NBSIR 74-621

Stability and Strength of Home Playground Equipment

Bal M. Mahajan

Product Systems Section
Product Systems Division

Final Report

8/74 – 10/74

Prepared for
Consumer Product Safety Commission
5401 Westbard Avenue
Bethesda, Maryland 20016

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U. S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary

NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

Introduction

This study was conducted as a part of the Home Playground Equipment Project for the Consumer Product Safety Commission (CPSC). The project consisted of two study programs, the first dealing mainly with home swing sets, and the second dealing with other items of home playground equipment. The overall objective of the project was to develop criteria and test methods, along with the necessary data, for preparing a safety standard for home playground equipment.

The first study program was completed by the end of July 1974, and its findings were presented in an interim report entitled "Recommendations for a Safety Standard for Home Playground Equipment - Swing Sets" (NBS Report No. NBSIR 74-563) 1/. This interim report provided some necessary data and suggested criteria and test methods for formulating a safety standard for home swing sets.

Work on the second study program of the Home Playground Equipment Project was started in the beginning of August 1974. The Consumer Product Safety Commission had expressed concern about the stability and strength of the equipment. Therefore, the first subtask of this study was to conduct stability and strength tests on samples of various playground items. The objectives of these tests were to determine whether or not the equipment could withstand the tipping moments and loads expected with the equipment in use.

However, CPSC decided to follow Section 7 of the Consumer Product Safety Act, and the study program was terminated in its early stages, near the end of October 1974. At that time, the NBS investigator was asked to prepare a report describing the work done to date.

When the program was terminated, the investigator had completed the first series of stability and strength tests on samples of a few home playground items and was in the process of analyzing the preliminary test data. Hence, this report deals mainly with the preliminary stability and strength tests performed on a restricted sample. It describes test procedures and presents test results.

Items of Home Playground Equipment Tested

Nine different items of home playground equipment, randomly selected, were purchased from local retailers. These included a A-climber (figure 1), a climbing tower (figure 2), a dome climber (figure 3), a tangle tower (figure 4), a play center (figure 5), a gym set or swing set (figure 6), a free-standing slide (figure 7), a space rocker (figure 8), a merry-go-round (figures 9A and 9). These items were assembled and installed in

accordance with the written instructions provided by the manufacturers. The equipment, for which anchoring was recommended by the manufacturers, was anchored to the ground by utilizing steel ground anchors.

Stability Tests

If the moment required to tip over an item of playground equipment is greater than the tipping moment likely to be experienced by the equipment during use, then the equipment may be considered to have adequate stability.

Tests were performed on some items to determine if they had adequate stability. To generate the moment necessary for tipping the equipment over, a member near the top was subjected to a pull force, F, acting in a direction parallel to the ground and perpendicular to a tipping axis. The tipping axes of a typical item are shown in figure 25. The magnitude of the force, F, required to tip was measured. The tipping moment generated by F may be calculated, if desired, by multiplying F by the perpendicular distance between the line of action of F and the ground. Stability may be determined by comparing the moment required to tip over the equipment with the tipping moment likely to be experienced by the equipment when it is in use.

Test Procedures

A steel cable was used to apply the force, F, to the equipment under test. One end of the cable was attached to the selected member of the equipment, and the other end of the cable was connected to a force gage (figure 25). The equipment was pulled either manually, where possible, or with the aid of a tow truck. The pull force was increased gradually until the equipment was about to tip over. The force, F, required to start the tipping of the equipment was read on the force gage and recorded.

The A-climber, climbing tower, tangle tower, and free-standing slide were tested for tipping about more than one tipping-axis of the equipment. All the stability tests were conducted with the equipment installed in accordance with the written instructions provided by the manufacturers.

Test Results

The results of stability tests are given in figures 26-31. These figures show the equipment tested, the member (or members in case of more than one test) subjected to pull force, the direction of applied force, F, and the magnitude of force, F (or forces F_1, F_2, etc.) required to initiate tipping.

Strength Tests

Tests were performed by statically loading components of some items of home playground equipment with estimated test loads to determine if the tested equipment had adequate strength. The estimated test load for a component is obtained by multiplying the expected load by a safety factor (reference 1). The expected load for a component is the maximum load likely to be carried by the component when the equipment is in use. If the equipment does not suffer structural failure when subjected to estimated test loads, the equipment may be considered to have adequate strength.

The estimated test loads, for those components which were tested, are given with other test data. Calculations leading to these values are not given in this report. Samples of such calculations may be found in reference 1, where the estimated test loads for home swing set components were calculated. The estimated test loads used in these tests, being dependent upon subjective judgment to a certain degree, may be debatable.

Test Procedures

Several block weights, each weighing 50 pounds (22.7 kg), were used to load the components to be tested. In some tests, when the component to be loaded was wide enough, the block weights were placed directly on the component (figures 20-22). In other tests, when the component to be loaded was narrow, the block weights were placed on an aluminum platform suspended from a support mounted on the component (figures 12-19). The support used for suspending the platform was approximately 4 in (100 mm) long, and was constructed by cutting a 2.5 in (64 mm) outside diameter 0.25 in (6.4 mm) thick steel pipe along its axis. The platform suspension system (figure 11) weighed approximately 20 pounds (9.1 kg).

Procedures for testing various items of home playground equipment are given ebelow.

A. Selected components of the A-climber, climbing tower, dome climber, tangle tower, play center, gym set, and slide were tested one at a time. Tested components were randomly selected from those components of the equipment which are likely to be occupied by children when the equipment is in use.

   The component to be tested was gradually loaded as follows: the component was loaded with an initial load of 100 pounds (45.4 kg) when the block weights were placed directly on the component, and 120 pounds (54.4 kg) when the block weights were placed on the platform suspended from the component. The component loaded with this initial load was kept under surveillance for 10 minutes to observe any structural failure of the component or of the component's support system (i.e. connecting bolts, nuts, hinges, etc.); if no observable failure occurred,

an additional block weight was added to the initial weights to increase the magnitude of the load applied to the component by 50 pounds (22.7 kg). The component under testing now subjected to this increased load was observed for another 10 minutes for any structural failure; if no observable failure occurred, the applied load was increased by another 50 pounds (22.7 kg). This process of gradually increasing the load applied to the component under testing, by 50 pounds (22.7 kg) at 10 minute intervals, was continued until either the component failed or the magnitude of load applied to the component equaled or exceeded that of the estimated test load.

In all of the tests, when the equipment was tested by loading its components one at a time, the procedure of gradual loading of the component under test was followed.

The equipment components which were loaded for these tests are indicated in figures 1-7.

B. The gym set which had already been tested by procedure A, a space rocker, and a merry-go-round were also tested as follows. Those components of the equipment which were designed for occupancy (mainly seats) were loaded simultaneously with estimated test loads. The equipment thus loaded was kept under surveillance for up to 10 minutes to observe if any part of the equipment failed.

The equipment components which were loaded for these tests are indicated in figures 8 - 10.

Test Results

The results of the strength tests, indicating whether failure of any part of the tested equipment occurred or not, are given in figures 1-10. Components of the equipment loaded, applied load, and estimated test loads are also shown in these figures. Photographs of some items of the equipment under testing are shown in figures 12-22. Figure 23 shows the status of the play center after it was tested, and figure 24 shows the status of the gym set after it was tested by loading all of the swinging units simultaneously.

Test results indicate that all tested equipment, with the exception of two items, showed some sort of structural failure when subjected to estimated loads. The two exceptions among the nine items tested were the free standing slide and the space rocker.

Reference

Mahajan, Bal M., "Recommendations for a Safety Standard for Home Playground Equipment - Swing Sets," NBS Report No. NBSIR 74-563.

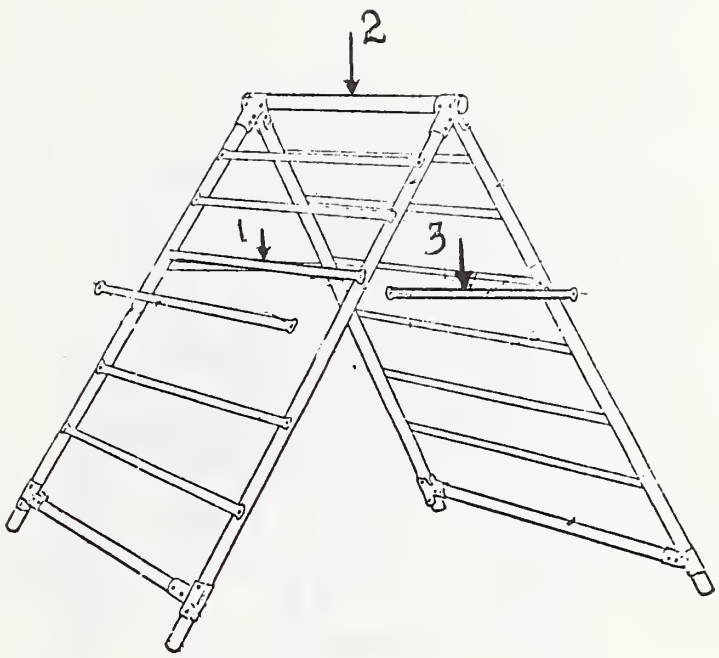


Figure 1. A-Climber

Strength Test Data

Location of Component Loaded	Estimated Load		Applied Load		Observations
	lb.	kg	lb.	kg	
1	300	136	320	145	No failure
2	300	136	320	145	No failure
3	300	136	120	54	No failure
			170	77	Bar bent

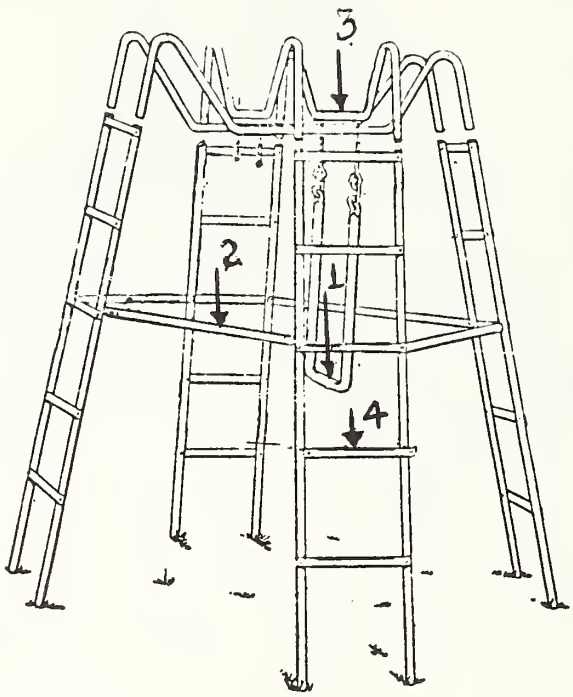


Figure 2. Climbing Tower

Strength Test Data

Location of Component Loaded	Estimated Load		Applied Load		Observations
	lb.	kg	lb.	kg	
1	220	100	220	100	No failure
2	220	100	170	77	No failure
			220	100	Bar bent
3	220	100	220	100	No failure
4	220	100	220	100	No failure

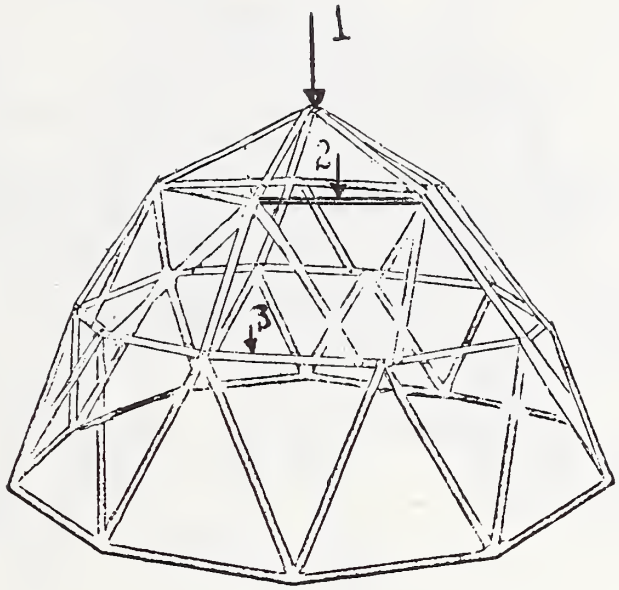


Figure 3. Dome Climber

Strength Test Data

Location of Component Loaded	Estimated Load		Applied Load		Observations
	lb.	kg	lb.	kg	
1	400	181	170	77	No failure
			220	100	All bars connected at point 1 caved in
2	220		170	77	No failure
			220	100	Bar bent
3	220	100	170	77	No failure
			220	100	Bar bent

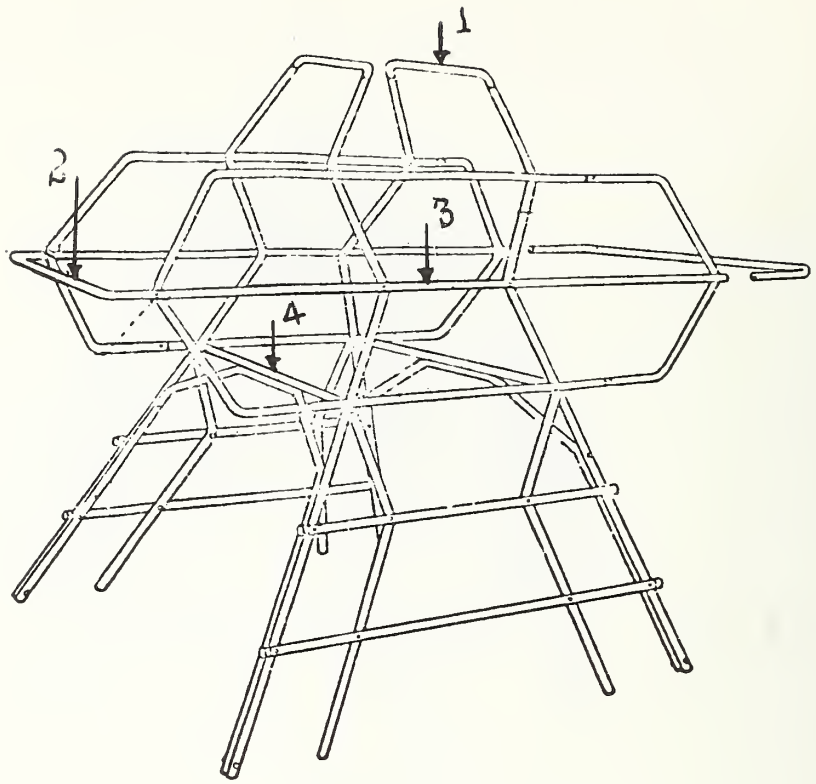


Figure 4. Tangle Tower

Strength Test Data

Location of Component Loaded	Estimated Load		Applied Load		Observations
	lb.	kg	lb.	kg	
1	350	156	420	191	No failure
2	350	156	220	100	No failure
			270	122	Bar bent and upper assembly pulled down
3	350	156	420	191	No failure
4	350	156	420	191	No failure

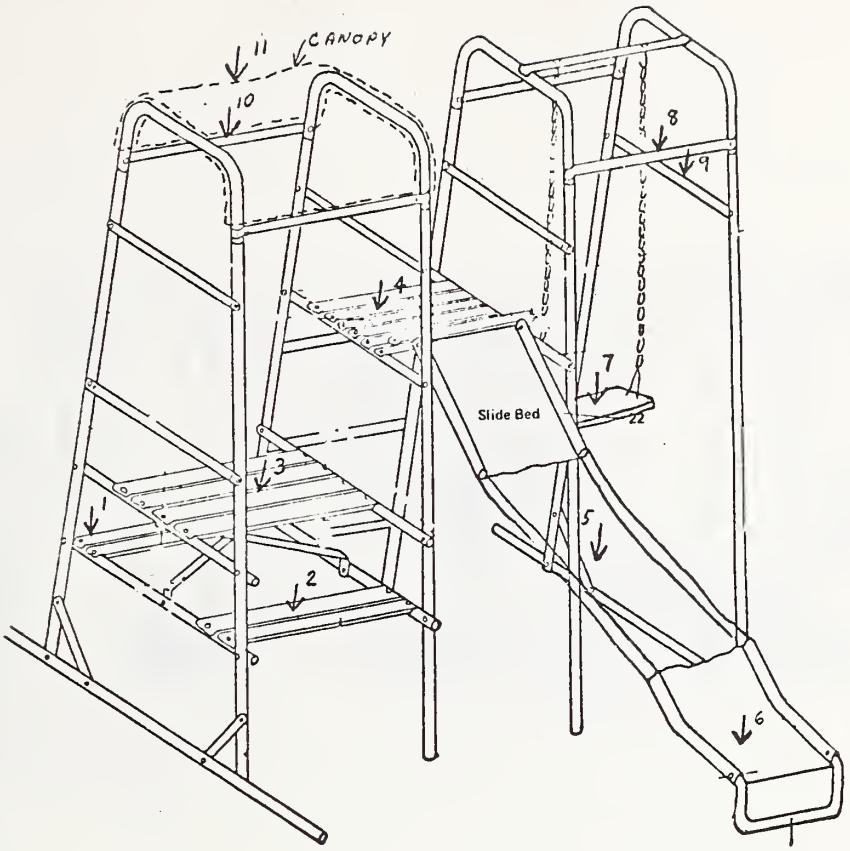


Figure 5. Play Center

Strength Test Data

Location of Component Loaded	Estimated Load		Applied Load		Observations
	lb.	kg	lb.	kg	
1	150	68	150	68	No failure
2	150	68	150	68	No failure
3	150	68	150	68	No failure
4	150	68	150	68	No failure
5	150	68	150	68	No failure
6	150	68	150	68	No failure
7	200	91	200	91	No failure
8	200	91	170	77	No failure
			220	100	Bar bent
9	200	91	220	100	No failure
10	200	91	170	77	No failure
			220	100	Bar bent
11	150	68	100	45	No failure
			150	68	Canopy torn

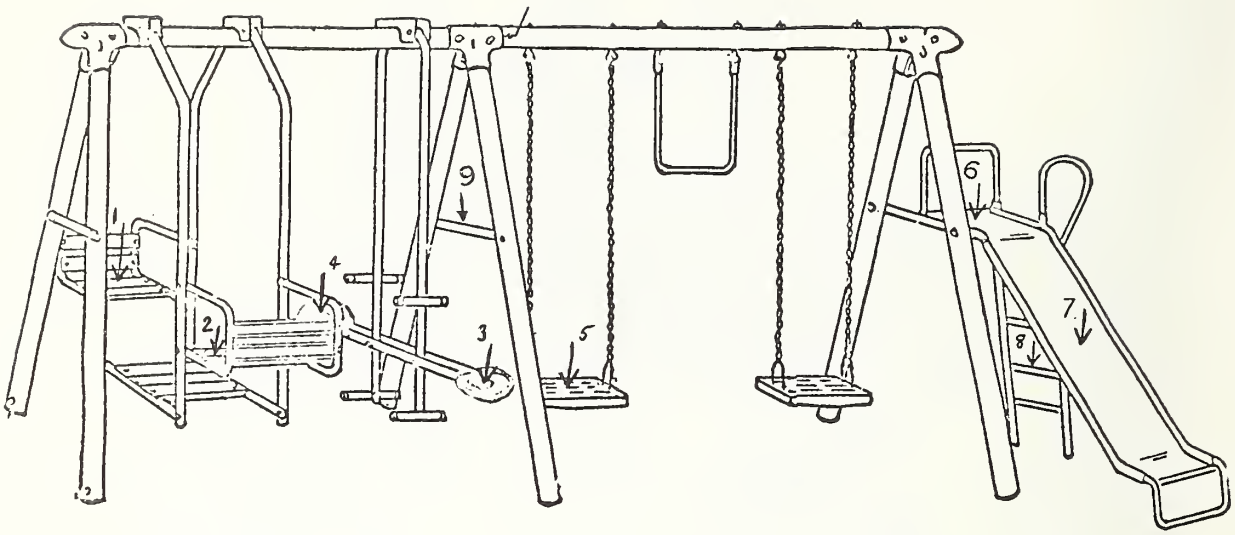


Figure 6. Gym Set

Strength Test Data

Location of Component Loaded		Estimated Load		Applied Load		Observations
		lb.	kg	lb.	kg	
1 and 2 were loaded simultaneously	1	300	136	300	136	No failure
	2	300	136	300	136	No failure
3 and 4 were loaded simultaneously	3	150	68	150	68	No failure
	4	150	68	150	68	No failure
	5	400	181	400	181	No failure
	6	200	91	200	91	No failure
	7	200	91	200	91	No failure
	8	200	91	220	100	No failure
	9	300	136	170	77	No failure
				220	100	Bar bent

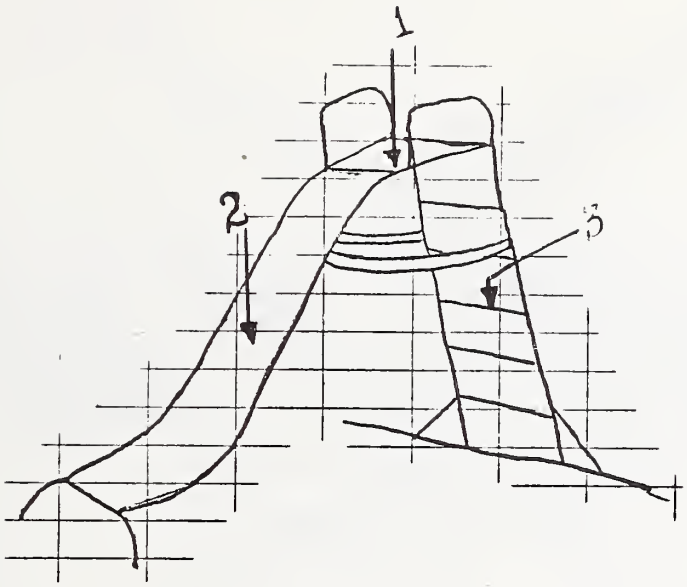


Figure 7. Free Standing Slide

Strength Test Data

Location of Component Loaded	Estimated Load		Applied Load		Observations
	lb.	kg	lb.	kg	
1	200	91	200	91	No failure
2	200	91	200	91	No failure
3	200	91	200	91	No failure

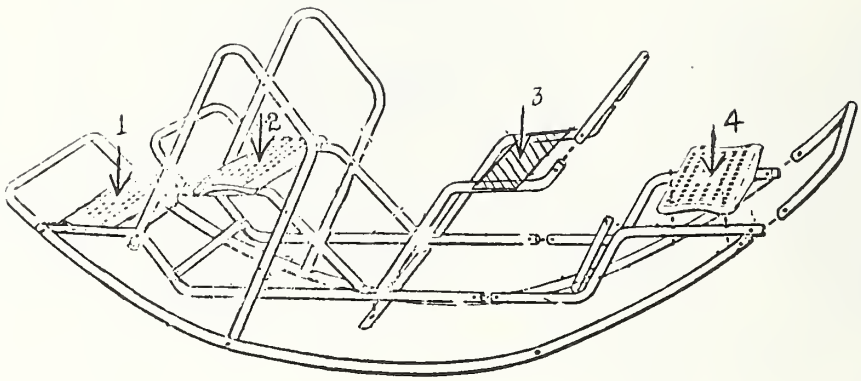


Figure 8. Space Rocker

Strength Test Data

Location of Component Loaded	Applied Load*		Observations
	lb.	kg	
1	200	91	All four seats were loaded
2	200	91	simultaneously. No failure.
3	200	91	
4	200	91	

*The applied load was the estimated load.

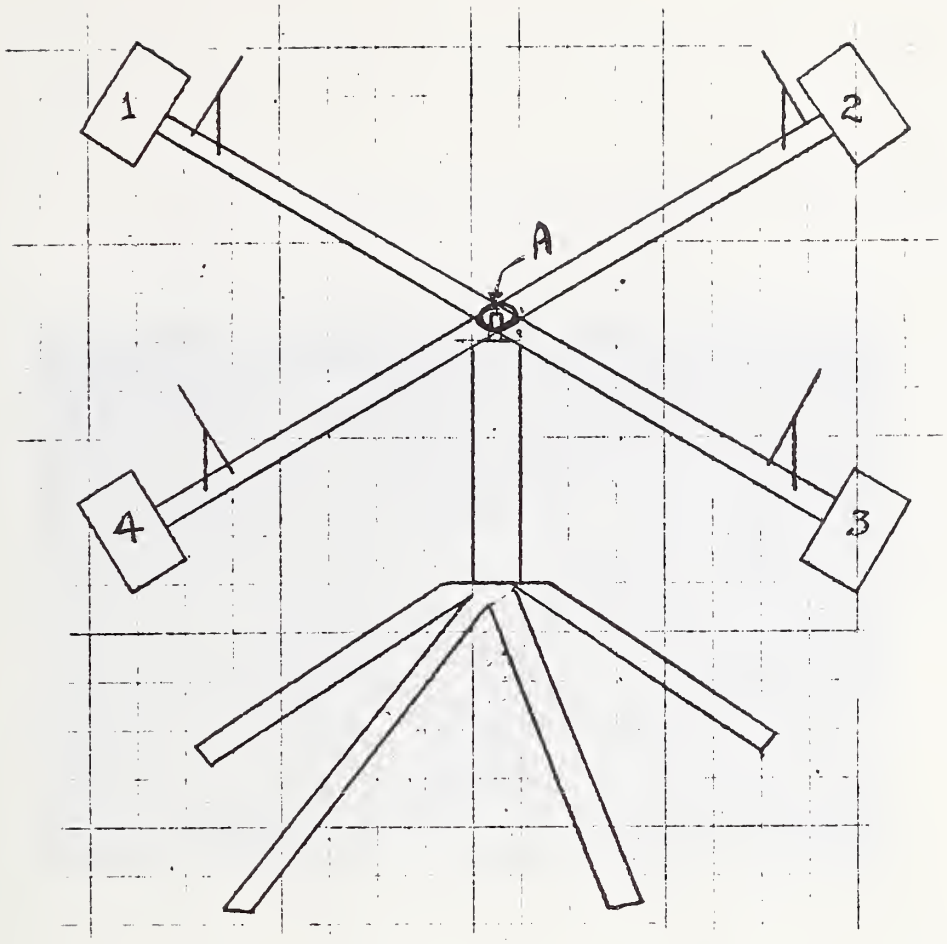


Figure 9. Merry-Go-Round

Strength Test Data

Location of Component Loaded	Applied Load		Observations
	lb.	kg	
1	150	68	All four seats were loaded
2	150	68	simultaneously. Pivot at "A" and
3	150	68	seat support bars near the pivot
4	150	68	failed.

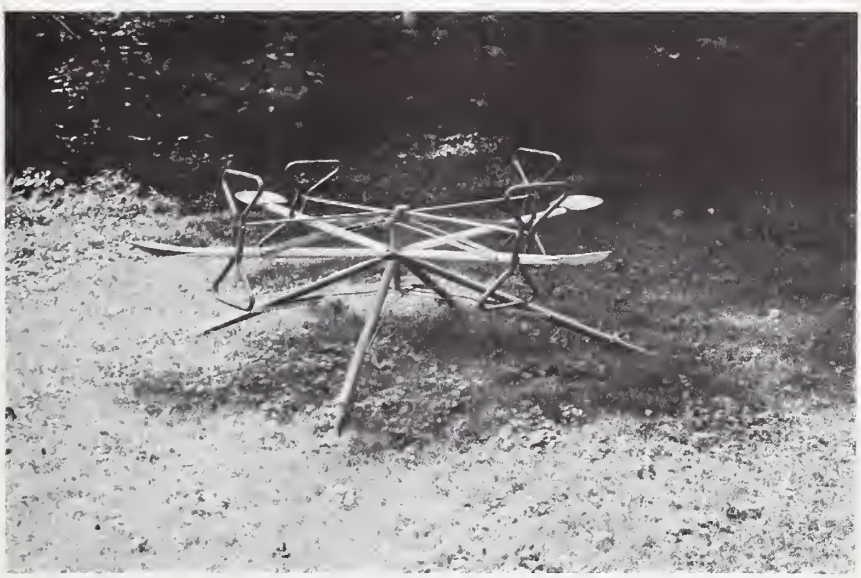


Figure 9A. Merry-Go-Round

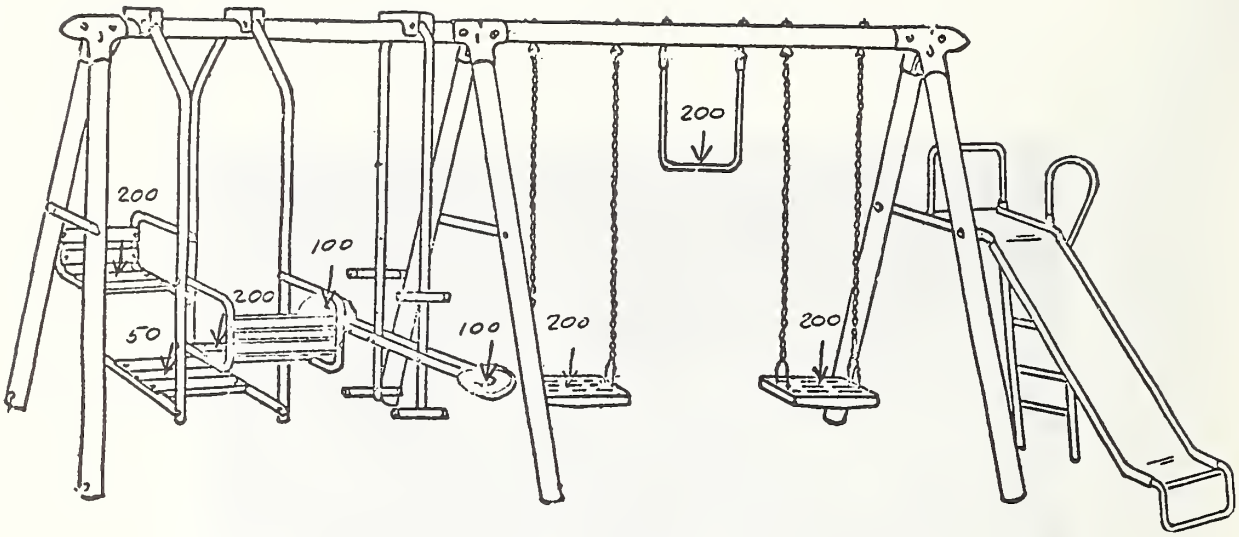


Figure 10. Gym Set

Strength Test Data

The equipment was loaded with a total load of 1250 lb. (567 kg) to test the strength of the top bar. The locations of components which were loaded and the respective magnitude of applied load is indicated in the figure above.

As soon as the last block weight was placed on the equipment, the equipment collapsed (figure 24).

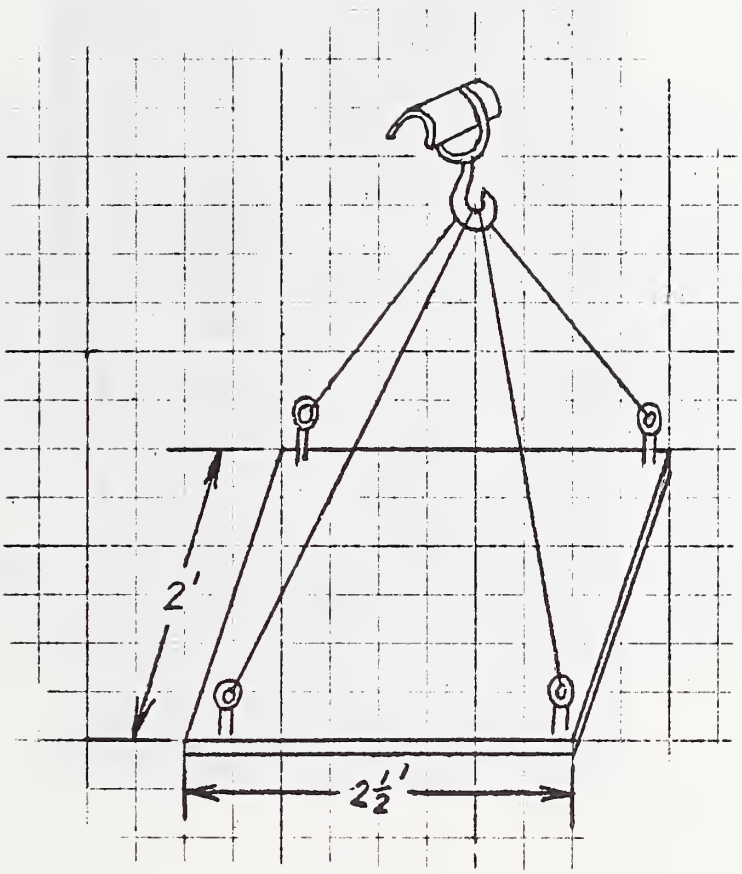


Figure 11. Loading Platform Suspension System.

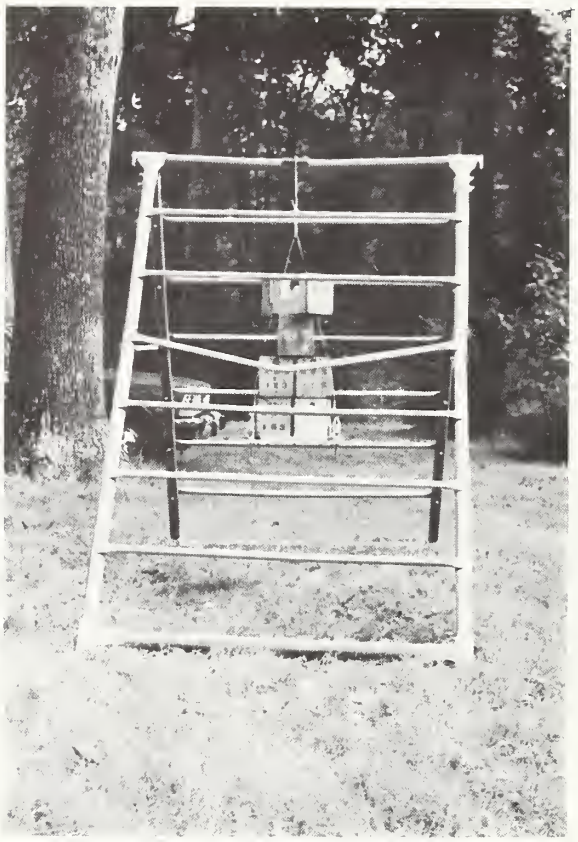


Figure 12. A-climber under test.

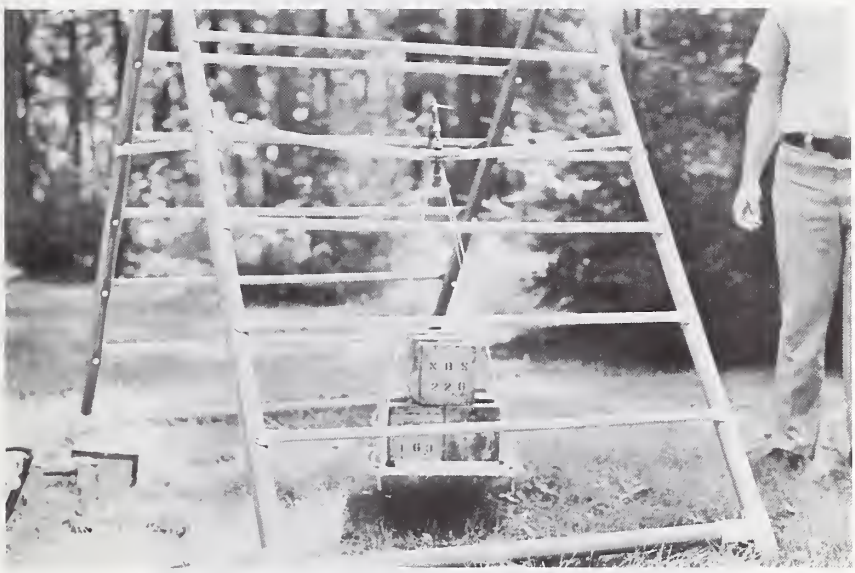


Figure 13. A-climber under test.

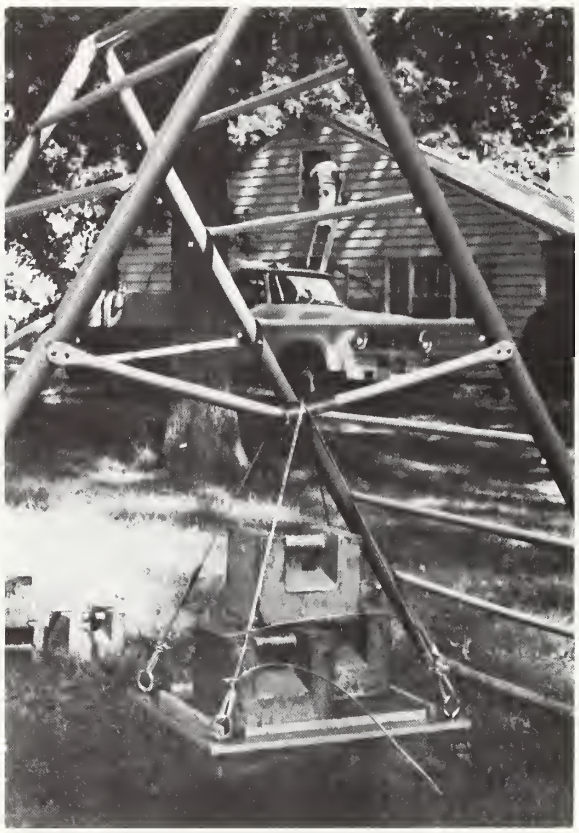


Figure 14. A-climber under test.

Figure 15. Climbing tower under test.

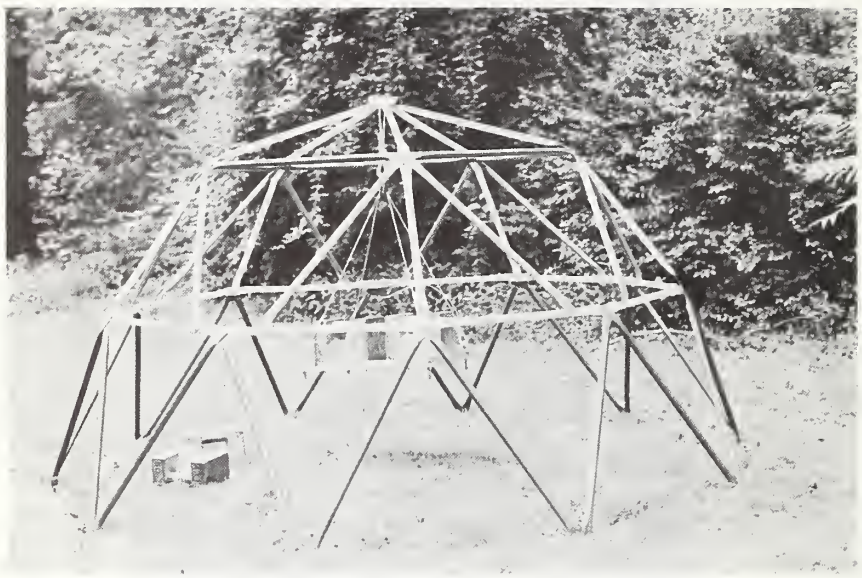


Figure 16. Dome climber under test.

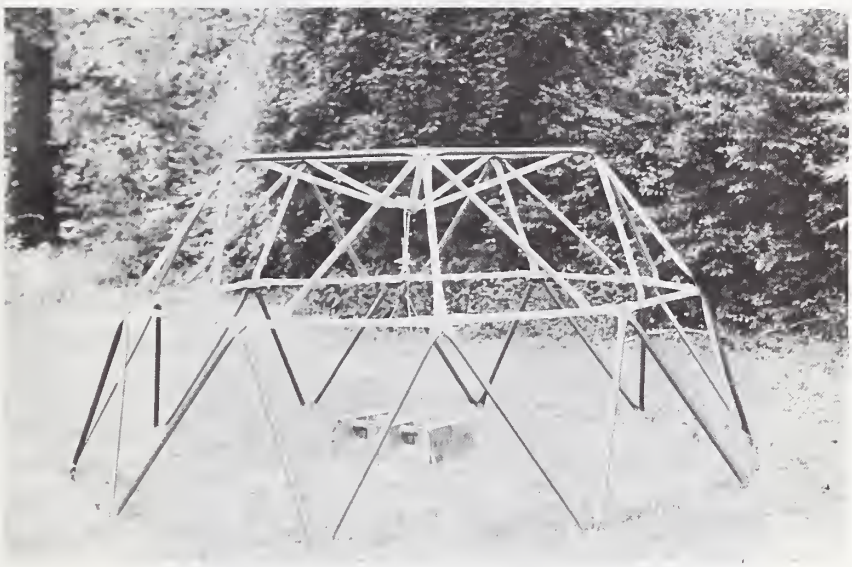


Figure 17. Dome climber under test.

Figure 18. Tangle tower under test.

Figure 19. Gym set under test.

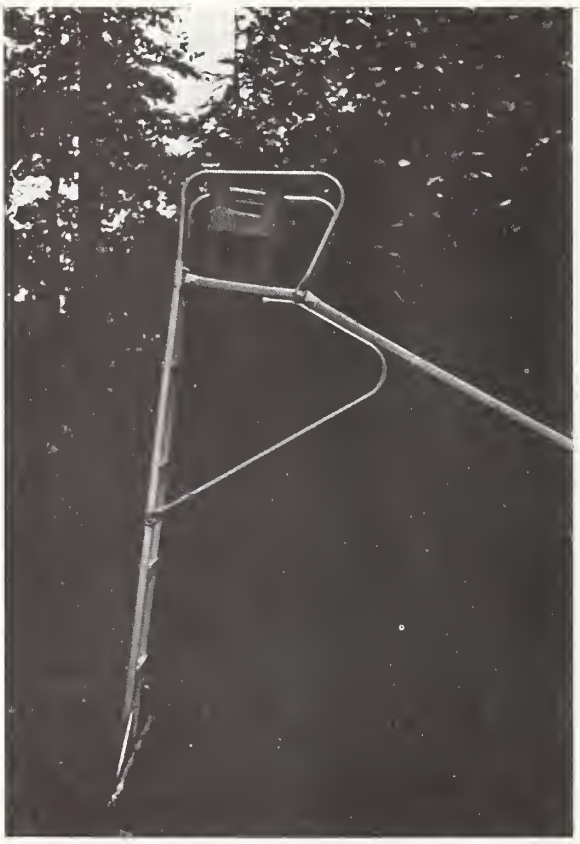


Figure 20. Free standing slide under test.

Figure 21. Free standing slide under test.

Figure 22. Space rocker under testing.

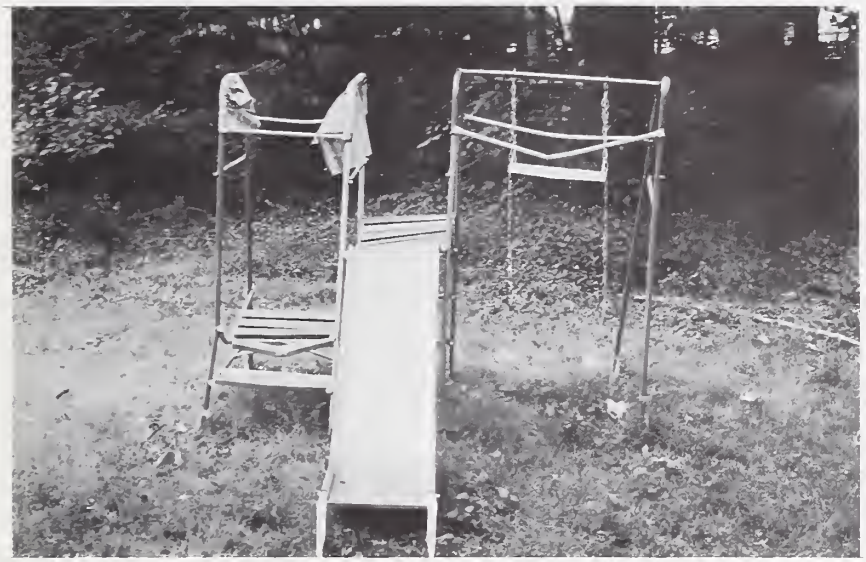
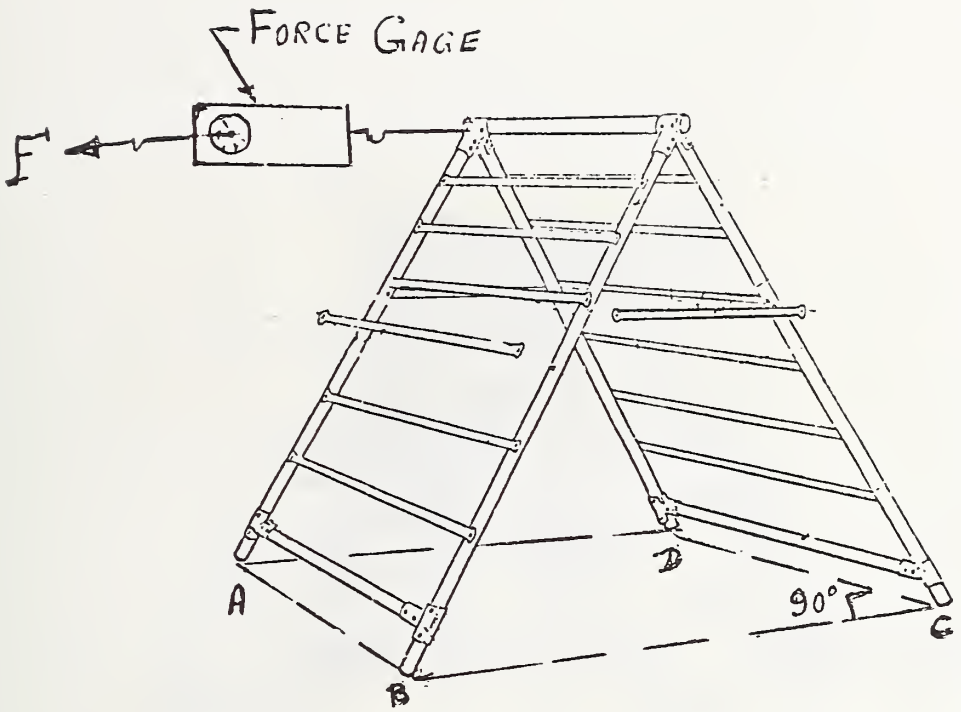


Figure 23. Play center after loading test.

Figure 24. Gym set after loading all of the seats simultaneously (figure 10).



Lines AB, BC, CD, and DA are the possible tipping axes (T.A.) for this equipment

Figure 25. The tipping axes of a typical home playground item, and schematic set-up for applying the pull force, F, to the equipment under stability tests.

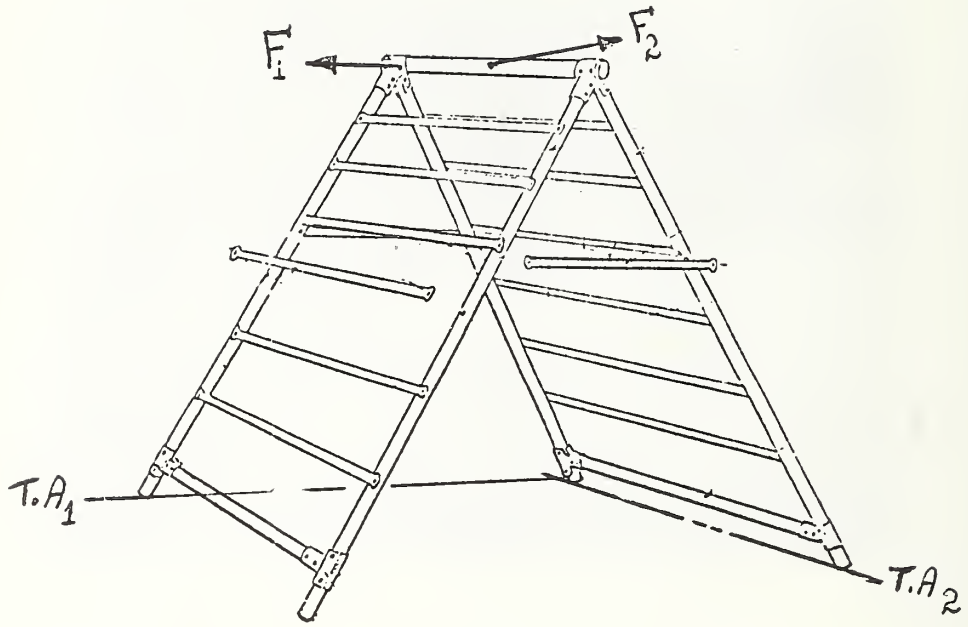


Figure 26. The A-frame's stability test.
Force to start tipping
F_1 = 24 lb. (107 N)
F_2 = 43 lb. (191 N)

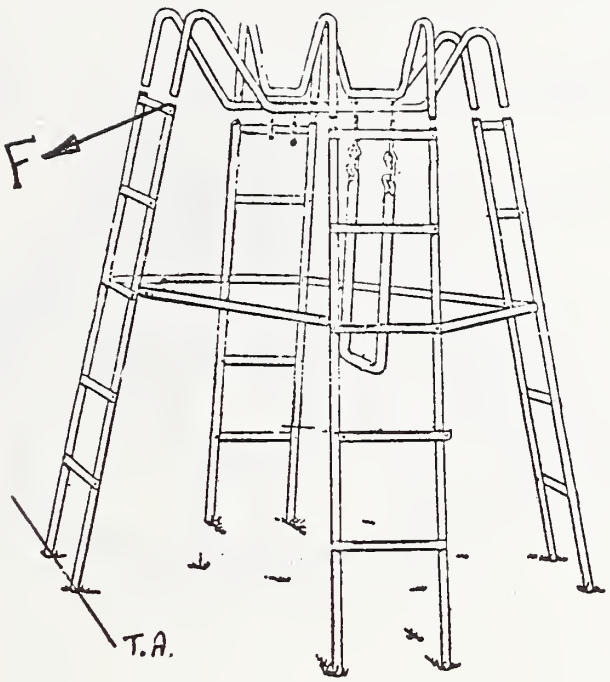


Figure 27. Climber tower's stability test.
Force to start tipping
F = 23 lb. (102 N)

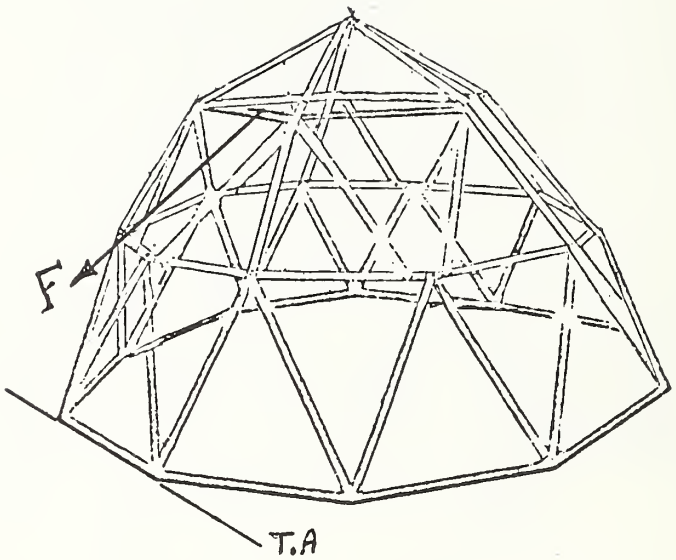


Figure 28. Dome climber's stability test.
Force to start tipping
F = 48 lb. (214 N)

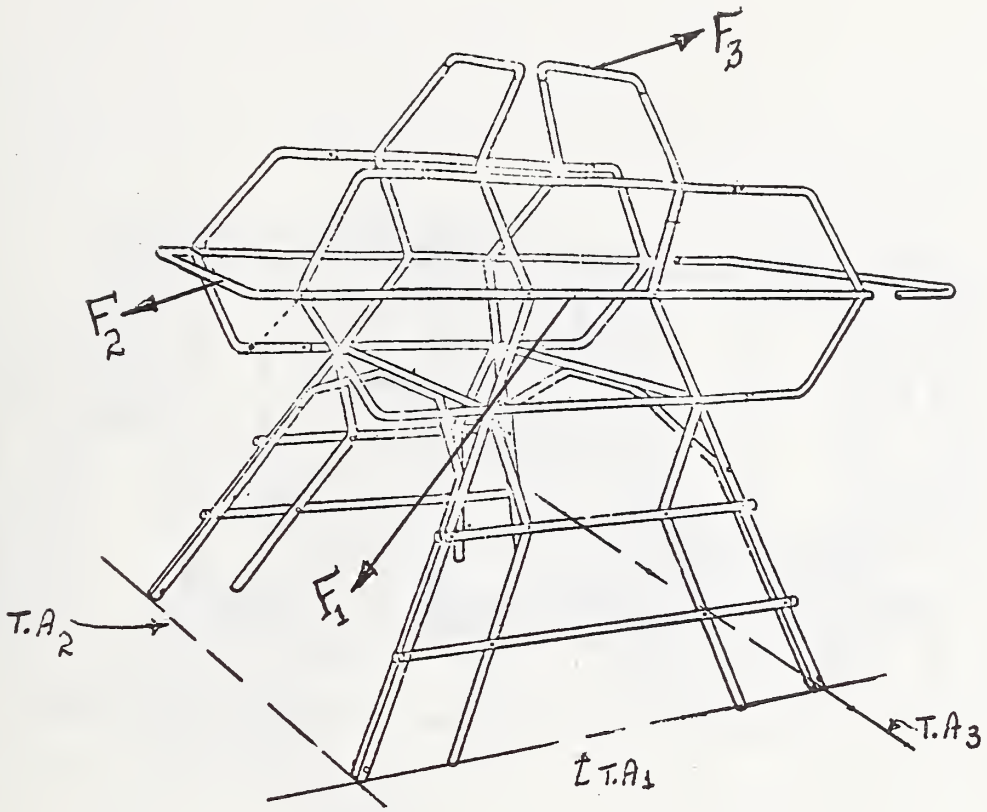


Figure 29. Tangle tower's stability test.
Force to start tipping.
F_1 = 30 lb. (134 N)
F_2 = 36 lb. (160 N)
F_3 = 24 lb. (107 N)

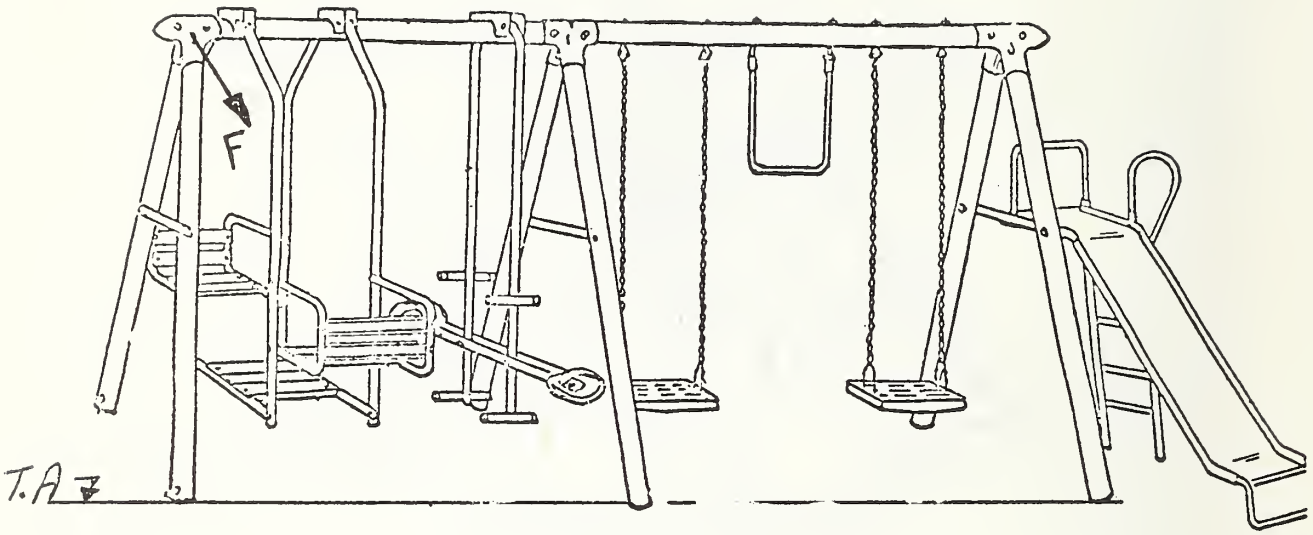


Figure 30. Gym set's stability test.
Force to start tipping
F = 225 lb. (1000 N)

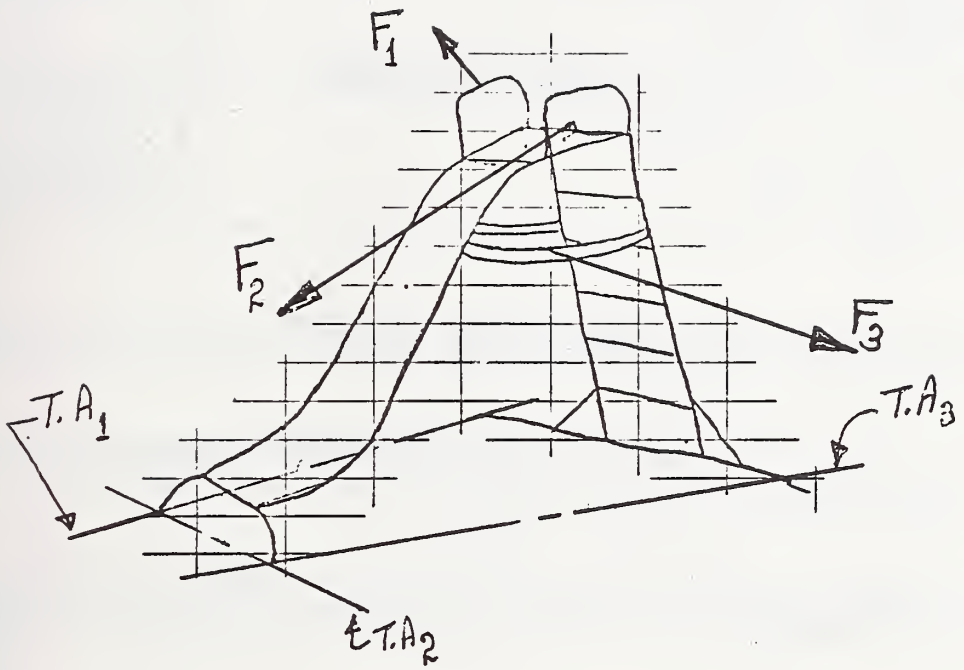


Figure 31. Free standing slide's stability test.
Force to start tipping .
F_1 = 5 lb. (22 N)
F_2 = 21 lb. (93 N)
F_3 = 34 lb. (151 N)

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

Stability tests were performed on some items of home playground equipment to measure the magnitude of the force, applied to generate tipping moment, required to start the tipping of the equipment.

Strength tests were conducted by loading certain components of home playground equipment with estimated loads to determine if the tested equipment had adequate strength.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Home playground equipment; stability; strength; test; testing; tipping

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