THE BOUNCING BALL

It's easy to despair in the face of field guide coordinates, registration pegs, aspect ratios, and safe areas. In fact, there's probably something wrong with you if you're not inundated with details. However, all this information can be effectively assimilated if you put the information into real operation. Complete the following project. The challenge is to use paper sheets to animate a bouncing ball. This is one of the two classic exercises in animation. The other is the walk. As best you can, try to follow these instructions. You'll make mistakes—anticipate that at the outset. But you'll be familiarizing yourself with the basic process. And that will help you to understand the more detailed explanations and refinements yet to come.

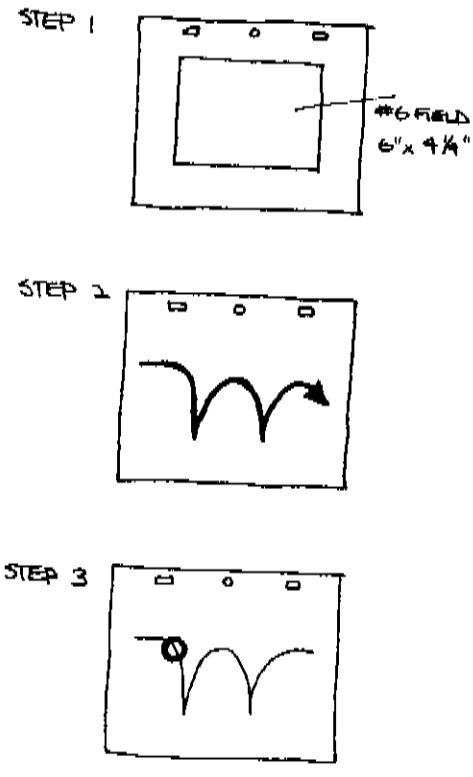
Step 1: Field. Using a field guide and whatever registration system you have (the edges of the sheets will do), draw the outside perimeters of a #6 field. Center the field so that the coordinates are 0-0.

Step 2: Path. Using either tracing paper or a light table to help you see through more than one piece of paper, place a fresh sheet over the one showing your field and draw a path a bouncing ball might take if it were to enter the frame from the left and then hit the ground twice as it moves across the field and disappears off the right side of the frame.

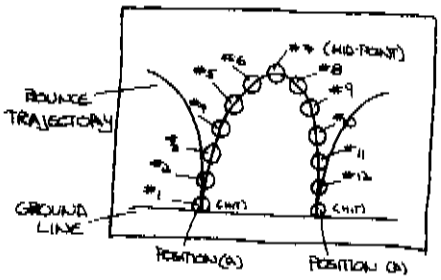
Step 3: Ball Size. Select a size for the ball you will animate. Don't make it too small or too large- -something in the area of 1 inch in diameter ought to work well in this project.

Step 4: Timing. In this exercise you should try to pace the drawings so that the ball will hit the ground at intervals of exactly 1 second. You will be shooting on twos, so twelve drawings are required to make 1 second of screen time.

Step 5: Draw It. Without further explanation, try the problem of the bouncing ball. Use the path diagram as a guide and use a different sheet of paper for each new position. Try to have twelve drawings between each bounce of the ball. Remember, there should be two bounces as the ball moves across the screen. Number each sheet of paper in the upper-right-hand corner. Attacking this problem will require about thirty-six pieces of paper and several minutes of your life, but it will prepare you for the discussions to follow and for all the fine points of animating with line drawings and finally with plastic cels.



14.7 The bouncing ball



14.8 A mathematical bounce: A 1-second duration means there are 24 frames between each contact of the bouncing ball with the ground. Shooting on twos would thus require the animator to produce 12 drawings that start with position A and end *just before* position B. The ball hits only once per second and here we start each second with that hit.

Step 6: Preview. After you've completed the problem, hold the stack of drawings in one hand and flip through the pile with the other hand. This will let you preview your work.

CONTROLLING MOVEMENT AND TIME

It is, of course, the amount of change in position between one drawing and the next that creates the illusion of movement, but how can you tell how much to change each drawing from the ones preceding and following it? How is it possible to plan ahead so things end up where you want them and at the right

ANIMATION TIMING CHART

FILM FORMAT	SUPER 8MM		16 MM		35 MM	
PROJECTION SPEED (FRAMES PER SEC.)	18	24	24		24	
RUNNING TIME AND FILM LENGTH	FEET+FRAMES	FEET+FRAMES	FEET+FRAMES		FEET+FRAMES	
SECONDS 1	0 19	0 24	0	24	1	8
2	0 36	0 48	1	8	3	0
3	0 54	1 0	1	32	4	8
4	1 0	1 24	2	16	6	0
5	1 18	1 48	3	0	7	8
6	1 36	2 0	3	24	9	0
7	1 54	2 24	4	8	10	8
8	2 0	2 48	4	32	12	0
9	2 18	3 0	5	16	12	8
10	2 36	3 24	6	0	15	0
20	5 0	6 48	12	0	30	0
30	7 36	10 0	18	0	45	0
40	10 0	13 24	24	0	60	0
50	12 36	16 48	30	0	75	0
MINUTES 1	15 0	20 0	36	0	90	0
2	30 0	40 0	72	0	180	0
3	45 0	60 0	108	0	270	0
4	60 0	80 0	144	0	360	0
5	75 0	100 0	180	0	450	0
6	90 0	120 0	216	0	540	0
7	105 0	140 0	252	0	630	0
8	120 0	160 0	288	0	720	0
9	135 0	180 0	324	0	810	0
10	150 0	200 0	360	0	900	0

SUPER 8 MM — 72 FRAMES PER FOOT
16 MM — 40 FRAMES PER FOOT
35 MM — 16 FRAMES PER FOOT

14.9 Animation timing chart

moment as well? Is there a way to speed up the process of drawing? And how can you get a real feeling of character or personality into a particular movement?

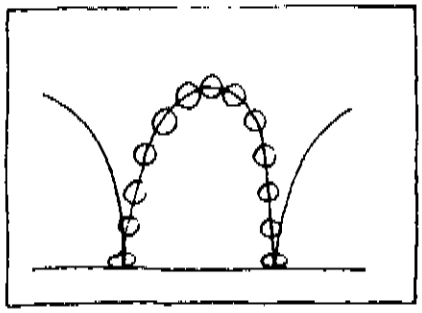
If we were to undertake a structural analysis of the bouncing-ball problem, we would divide the distance to be covered by the time required for a particular movement. If you looked at a single, complete bounce of the ball, you would have a series of drawings that were symmetrically placed. The plotting of the balls in Figure 14.8 has been determined through straight arithmetic.

In real life, a ball accelerates as it approaches the ground and decelerates as it reaches the top of its bounce. This change of speed has to be designed into the animation. More than that, this nuance in the reality of a bouncing ball must be accentuated. There is a way to help decide where to place each drawing of the ball. The key lies in the analysis of the time for any given movement.

By now it should almost be second nature for you to change time in seconds into time measured in drawings. The process becomes almost unconscious once you've done it a few times. The camera shoots on twos. Each drawing will become 2 frames of film. Therefore twelve drawings are needed for 1 second of finished film.

To always know the number of frames comprising a given amount of "screen time," mount a *time chart* close to the work area where you draw and shoot your animation. Such a chart is shown in Figure 14.9. If you'd like, you can cut this out of the book, put it into an ornate rococo frame, and hang it over your drawing table.

Back to the bouncing ball. The given time in the problem is 1 second between bounces. The second-to-drawing computation is easy; shooting on twos, you need twelve individual drawings to fill the 24 frames of 1 second. Figure 14.10 shows the same bounce trajectory as used in Figure 14.8. Note, however, a different selection of positions for the twelve individual balls. This new spacing plan takes into account the unique way in which a ball really bounces: slower at the top of its arc, faster as it approaches the ground. Look at the ball's positions on the curve. Although these points are symmetrically placed on either side of the bounce (after all, things go up and down with the same flow), the positions of the six ascending and the six descending locations are asym-



14.10 An exaggerated bounce: Field, trajectory, and ball size are identical with those in Figure 14.8. Note, however, the different placement of individual positions on the arc. This bounce will look and feel "right," but even greater exaggeration would read correctly when filmed.

14.11 A live-action bounce: This enlargement of a 16mm film clip shows the positions of an actual rubber ball as it bounces in real time. In this example, the ball appears to be hitting at roughly a half-second interval—each 10½ frames.

metrically arranged. This arrangement will accommodate the varying speed of the ball.

Study Figure 14.10 carefully. The slower you want the ball to appear to move, the closer must be the positions of consecutive drawings. Remember that in filming and then in projecting, these closer images will show less change over the same period of time than would wider-spaced images. Speed is always relative. To make the movement appear faster, the positions are spaced farther apart.

The series of positions in the arc actually exaggerates the positions of a real bouncing ball. In Figure 14.11 you'll see frame enlargements of a bouncing tennis ball from an actual film taken at live-action speed. Compare the difference in spacing in the real version with the animated version.

The spectacular squashing of the ball as it bounces summarizes the difference between an animated movement and the real thing. As gross as the squash may appear in the spacing guide (Figure 14.10), its effect will "feel" right in the finished movie. Exaggeration is the single most important quality in giving "personality" or "character" to an animated movement.

Here's another fine point that you can study through experimentation. Movement is always perceived relative to the size of the objects and background, as well as to the speed of other objects. Different-size balls will seem to move at different speeds. Smaller balls look faster than larger ones even if the different balls are traveling the same trajectory for the same period of time. A similar effect exists with field sizes. The same set of drawings will be perceived differently according to the composition and size of the field in which they are placed.

EXTREMES AND IN-BETWEENS

If you have tried to animate the bouncing ball, you have probably found yourself beginning with ball #1 and then working steadily through the remaining drawings in numerical order. Somewhere in the process, I suspect, there may have come a moment when you realized that you must plan ahead so that things would come out right. In this case, the thirteenth drawing would show the ball hitting the ground as it initiates the second bounce. Getting to the right position at the right time is

a universal problem in animation. With those techniques that demand precise timing, planning ahead is absolutely essential. The best way to animate fluid movements that must arrive where you want them when you want them is to employ a process called *extremes and in-betweens*. The process generally begins not with one of the actual drawings but with a schematic sketch that outlines the course of a movement and the relative positioning of the entire set of drawings. This is called a *spacing guide*. A sample has been introduced already in Figure 14.10.

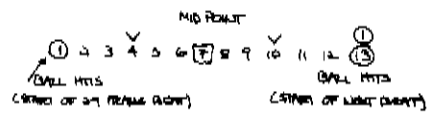
There is a second notation/planning device that animators often use before they start drawing. It's called a *breakdown count*, and it gives the animator an order in which to do the individual drawings. In the bouncing-ball exercise, the ball was to hit the ground at the beginning of each second. This is called a *24 beat*, one hit every 24 frames. As we've seen, the sequence requires twelve drawings. The animator begins by writing out the numbers of all the drawings required in the first beat (Figure 14.12).

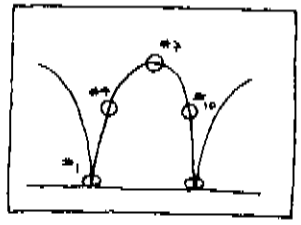
The numbers representing the beats are circled. In our example, #1 and #13 represent the start of the first and second beats. These become a first set of *extremes* and should be drawn first. Next, the midway points between these extremes are located and drawn. In the example in Figure 14.12 this is #7. The midway points between the new extremes—#4 and #10—are drawn next.

Whatever the length or speed or quality of a movement, the extreme positions should always be drawn first. Because the light table enables the animator to see through at least three sheets of paper at the same time, extremes become very concrete guides to where to place and how to draw the remaining images—called *in-betweens*.

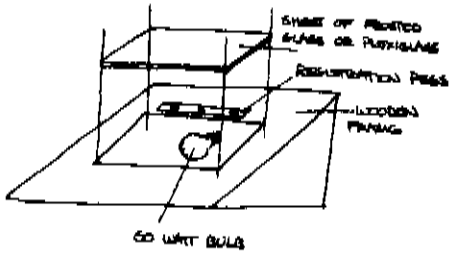
Only after the extremes have been drawn does the animator finish up the series by doing the remaining drawings. In our exercise, the in-betweens are numbers 2, 3, 5, 6, 8, 9, 11, and 12. While independent animators generally draw these themselves, in large studios the chief animator often does just the extremes and an assistant animator finishes off a particular movement or scene by drawing all the in-betweens.

Project: Bouncing Ball Revisited. To assimilate all this information and master the awkward process it requires, you should undertake another bouncing-ball problem. Use a #8

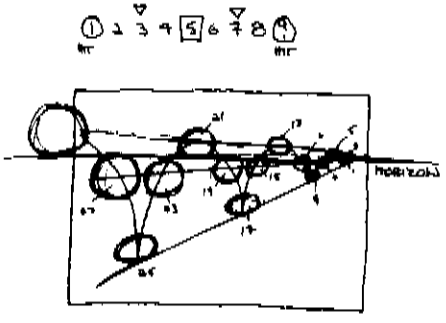




14.12 Breaking down the beat

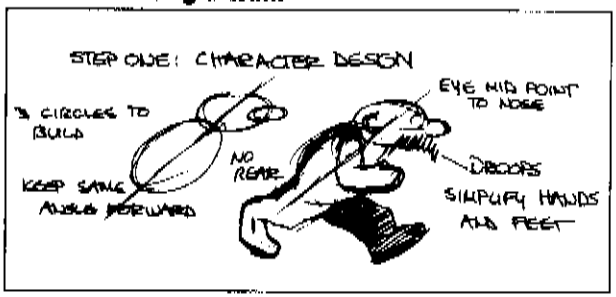


14.13 A rear-lighted drawing table: The sketch suggests the features of an animator's drawing table. The raised angle makes it easier to draw. Light tables can be easily jerry-rigged. For example, a sheet of glass with tracing paper on its underside can be suspended between two piles of books, allowing a desk lamp to light the surface of the glass from underneath.

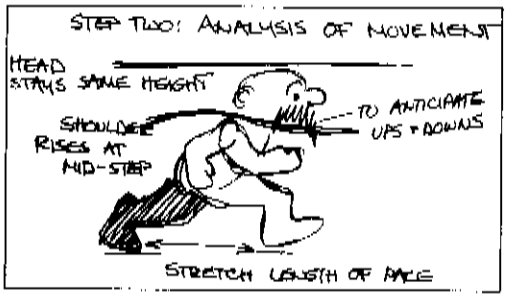


14.14 A perspective bounce: This sketch suggests the loose working style that many animators use in roughing out a spacing guide and in breaking down a given time-distance problem.

14.16 Animating a walk



Step one: Character design: Easily drawn circular shapes are used as the foundation of the character. All nonessential details should be eliminated. The rear leg is shaded to help distinguish right and left legs.



Step two: Analysis of movement: Spend time studying how different kinds and degrees of movement will best express the distinctive personality you wish your walking character to exhibit. This is a critical step.

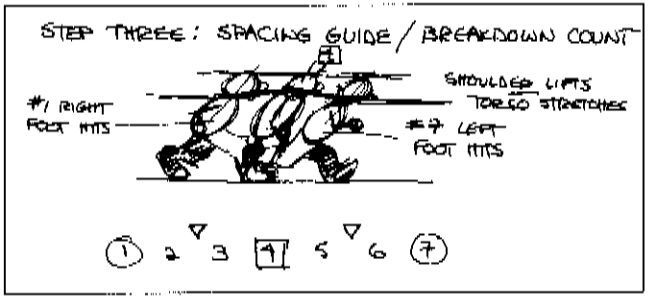
ANTICIPATION, EXAGGERATION, AND MOTIVATION

In reading all this, and in trying it, you may begin to feel that the technique of animating with registered sheets has become its own end; that figuring out and then executing a series of drawings is the highest goal and most prized competency an animator can attain. But in animated filmmaking, as in all other art forms, technique is meant to serve the primary goal of expression. How something is realized is never more important than what is being realized. Execution should never be of more importance than content.

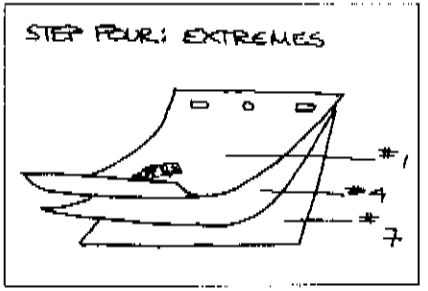
As you are laboring with your spacing guides and extremes, try to keep part of your mind focused on the following kinds of questions. Is this movement right for the character? Does it have the same qualities as real movement? Does the movement reveal subtle qualities about the character or about the story? In the final analysis, does the movement "move" the mind and the feelings of the viewer?

Learning how to block out and animate a bouncing ball is only a means in that by mastering the process you'll be able to bring to life a drawing of your own design and make it move in ways that are unique and fitting to it.

Anticipation and *exaggeration* have become special concepts in character animation. Wherever and whenever possible, the animator tries to give a character a distinct physical movement in anticipation of what is to be a major movement. If Porky Pig is to walk toward screen left, that



Step three: Spacing guide/breakdown count: A foot is to hit the ground each half second or every 12 frames. This happens to be the timing of a "normal" walking step.

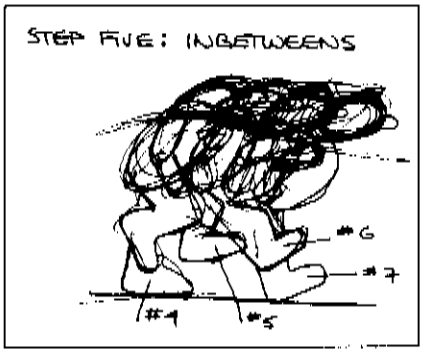


Step four: Extremes: In animating a walk, it is necessary to simultaneously see through at least three sheets of paper. Common tracing paper will allow this, or you can use a simple light table like the one shown in Figure 14.13. In drawing extremes, remember that if the character has weight, the position of whichever foot is on the ground will remain fixed throughout an entire step (in this case, for six drawings).

movement is first prefaced and anticipated by a small movement toward screen right. You've probably noticed how cartoon characters always seem to pause miraculously in midair before they begin their fall after walking over the edge of a cliff. This pause is "anticipation." And then the fall itself is often exaggerated. Wile E. Coyote chasing the roadrunner seems to fall off cliffs that are at least five miles high. And the impact of the fall causes the poor coyote to disappear into a deep hole. Exaggeration again.

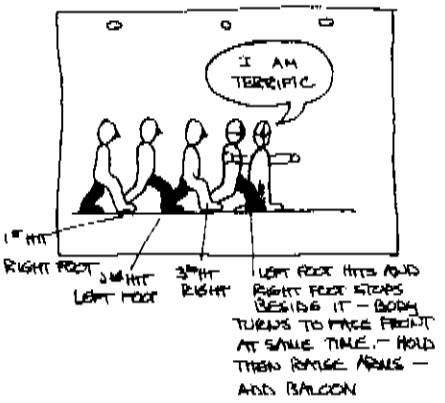
So central is the use of extreme anticipation and exaggeration in classic American cartoon animation that the matched concepts have taken on more informal names. When talking about the aesthetics of their craft, animators will speak generically of *stretch* and *squash*. The terms are synonymous with *anticipation* and *exaggeration*. The bouncing-ball problem should have introduced both of these quite clearly.

One of the animator's most creative acts is the study of real movement. Hours must be spent watching how a friend walks, studying the mannerisms of animals, peering with concentration at one's image in a mirror. Yet understanding how and why things move as they do is only part of the creative process. If a movement is to work, it must be properly *motivated*. The animator has to convince the audience that the only



Step five: In-betweens: This ought to be an easy step. A registration system is required, of course, in steps four and five as well as in the eventual filming of the drawings.

Step six: Cleanups: Depending upon how roughly you work, it may be important to redo each drawing quickly so that the clarity and simplicity of the original design (step one) is maintained consistently throughout the walk. This is also a good time to check the details of movement and characterization that you've designed in step two (anticipation, exaggeration, motivation, stretch, and squash).



14.17 Spacing guide for walk project

possible kind of movement for a given situation is precisely that movement the animator has created. Developing motivation for a particular sequence and movement becomes another central aesthetic concern.

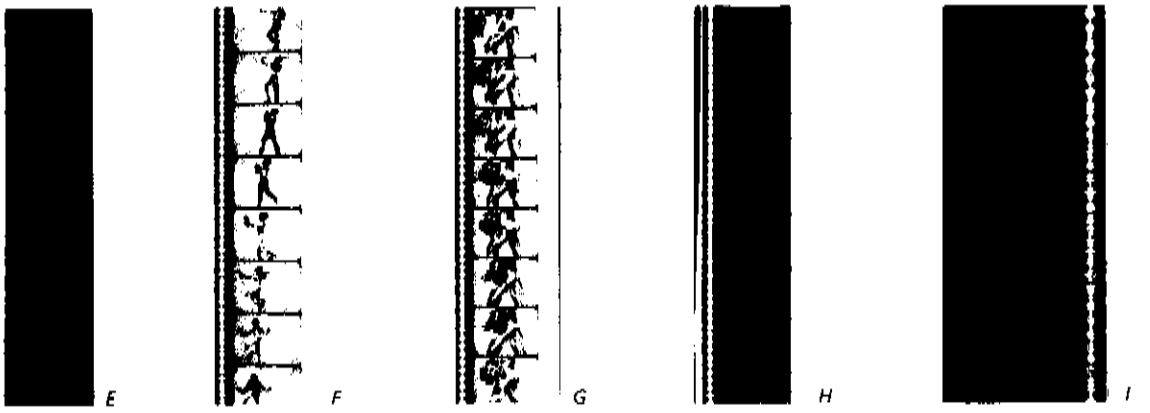
THE WALK

Needless to say, a ball is a lot easier to draw than even the simplest cartoon character. The classic bouncing-ball project is often followed by another classic, the walk. Animating a walking character for the first time just has to be one of the most difficult and challenging problems you'll ever set for yourself.

The illustrations in Figure 14.16 clarify some basic principles about animating a walk. Note that the process of planning the drawing is exactly the same as the process used in executing the bouncing-ball problem

Project: Your Very Own First Walk. This project assigns you the same specifications as the sample walk just presented: a #10 field size, a 12-frame beat, and a figure of approximately the same height and width of gait. But this time it's *your* character, a creation of your own mind that will move with the style you draw into it. The degree of exaggeration and anticipation that you select for your walking person is for you alone to decide. You can, if you want, even have the character look a little like yourself.

Here's a simple narrative framework for this walk sequence. Your character enters the screen from the left and



A

C

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M

14.18 Ryan Larkin's Walking: In Ryan Larkin's deceptively simple film, the screen shows us beautiful studies of people in motion. Done with sheets of paper, not acetate cels, *Walking* explores different walking gaits, different kinds of walkers, different angles of observation, different moods, and different—boldly different—styles of animation, *(A)* through *(N)*. *Stills courtesy National Film Board of Canada and Learning Corporation of America. Film strips by the author.*

takes two full paces (four steps) into the middle of the field. Plan this so that when the character comes to a standstill after the second full pace, he or she will still be within the given field size. At this point, have your character pause for ½ second and then, in another ½ second, turn the character so that it faces the camera. Let there be another pause, this time for a full second. Finally, raise your character's arms in a move that takes ½ second. In the last drawing of the sequence have a "bubble" pop onto the screen beside your character with this written inside: "I'm terrific." This project should require in the neighborhood of thirty-five drawings on separate sheets of paper. Figure 14.17 gives a scaled-down suggestion of how your spacing guide might look.

EASING IN AND EASING OUT

It's the moment for an import digression. In animating a pan, or any other movement, it is necessary to move *gradually* up to the full speed of the movement. A character can't suddenly appear to walk at full speed any more than someone in real life can suddenly jerk into full movement. A transition is required.

In animation, this transition from stasis to a steady rate of movement is called *easing in* and *easing out*. Complex formulas have been invented to help the animator chart the initial movements in this transition. At this level of exploration, however, it is enough to improvise easing in or easing out of a pan by gradually increasing the distance between positions during the initial phase of filming.

CYCLES AND HOLDS

Animators love shortcuts. It's not surprising. Shortcuts allow one to make the longest film for the least labor. Shortcuts stretch the impact of an animator's art. You'll grow to love shortcuts too!

In doing the walk problem, you can use a single drawing for a full twenty-four frames at the pause before the character lifts his or her arms. Such a moment is called a *hold*. This shortcut enables the animator to avoid drawing the stationary figure twelve times.

A *cycle* accomplishes the same thing, increasing the number of times a single drawing can be used. But a cycle does this with movement. In the walk, you were asked to draw two full paces, which was accomplished in twenty-four drawings (the "beat" was twelve, which required six drawings for every step). A cycle allows you to accomplish the very same visual effect with just twelve drawings, half the total number normally required.

The principle of a cycle is based on the ability to design a series of drawings so that the last drawing leads smoothly back to the position of the first drawing. This means, of course, that the same set of drawings can be used again and again as long as you want the sequence repeated.

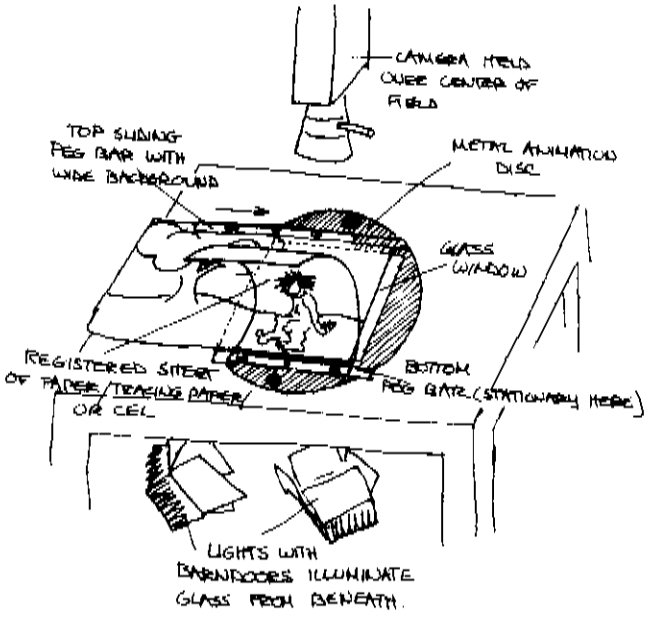
In order for the last drawing in the cycle (#6) to lead smoothly into the first drawing (#1), the drawings must be modified so that there is no forward movement. The character's head stays in the same position, although the legs continue to move as before. This means that the character's feet must "slide" somewhat between drawings so that the walking figure always returns to the same initial position.

No matter what kind of character or object you are animating (a car, an animal, a spaceship) or how many drawings comprise the cycle, the movement will appear correct if the last position leads smoothly back to the first position.

To get a feeling of *forward movement*, a separate background is made, which will pass under the walking figure while it remains in exactly the same place. To achieve this effect, it is necessary to see through the top paper sheets to a background sheet. This is most effectively done with clear acetate sheets, as opposed to paper sheets. However, by using a rear-lighted surface under the camera, it's possible to see through more than one page of the paper sheets (Figure 14.19).

Try to cycle the animated walk you designed in the last project. Create the effect of forward movement by panning a background beneath the walking figure, using rear lighting, or by simply advancing the drawings of the cycle under the camera without a background of any kind.

14.19 Cycling with paper sheets: The sketch shows an animation disc that has been mounted into a table and then lit from beneath. In addition to the frosted glass or Plexiglas insert in its center, the disc bears two sliding peg bars. In filming a cycle, one set of pegs remains stationary (it bears the cycle of drawings) while the other set of pegs (bearing the same background) is moved incrementally between exposures.



MOVEMENTS OF THE TWO LEGGED FIGURE

HERE IS A COMPARISON OF THE VARIOUS TWO LEGGED FORWARD MOVEMENT CYCLES -I HAVE DRAWN ONE HALF OF EACH CYCLE BELOW--REVERSE HANDS +FEET FOR THE OTHER HALF. -THESE CYCLES CAN BE USED AS "REPEATS"-(THAT IS THE DRAWINGS MAY BE REPEATED OVER +OVER IF THE FIGURE REMAINS CENTERED ON THE SCREEN AND THE BACKGROUND MOVES.