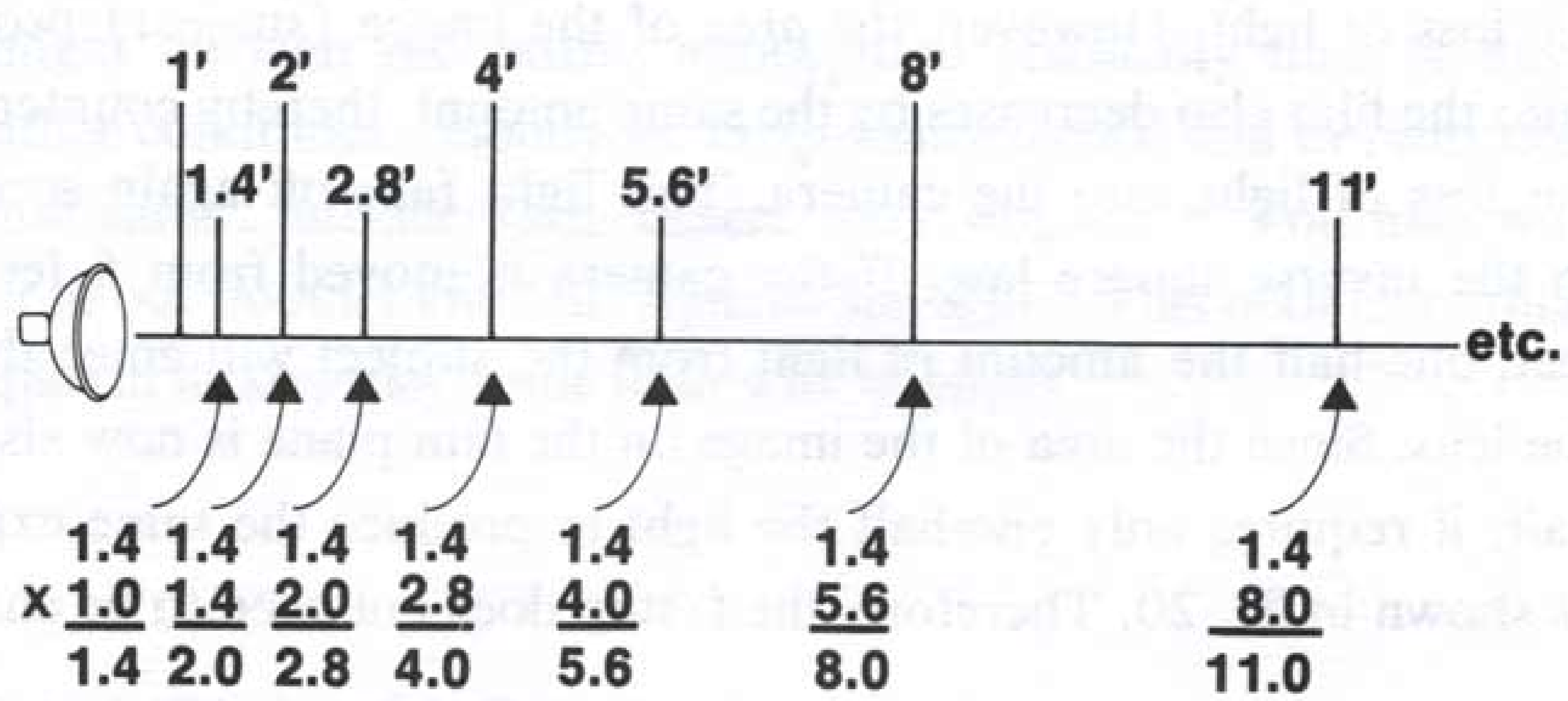
At five feet from the light, the *area* of illumination is 25 times greater than at one foot. Therefore, you are left with only 1/25 of the light actually illuminating the subject. (If you are photographing in foggy (or smoggy) atmosphere or underwater, a small percentage of the light is reflected and refracted in a way that will slightly alter this inverse square law.)

As the light-to-subject distance is extended by a factor of 1.4 times, the area of coverage doubles. Photographically speaking, this means that you lose one f/stop every time you move the light back from the subject to a distance equal to 1.4 times its previous distance. We already know that doubling the light-to-subject distance results in a 2 f/stop reduction, but this 1.4 factor if thoroughly understood will make a world of difference in your comprehension of "how it all fits together." Slow down at this point and work at understanding the significance of this 1.4 factor as diagrammed in fig. 19.

Fig. 19



Notice how this 1.4 factor not only gives us a 1 f/stop light reduction, but it also relates exactly to the f/stop sequence engraved on the camera lens holder. The word *area* is the key to this correlation — a 1 f/stop light reduction is caused by doubling the *area* of coverage.

"F/stop" relates to the amount of light entering through the *area* of lens. As the diameter of the iris diaphragm is increased by the factor 1.4, its area is doubled, allowing twice as much light to enter through the lens.

Therefore, both progressions are exactly the same. So, rather than committing light-to-subject distances to memory, we can use the numbers that we already know are engraved on the camera lens holder.

WHY DOESN'T MOVING THE CAMERA FARTHER FROM THE SUBJECT AFFECT THE F/STOP?

We all know that unless we are using a bellows extension, changing the camera-to-subject distance does not affect f/stop as long as the light-to-subject distance does not change. But why is this true? Since from the same subject less light will enter through the camera lens as the camera is moved further away, it would appear that we would have to open up the lens diaphragm to compensate for the loss of light. However, the *area* of the image (subject) projected onto the film also decreases by the same amount, thereby counteracting the loss of light into the camera. This light falls off again according to the inverse square law. If the camera is moved from 5 feet to 7 feet, one-half the amount of light from the subject will enter through the lens. Since the area of the image on the film plane is now also one-half, it requires only one-half the light to produce the same exposure as shown in fig. 20. Therefore, the f/stop does not need to be changed.

Fig. 20

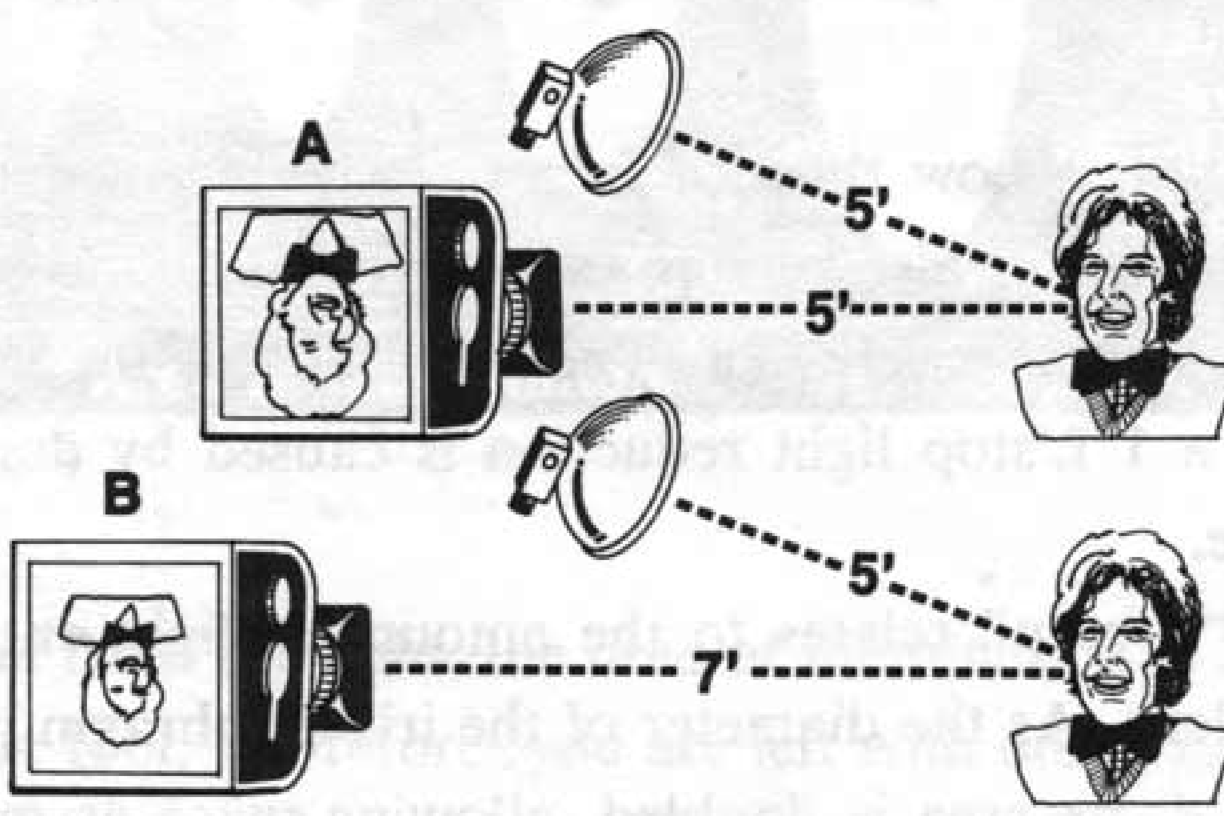


Image size is ½ the area of A

Again we see the 1.4 constant (outlined in the previous section) at work.

WHAT ABOUT SUNLIGHT?

We have outlined the inverse square law as it applies to photography when using artificial lighting. Sunlight also falls off as the square of the distance, but since the sun is 93 million miles away, a few thousand feet one way or the other isn't going to make any difference in exposure. The only variances that you will experience in sunlight are changes in light quality and intensity due to changes in the angle of sunlight through the earth's atmosphere (basically time of day), to weather conditions (cloudy vs. crisp sunny days), and to reflections from the earth's surface (sea, desert, dark soil, etc.). You may want to refer to our booklet entitled "Syncro Sunlight." This booklet outlines principles in mixing electronic flash with daylight.

CONCLUSION:

You have now read about the principles of the inverse square law. You have the knowledge to utilize them to produce fine photographs for the satisfaction of you and your customers. But you must work at applying these principles so that they will become second nature to you. When this is accomplished, you will have developed the skill to win the Battle Between Depth of Light and Depth of Field.

Your questions and suggestions are always appreciated at Norman Enterprises, Inc. for they enable us to improve our products and to meet your continually changing needs.