NASA CR –134528
ITI P –1246

FINAL REPORT
ON

EXPERIMENTAL BALL BEARING DYNAMICS STUDY

by

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prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA Lewis Research Center
Contract NAS 3-16730
H. H. Coe, Project Manager

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA CR-134528		

4. Title and Subtitle	5. Report Date
EXPERIMENTAL BALL BEARING DYNAMICS STUDY	October 1973
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Hans R. Signer	P-1246
	10. Work Unit No.
9. Performing Organization Name and Address	11. Contract or Grant No.
Industrial Tectonics, Inc. Compton, California 90221	NAS 3-16730
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	Contractor Report
National Aeronautics and Space Administration Washington, D.C. 20546	14. Sponsoring Agency Code

15. Supplementary Notes

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16. Abstract

A photographic method was employed to record the kinematic performance of rolling elements in turbo machinery ball bearings. The 110 mm split inner ring test bearings had nominal contact angles of 26° and 34°. High speed films were taken at inner ring speeds of 4,000, 8,000 and 12,000 rpm and at thrust loads of 4,448 N and 22,240 N (1,000 and 5,000 lbs). The films were measured and this data reduced to obtain separator speed, ball speed and ball spin axis orientation.

The experimental results, which show logical trends, should now be compared to theoretical values to establish correlation.

The program yielded useful information on ball dynamics. However, further refinements of the experimental and data reduction techniques are possible and would result in improved data.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Ball bearing dynamics Bearing tests Photographic test method High-speed photography	Unclassified - unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	120	$ 9.00

* For sale by the National Technical Information Service, Springfield, Virginia 22151

P R E F A C E

The author gratefully acknowledges the efforts of Mr. R. W. Anderson of Pratt & Whitney Aircraft Division, East Hartford, Connecticut who developed the computerized data reduction for this program. The cooperation of Messrs. R. P. Schevchenko and P. F. Brown, also of P & WA Div.,in this and earlier programs was instrumental in developing the Separator Study Machine into a viable research tool.

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1.0 SUMMARY AND CONCLUSIONS

Present bearing theories enable computerized optimization of high performance rolling element bearing designs, and theoretical predictions of bearing performance to be made. There is, however, a need to verify these solutions by advanced test methods.

The difficult task of measuring the dynamic behavior of rolling elements, especially in a ball bearing, has been solved by a photographic method. The Separator Study Machine which was used for this investigation produces high-speed movies of the rolling element under investigation at programmed speed and load conditions.

The research which is reported herein had the objective to measure separator speed, orientation of the ball spin axis, and ball rotational speed in a ball bearing operating at high speeds.

The tested ball bearings were of split inner ring design, 110 mm bore size, and had nominal contact angles of 26° and 34°. These bearings were prepared for optical measurements by providing an open pocket separator and a test ball which was marked with shallow but indelible markings.

High-speed motion pictures were obtained of these bearings at inner ring speeds of 4,000, 8,000 and 12,000 rpm and at thrust loads of 4,448 N and 22,240 N [1,000 and 5,000 lbs]. The high-speed movies represented true and accurate records of the dynamic behavior of the bearings at the above test conditions.

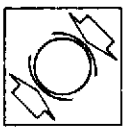
The high-speed films were subsequently examined to determine instantaneous ball positions and this data reduced to obtain separator speed, ball speed, and ball spin axis angle orienta-

tion in two planes. The orientation of this spin axis was expressed in pitch and yaw angles.

The experimental results show logical trends. They should now be compared to calculated results obtained from computer runs for the same operating conditions for an evaluation of how well the measured data correlates with theoretical predictions of ball dynamics.

While the high speed films represent true and accurate records of the ball motion, it was found that there are some inaccuracies in the process used to reduce the photographed data to obtain the numerical values expressing ball motion. These inaccuracies suggest that several refinements should be considered to improve the data in future investigations. Such refinements are possible and practical in the filming technique itself, and also in the film measuring technique, as well as in the computerized data reduction procedure.

The program yielded useful information on ball dynamics. However, further refinements of the employed techniques are possible and would unquestionably result in improved data.



2.0 INTRODUCTION

Computerization of high-speed bearing theory enables the optimization of rolling element bearing designs and the theoretical prediction of bearing performance. These computerized results and the theories on which they are based, while extremely helpful to the design and research engineer, have yet to be fully verified by actual bearing tests. Bearing performance tests and computer studies will always be needed to refine bearing designs for many critical applications.

The interaction in a bearing between the rolling elements, raceways and separators is particularly difficult to measure due to the random nature of their motion and forces. The kinematic behavior and the resulting forces acting on a rolling element/separator/raceway assembly could previously be measured only in tests where the operating conditions were drastically simplified.

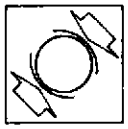
To solve this measurement problem, ITI has developed the Separator Study Machine. This machine was designed and built as a research tool and is capable of measuring, by photographic methods, the motions of rolling elements within a bearing. The machine thus makes it possible also to study the interaction between these rolling elements and the bearing separator and raceways under a variety of load and speed conditions.

The technique employed relies on a derotation prism to eliminate optically the gross rotation of the test bearing separator. Measurements can be performed on test bearings of 100 to 110 mm bore size, operating at speeds up to 15,000 rpm and under any practical combination of thrust and radial loads up to 66,720 N and 13,350 N [15,000 lbs and 3,000 lbs] respectively.

An initial investigation (1)[1] of the rolling element and separator dynamics in a 100 mm cylindrical roller bearing proved that the machine is capable of performing these tasks, and that this data collecting method is viable. Subsequent efforts were directed toward developing measuring techniques on ball bearings. The difficult problem of photographing a ball in a ball bearing and measuring its position from the film frame was solved (2). A computerized data reduction technique was then developed (3) and checked out (4) to calculate ball velocities and spin axis direction from the measurements taken of high-speed motion pictures.

In the program reported herein, measurements were made on test ball bearings of 110 mm bore size with mounted, nominal contact angles of 26° and 34°, operating at speeds of 4,000, 8,000 and 12,000 rpm. It was the objective of these tests to gain information on separator speeds and on ball motion, such as orientation of spin axis and rotational speed about this axis as a function of the ball position relative to the bearing outer race.

[1]Numbers in brackets () designate references at end of report.



3.0 TEST FACILITY

The tests were conducted on the Separator Study Machine. This test machine is capable of taking high-speed photographs of a selected target in a test bearing which is operated at programmed speed and load conditions. The target can be a rolling element and/or a portion of the bearing separator.

Figure 1 shows a view of the Separator Study Machine:

- A welded frame structure supports the test spindle with its drive mechanism, a load system to apply static loads to the test bearing, and an electro-optical scanning unit, as well as the main control panel.

- The bulk of the electronic hardware and the capacitors for the strobe lights are mounted in free standing relay racks.

3.1 Main Spindle Assembly

Figure 2 illustrates the main spindle assembly which was used in this program. The test bearing is cantilevered from the main spindle, which in turn is supported by preloaded turbo-engine main shaft ball bearings.

The test bearing housing is supported by the test bearing and a large thin section bearing. Radial and thrust loads are applied to the test bearing through load cables which are attached to the periphery of the test bearing housing. The test bearing itself is exposed in the front to allow clear entrance of the optical path and illumination. The bearing is lubricated through a series of orifices from the inside of the test bearing housing.

3.2 The Scanner and Lighting Systems

The bearing scanner is used to observe and photograph an individual separator pocket of the test bearing.

Due to the high tangential velocities when a bearing rotates at shaft speeds up to 15,000 rpm,conventional photographic techniques are inadequate. The difficulty lies in obtaining pictures having sufficient resolution for analysis when very short exposures are required to freeze the motion of the bearing elements. This problems has been overcome by eliminating the gross rotational motion using a derotation prism. The derotated image thus presents the differential motion between the separator and the remaining bearing components.

The synchronization of the prism with the test bearing separator is accomplished by a servo-drive which receives its command signals from a UV-light illuminated target on the bearing separator.

An array of strobe lamps and UV lamps are supported by a lamp housing (figure 3) which fits tightly against the shroud in front of the test bearing. The shroud collects the lubricating oil, and with the assistance of an air blanket, keeps the oil from splashing against the glass window which separates the shroud cavity and the lamps.

To photograph a ball in a ball bearing, the front strobe lights are augmented by a light which provides a luminous background. Thus, the contour of the test ball becomes visible as a silhouette, and the ball center can be determined when the movie frames are analyzed.

Two cameras are tuned to the lens system of the scanner:

- a 35 mm, pulse-operated camera takes pictures at the rate of up to 16 frames per second. It is used mostly to investigate forces and relative motion

within a test bearing.

- a 16 mm Fastax camera capable of up to 8,000 frames per second is used for motion studies or other investigations where continued motion recording is of prime importance.

Figure 4 shows the optical paths through the bearing scanner.

Specification of Optical Bearing Scanner

The optical bearing scanner performs to the following specifications:

- separator speed range for picture taking	200-7000 rpm
- speed variation of separator	$\pm$ 5% of nominal rpm/ revolution
- field of view	28.6 mm x 25.4 mm [1-1/8" x 1"] rectangular segment of bearing having an O/D of 177.8 mm [7"] and an I/D of 101.6 mm [4"]
- optical resolution	25 lines/mm at the object
- strobe duration	$\sim 1\,\mu$ second
- maximum strobe rate	max. 16 strobes/second for pulse camera max. 8,000 strobes/second for Fastax operation, up to 200 frames per run.

4.0 LUBRICANT

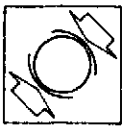
The test bearing was lubricated with a type II oil which is qualified to MIL-L-23699. The viscosity of this oil is 10.8 centistokes at 339°K [150°F] and 5.7 centistokes at 367°K [200°F].

5.0 TEST BEARING PREPARATION

The tested ball bearings were ABEC 7 grade, split inner ring design, of 110 mm bore size. The reported test program was performed with bearing ITI 13453 which has a nominal contact angle of 26° and with ITI 13454 which has a nominal contact angle of 34°. The detailed dimensional data on both test bearings are given in paragraph 5.1 and in figure 5.

5.1 Dimensional Data of Test Bearings

Bearing P/N	ITI 13453	ITI 13454
used in tests series	IA	IB
Contact Angle (static)	26.1°	33.7°
Bearing Clearance, cm [inches]		
- radial	.0130[.0051]	.0239[.0094]
- axial	.056 [.022]	.079 [.031]
Race Radii, cm [inches]		
- inner	.980 [.386]	.986 [.388]
- outer	.988 [.389]	.991 [.390]
Surface Finish - Inner Race, μm[μin]		
- circumferential	.10-.15 [4-6]	.05-.10 [2-4]
- transversal	.15-.20 [6-8]	.13-.20 [5-8]
Surface Finish - Outer Race, μm[μin]		
- circumferential	.05-.10 [2-4]	.08-.10 [3-4]
- transversal	.13-.18 [5-7]	.13-.18 [5-7]
Ball Size, cm [inches]	1.9048 [.749910]	1.9048 [.749910]
Number of Balls	20	20
Separator Clearance, cm [inches]		
- pocket	.046 [.018]	.046 [.018]
- inner land	.053 [.021]	.056 [.022]
Separator Balance Level gm-cm	3	3



5.2 Open Pocket Separator

To investigate ball kinematics it is necessary to expose the test ball to the view of the camera without interfering with its typical performance. A special separator was provided for this purpose (figure 6). The internal geometry of the open pocket duplicated the standard pockets. Care was taken to ensure that the mass and strength of this separator were not significantly different from a standard separator. The separator was balanced to 3 gr-cm. Special attention was given to the shape of the light reflecting surfaces to either side of the open ball pocket. These reflectors serve to illuminate the test ball, increasing the visible test ball surface in a movie picture.

5.3 Test Balls

The ball marking had to provide a recognizable and indelible address to selected points on the test ball surface without interfering with the ball motion or strength.

The test ball was marked with electro-chemically etched symbols which were about 2.5 micro-meters [100 μ-in] deep. The symbols used were both visible and measureable. Figure 7 shows the principle of electro-chemical etching and a surface trace over an etched symbol. An electrical current transports particles from the ball surface to the electrode. In the electrolyte these iron particles are oxidized and transported back to the ball, resulting in a black line which does not significantly mar the ball surface.

Test balls with typical selections of marking symbols are shown in figure 8. The corners and intersections on these symbols are measuring points and have known addresses on the ball surface. The symbols are recognized and their positions measured on the test movie frames (figure 9).

6.0 TEST PLAN, PROCEDURES AND TEST CONDITIONS

The reported project consisted of two major tasks. In task I the test hardware was prepared, the optical angle of the camera system was calibrated, and the bearing tests were performed. In task II the films were measured and the ball motion computed.

6.1 Task I - Bearing Tests

Bearing performance was investigated for ten operating conditions:

Test bearing ITI 13453 (26°)

Run No.	Spindle Speed RPM	Thrust Load N [lbs]
IA-1	4,000	4,448[1,000]
IA-2	4,000	22,240[5,000]
IA-3	8,000	4,448[1,000]
IA-4	8,000	22,240[5,000]
IA-5	12,000	4,448[1,000]
IA-6	12,000	22,240[5,000]

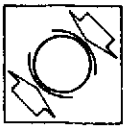
Test Bearing ITI 13454 (34°)

Run No.	Spindle Speed RPM	Thrust Load N [lbs]
IB-1	4,000	4,448[1,000]
IB-2	4,000	22,240[5,000]
IB-3	12,000	4,448[1,000]
IB-4	12,000	22,240[5,000]

The following values were held consistant in all runs:

Radial load	-	None applied
Lubricant oil flow	-	3.15×10^{-5} m^3/sec [.5 gpm] (introduced through multiple jets)
Oil inlet temperature	-	339°K $\pm$ 5.6° [150°F $\pm$ 10°]
Bearing outer ring temperature	-	367°K $\pm$ 5.6° [200°F $\pm$ 10°]

In all of the scheduled tests, high speed movies were taken. Some of the runs had to be filmed several times to obtain the high quality images which are needed for reliable data reduction. A movie was considered of acceptable quality if (1) over its entire duration a sufficient number of measuring points can be seen and



identified, and (2) when the tracking of the optics was such that the test ball was centered in all photographs so that the maximum possible portion of the ball silhouette was visible.

6.2 Task II - Data Reduction

6.2.1 Data Collection

Each high-speed movie produced an exact record of the ball motion within the bearing. Two sets of measurements were required to determine this ball motion: mapping of the target points on the test ball, and measuring of these points on the individual frames of the test movies.

6.2.2 Mapping of the Test Ball

To map the address of each measuring point, an x,y,z coordinate system was assigned to the ball, and the pierce points of these axes with the ball surface were marked. The ball was then fastened to an indexing spindle which was part of a table with micrometer adjustments in the y and z directions. The ball axes were aligned with the axes of the table and the spindle. The individual target points on the ball periphery could now be aligned with an optical eye piece, and their location relative to the ball coordinate system could be recorded. The ball map was established by measuring each target point in two axes and then calculating the third coordinate. Figure 10 illustrates the fixture used for these measurements, and appendix 3 lists the ball maps.

6.2.3 Film Measurements

The position of the test ball within the bearing is defined by the ball center relative to the inner and outer races and the position of two known points on the ball periphery. In a test movie frame (figure 9) the projected ball center

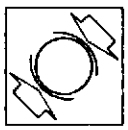
is found readily with the aid of a template which is lined up against the ball image. The inner and outer ring clamps and the ball contour assist in this step. The ball center and the coinciding template center represent the 0 point of an x', z' coordinate system in the photographic plane (figure 11). The film plane coordinates x' and z' of the selected points on the ball periphery can now be measured.

The large number of points which were marked on the test ball, and the light reflecting separator made it possible to recognize and measure 3 or 4 points in most film frames of the test movies. Since only 2 points on the ball periphery are needed to establish ball position, the additional points can be used to assure the correctness of the measurements. For instance, with three known surface points it is possible to calculate three ball positions, 4 points yield six possible ball positions. If one of the measured points is in error, a remarkable difference shows up in the computed results. This point could thus be eliminated and the ball position determined by averaging the remaining points.

6.2.4 Mathematical Data Reduction

The film measurements yield a record of the instantaneous ball position within the test bearing at the time of exposure. The kinematics of this rolling element can now be computed on the basis of a measured time interval between film frames.

The data reduction computer program which is based on (3) and the model shown in figure 11, solves for orbital ball speed (separator speed), orientation of ball spin axis (pitch and yaw), and rotational ball speed about this axis as function of ball center position relative to the bearing outer race.



The first step in this program determines the ball position in a film frame, based on the location of measured points on the target ball. The optics and location of the camera influence the measurements, and the locations of the target points must be translated into a suitable coordinate system. Figure 11A shows the relationship of the camera and bearing and the coordinate system used. The origin is the test ball center, with x tangent and z perpendicular to the pitch circle and y parallel to the bearing axis. The camera focal point is on the bearing axis and is, therefore, offset from y (in the y-z plane) by the bearing pitch radius. Program step 1 determines the x,y and z coordinates for a point on the ball, corrected for the offset condition.

Figure 11B shows the projection of a point on the ball onto the film plane, expressed in the x,y,z system. The overall magnification of x and z on the film is determined by photographing a reference distance and measuring it on the film. The ratio of the reference to measured distance is the photographic magnification.

To determine ball rotation, the location of two points must be found for two successive film frames. However, a pair of points visible on one frame is generally not visible on the next. The second step is, therefore, to calculate the locations of a pair of points based on the observation of two other points. This is accomplished with a vector scheme, based on the ball map generated from the measurements outlined in paragraph 6.2.2.

In step 3 the ball spin axis orientation, the angle of rotation and orbital speed is computed from the established ball positions in two successive film frames.

7.0 RESULTS AND DISCUSSION

7.1 Interpretation of Test Results

As outlined in the previous paragraph, ten photographic runs were conducted at spindle speeds of 4,000, 8,000 and 12,000 rpm, each under a thrust load of 4,448, and 22,240 N [1,000 and 5,000 lbs]. Six runs used the 26° contact angle bearing and four runs used the 34° contact angle bearing.

A computer print out of the ball motion (figures 12 thru 21) shows separator speed, ball speed, and ball orientation or spin axis angle in two planes. The pitch angle lies in a plane defined by the bearing axis and the ball center, the yaw angle defines the deviation of the ball spin axis from this plane. The sign for yaw angle indicates the direction of the spin axis deviation from the y-z plane (figure 11) and has the same sign (positive or negative) as the x-value for the target ball pole.

The examination of the plotted results indicate fairly large momentary excursions from the expected (relatively smooth) motion of the rolling element. These deviations are presently thought to have their origin in measuring errors which are further discussed in paragraph 7.2. After technique improvements are made, it is expected that the ball motion measurements will yield precise information on ball dynamics at a given location within the bearing as a function of the imposed operating conditions.

An average value representing each one of the operating conditions was plotted in figures 22 thru 24. These graphs show the results from figures 12 thru 21 after further modifying them to reflect the values achieved by straight line averaging of the curves, ignoring the large magnitude instantaneous excursions (blips on curves).

Ball rotational and separator speed versus inner ring speed are illustrated in figures 22 and 23. The plots show a logical trend

of increasing ball speed with increasing inner ring speed for both, the 26° and the 34° contact angle bearings. The difference between 4,448 N and 22,240 N [1,000 and 5,000 lbs] thrust load appears to be almost negligible with the 26° bearing. The difference is more noticeable, especially at higher spindle speeds, with the 34° bearing.

The separator speed measurements plotted in figure 23 also show a logical trend of increasing speed with increasing shaft speed.

Ball spin axis orientation, expressed in pitch and yaw angles, is shown in figure 24. The trend in measured pitch and yaw angles of the 26° and 34° contact angle bearings appear to be logical. The absence of the 8,000 rpm data point for the 34° bearing makes the comparison somewhat more difficult (dashed lines indicate curves given by two data points only).

At high thrust load and low speed the pitch angle approached the static contact angle; with increasing speed the pitch angle decreased due to centrifugal effects.

At light loads, even at low speed, the centrifugal effects seem to cause immediate reduction in pitch angle. A low pitch angle is maintained throughout the speed range.

At low inner ring speeds the measured yaw angles were very small, indicating a small amount of ball spin while at 12,000 rpm this spinning action appears to increase. The difference in direction of the yaw angle at 12,000 rpm between the two contact angle bearings is not understood at this time.

These actual four measured parameters should now be compared to computed results that are based on theoretical bearing performance at conditions IA and IB to see how well the measured data correlates with theoretical predictions of ball dynamics.

If the data correlates reasonably well we can assume that the

computer program and the theory on which it is based, as well as the presented experimental data, are reasonably correct.

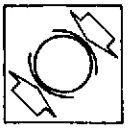
Should a wide disparity exist between the data of this report and that which a computer program predicts for theoretical bearing performance, (particularly if the disparity is in the character of the trends) then there are two possible conclusions: (1) Either the theory on which the computer program is based does not accurately reflect the true dynamics of the bearing, or (2) the data that was produced in this program is inaccurate and does not represent the true conditions of the bearing dynamics.

7.2 Accuracy of Experimental Data

High speed films, which are the output of the Separator Study Machine, represent true and accurate records of the dynamic behavior of the photographed object. We know, however, that there are two know inaccuracies in the process used to reduce photographic data to obtain the values of yaw and pitch angle and ball and separator speed.

The first source for errors in the method are certain inaccuracies in measuring ball position utilizing the etched ball hieroglyphics. This can be corrected by incorporating the program improvements suggested in paragraph 7.3.

The second inaccuracy has its source in the computerized data reduction program. Initially the instantaneous ball position was computed from measurements of the ball center and four points at the ball periphery. Because only two points are needed, one of the superfluous points was dropped and the ball position was then averaged to best fit the remaining three points. In the course of the program this procedure was changed, and only two measuring points were actually used for the computation. Quite good results were obtained in some cases; however, in some other movies the ball motion error was increased by this modification.



A further characteristic of the data reduction plots presented is that the printed "average" separator and ball speeds and attitude angles are arithmetical averages from all individual values of the plot. The computer print out shows varying numbers of erroneous data points (high blips on graphs) which would indicate that there were large instantaneous speed changes. These values now affect the "average" values, and should have been omitted in the analysis of these curves.

The data in figures 22 thru 24 representing the final results of this investigation have been modified to reflect the values achieved not by the average shown in the print out, but rather by straight line averaging of the curves, ignoring the large magnitude blips.

Test run IA-5 (figure 16) rendered perhaps the smoothest curves of all. They represent data taken at 12,000 rpm under 4,448 N [1,000 lbs] thrust load. On the other hand, the curves representing tests IA-1 (figure 12) which was taken at 4,000 rpm under 4,448 N [1,000 lbs] thrust load is quite irregular. The comparison of the graphs of these two tests indicates that measuring errors are not a function of bearing speed at which the data was taken, i.e. the photographic system records the bearing component motions faithfully at speeds of 4,000 and 12,000 rpm.

From the plots representing IA-5 (figure 16) it can also be seen that a relatively low error in ball speed results in smooth curves defining ball spin axis orientation.

It is evident on all graphs that the plotted separator speed variations are well within $\pm$ 2% limits. This is to be expected since separator speed measurements are much simpler to take than ball speed measurements.

7.3 Suggested Program Improvements

The above mentioned inaccuracies in the experimental results suggest that several refinements should be considered to improve the data in future investigations.

(1) Filming technique - It has been found that the film frames which show the greatest number of measurable target points on the test ball yield the most accurate data. The test data could thus be improved by increasing the illumination of the target ball during the filming sequence.

(2) Film measuring technique - Future large scale ball motion studies should be preceded by an evaluation of potential refinements in the film measuring technique.

The present technique requires manual measurements of target points on the film projection with the aid of templates. This procedure is time consuming, and the accuracy of the readings depends on the skill of the technician (movie-reader). A computer aided system could be set up where the coordinates of the target points in a film projection are measured using a graphical digitizer and the measurements are directly printed out and compared for compatability with their known relative position on the test ball periphery, i.e. with the established ball map. Such a system would not only result in considerable timesavings but would eliminate misinterpretations of target points and reduce erroneous readings. The major components for such a system are commercially available.

(3) Computerized data reduction - Large, instantaneous ball speed variations are, as previously stated, caused by

occasional measuring errors. Presently these erroneous readings, especially the very large blips in the curves, affect the "average" ball speed, as well as the derived data for ball spin axis orientation. The curves could be effectively smoothed if all measuring points which yield an apparent ball speed deviation in excess of a predetermined amount, say 50% or 60% from the average speed (by its present definition), were ignored. Permitting data points within the relatively high 50% or 60% limit would eliminate only true error points, but would still permit the detection of considerable, but expected variations of ball speed as function of ball location.

Further, of immediate interest, is an error analsyis to determine the effect of measurement errors on the results when the existing computer program is used. A paralleling effort should be performed to review the mathematical approach of the program itself to determine whether it is the best possible solution for the ball motion problem statement.

The foregoing indicates that this program resulted in useful information on ball dynamics. However, futher refinements of the employed techniques are possible and desireable, and would unquestionably result in improved data.

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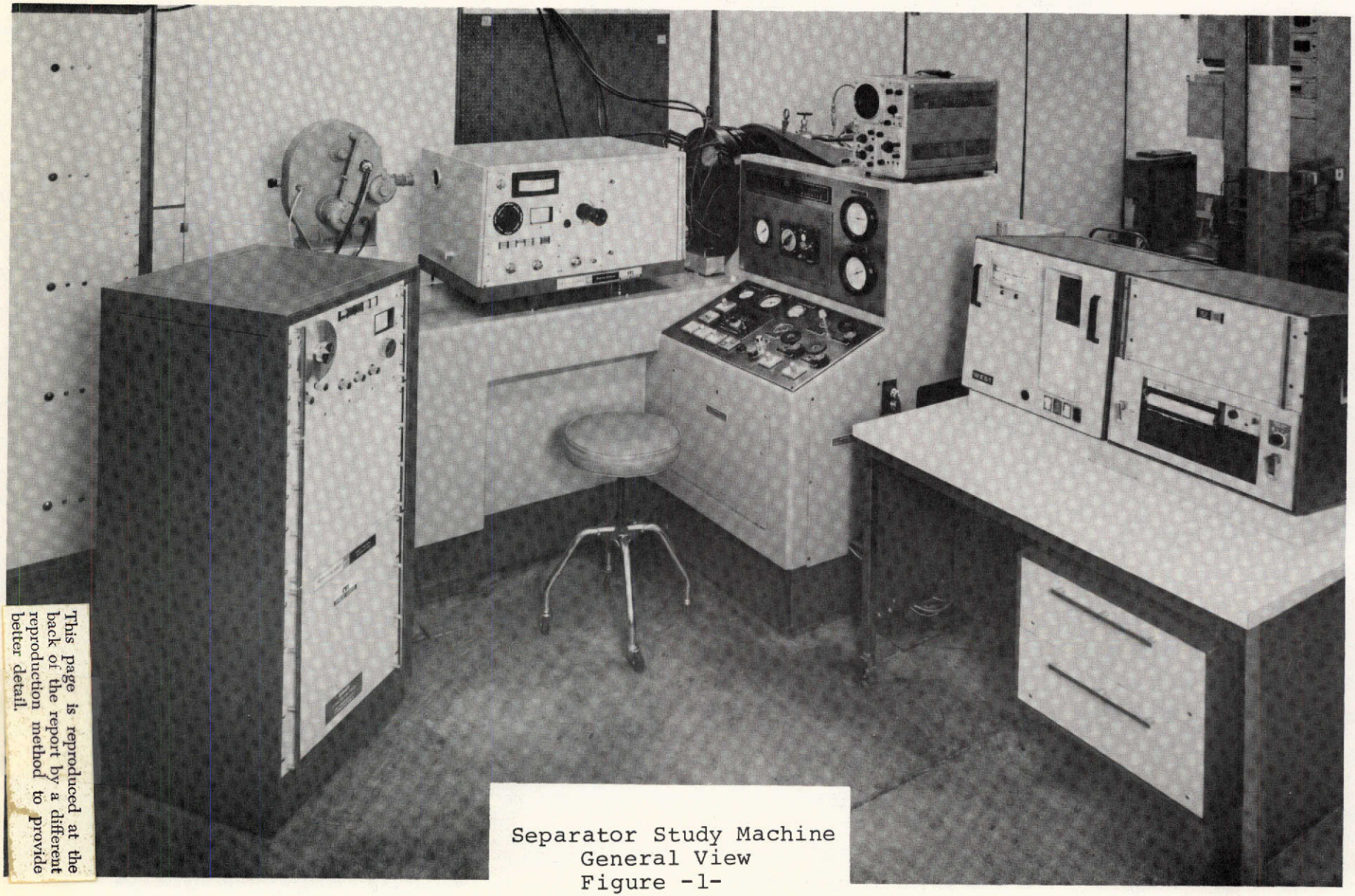
3. Anderson, R. W. and Brown, P. F. Jr., Pratt & Whitney Aircraft: A Method to Determine Ball Kinematics from High Speed Ball Bearing Movies, TDM-2306 of 5-19-72.

4. Fehlmann, U. O. and Signer, H. R., ITI: Final Report on Ball Kinematic Measurements to Checkout the Computer Program for Data Reduction, P-1230-I, submitted to Pratt & Whitney Aircraft 1-31-72.



Separator Study Machine
General View
Figure -1-

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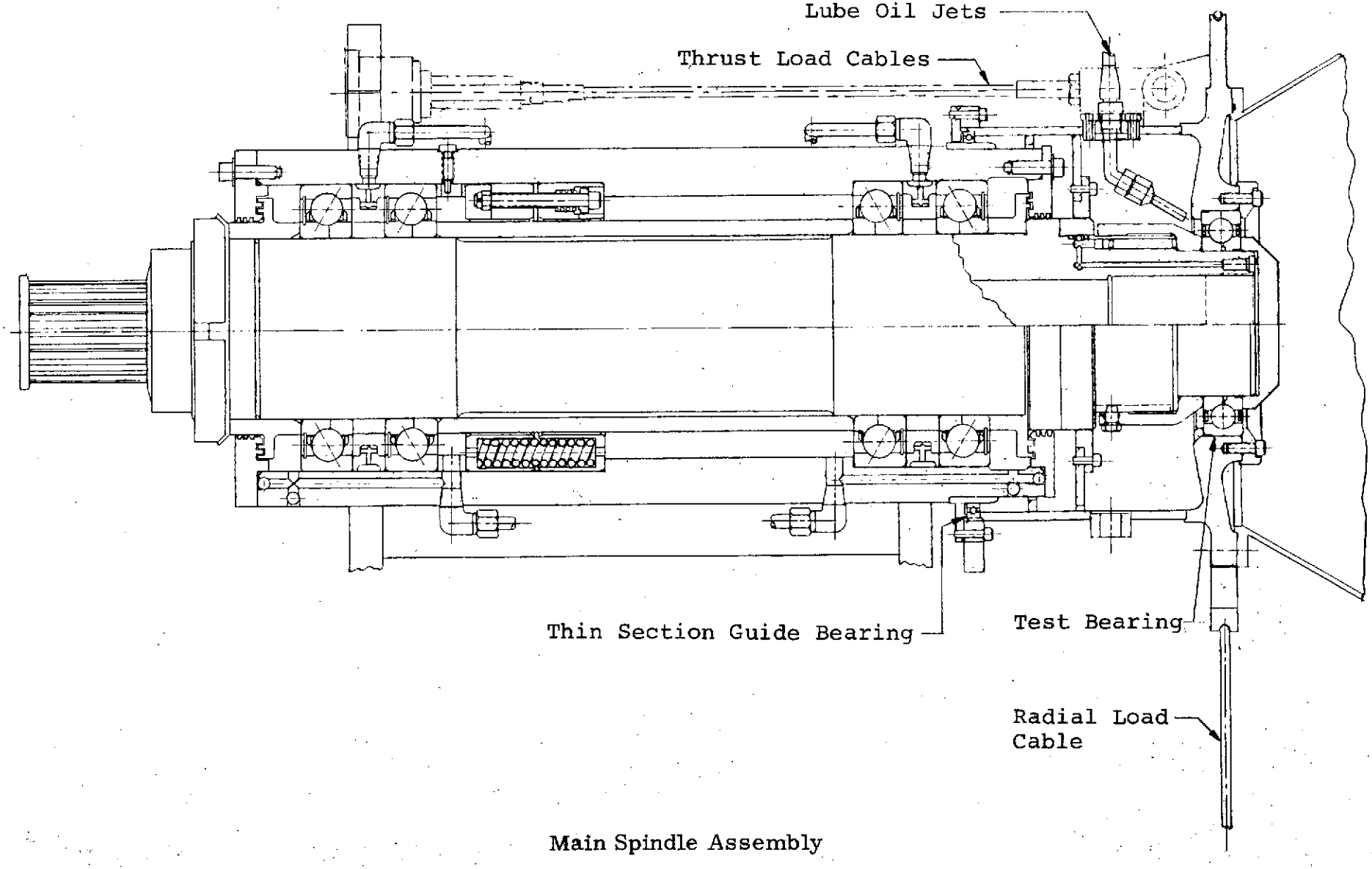
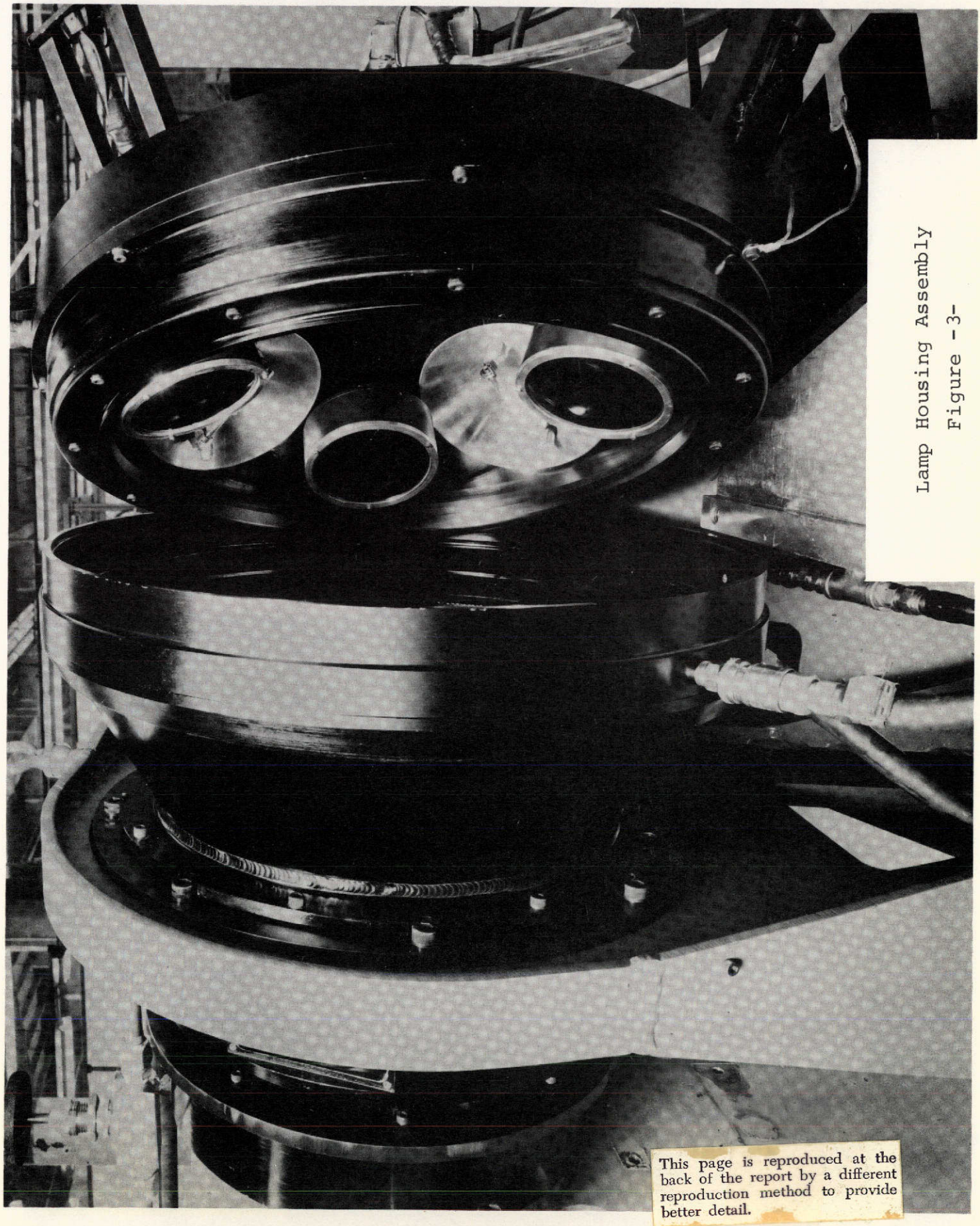


Main Spindle Assembly

Figure -2-



Lamp Housing Assembly
Figure -3-

This page is reproduced at the back of the report by a different reproduction method to provide better detail.

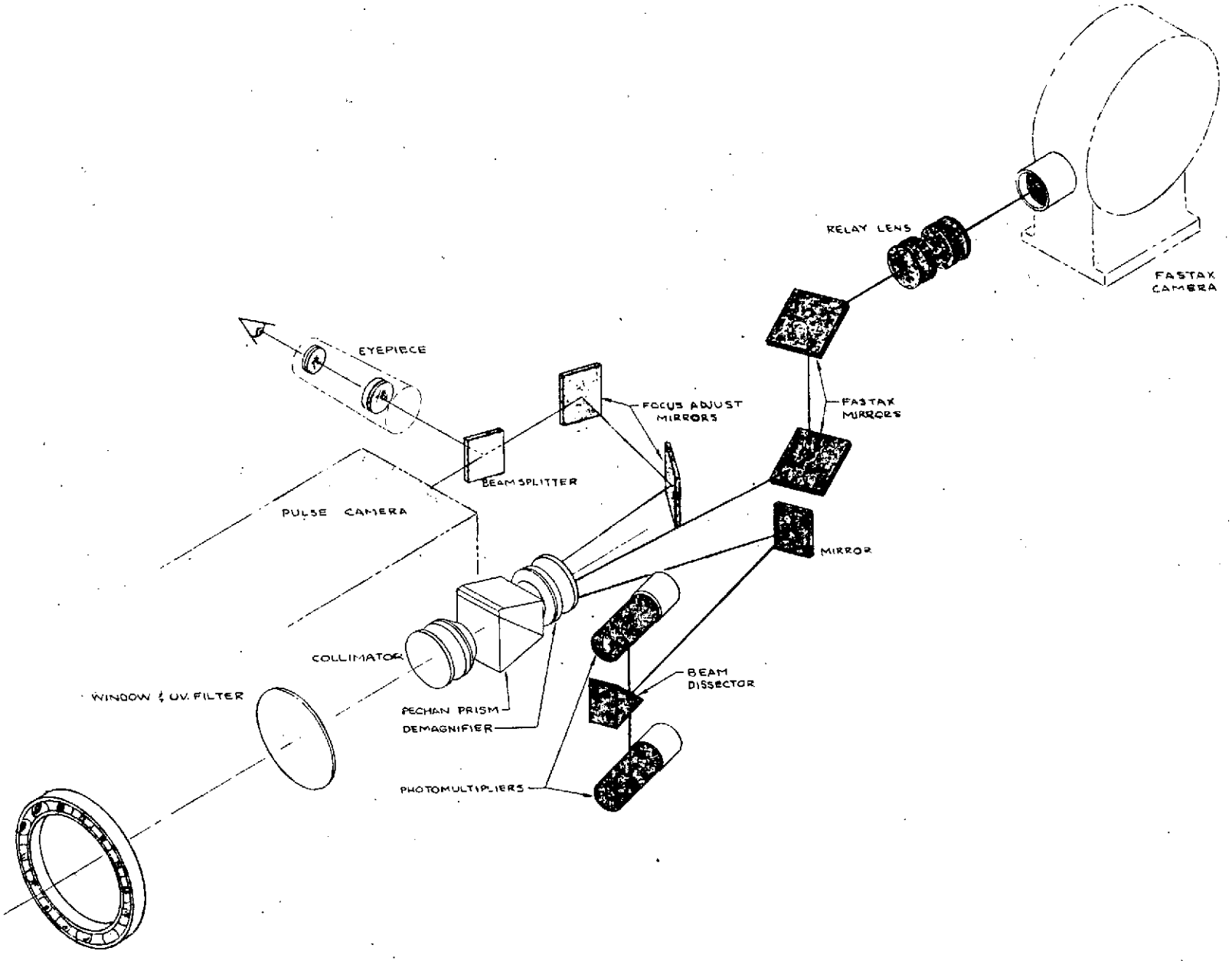


Figure -4-

Optical Paths through Bearing Scanner

INDUSTRIAL TECTONICS, INC.

C.R.	APP'D	ITI IDENTIFICATION NUMBER	REV.
P-1246	DR. KF	13453 / 13454 [3]	

RING MATERIAL	ROLLING ELEM. MAT		BEARING TYPE
CEVM M-50 R_c 61 MIN.	CEVM M-50 R_c 61 MIN.		SPLIT INNER RING BALL BEARING
SEP. MAT. AND TYPE: AMS 6415, 1 PIECE MACHD, R_c 28 - 30 [1]		CONTACT ANGLE [3]	RACE RADIUS, % BALL DIA.: 53 INNER, 52 OUTER
			NO. AND SIZE ROLL. ELEMENTS: 20 - .750 DIA. GRADE 10

OUTER RING	INNER RING	LUBRICATION
OD 6.890	OD 5.340	MIL-L-23699
ID 6.070	ID 4.330	
WIDTH 1.181	WIDTH 1.181	SEPARATOR: SPECIAL, OPEN POCKET [2]

NOTES:

[1] SEPARATOR INNER LAND GUIDED. Ag PLATED PER AMS 2410, .001-.002 THICK.

[2] BALANCED TO 3 GRAM CENTIMETERS.

[3] P/N 13453 - CONTACT ANGLE 24°-27°
P/N 13454 - CONTACT ANGLE 32°-35°

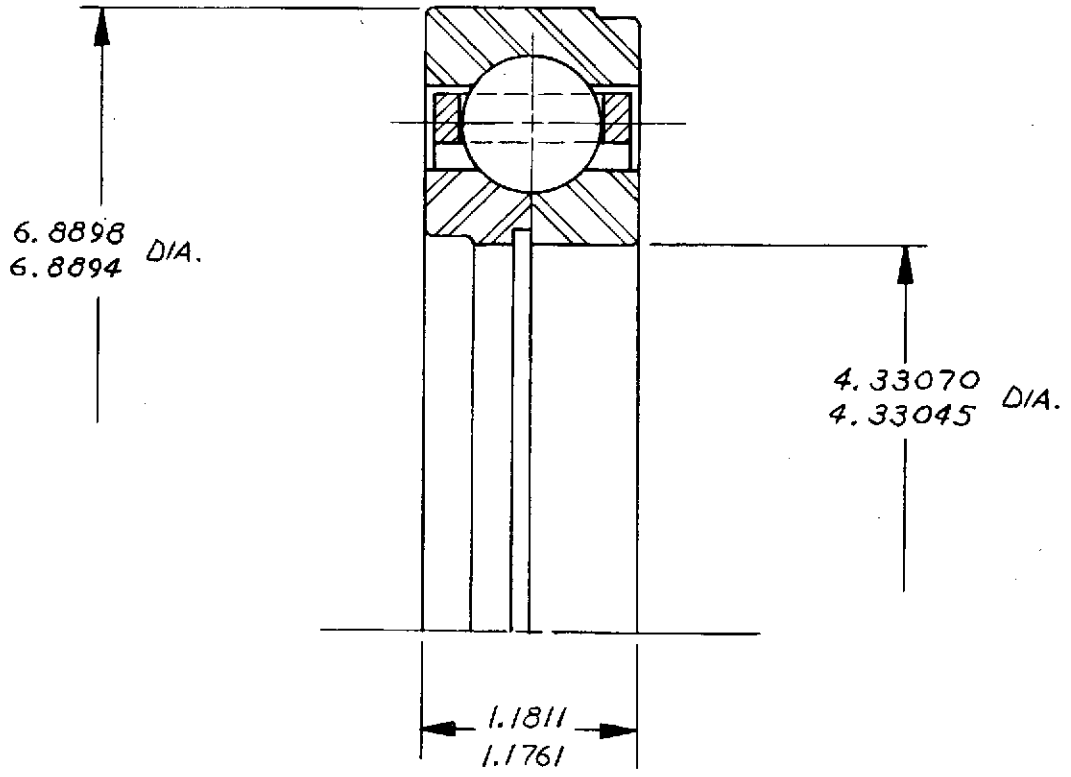
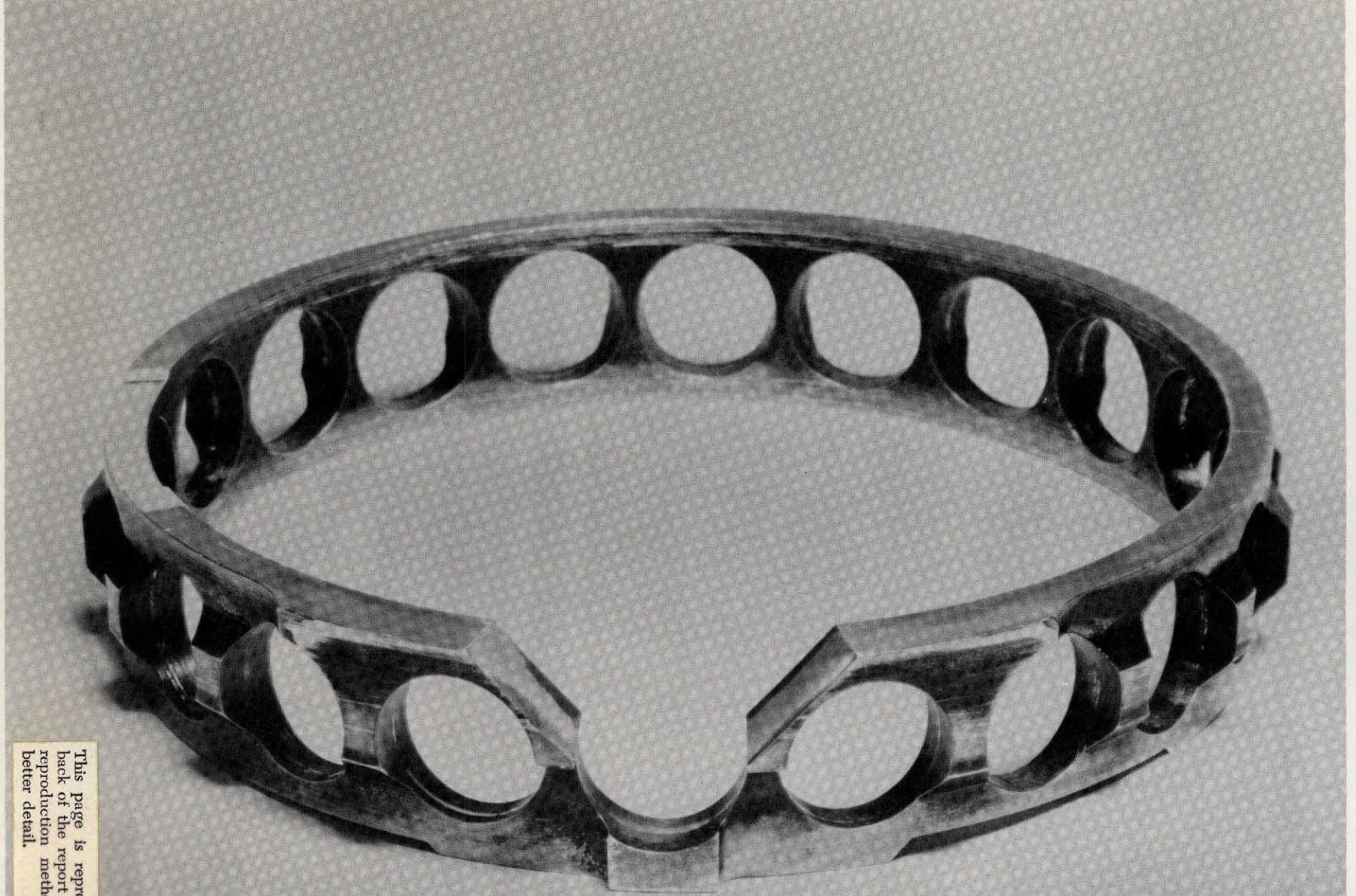
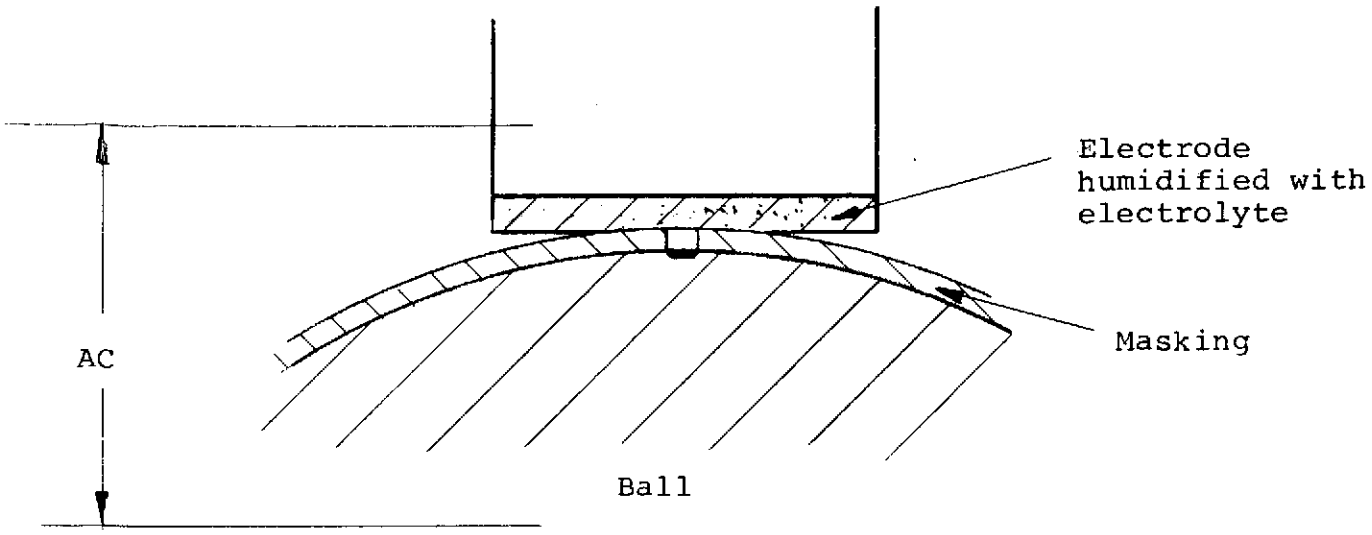


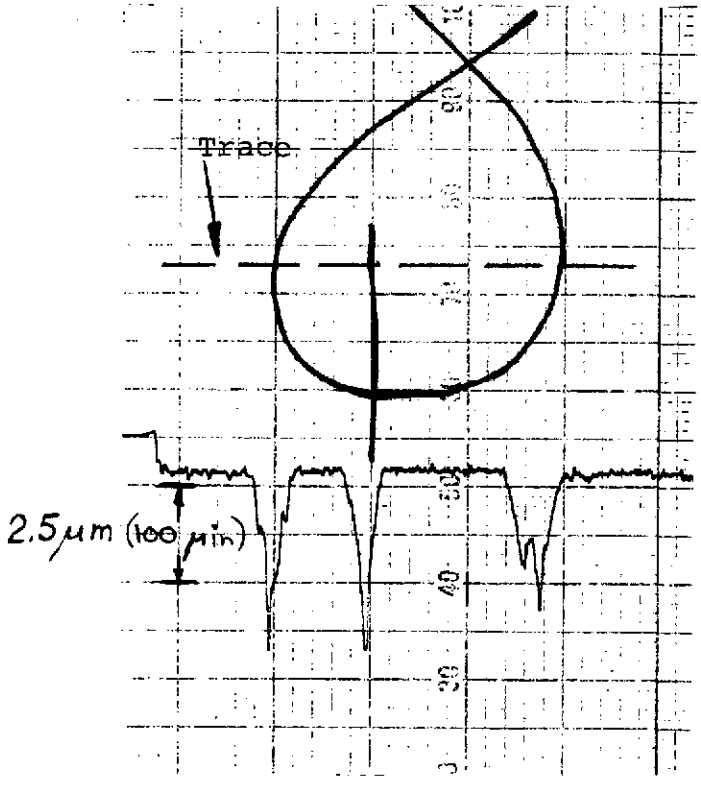
Figure -5-



Separator with Open Ball Pocket

Figure -6-





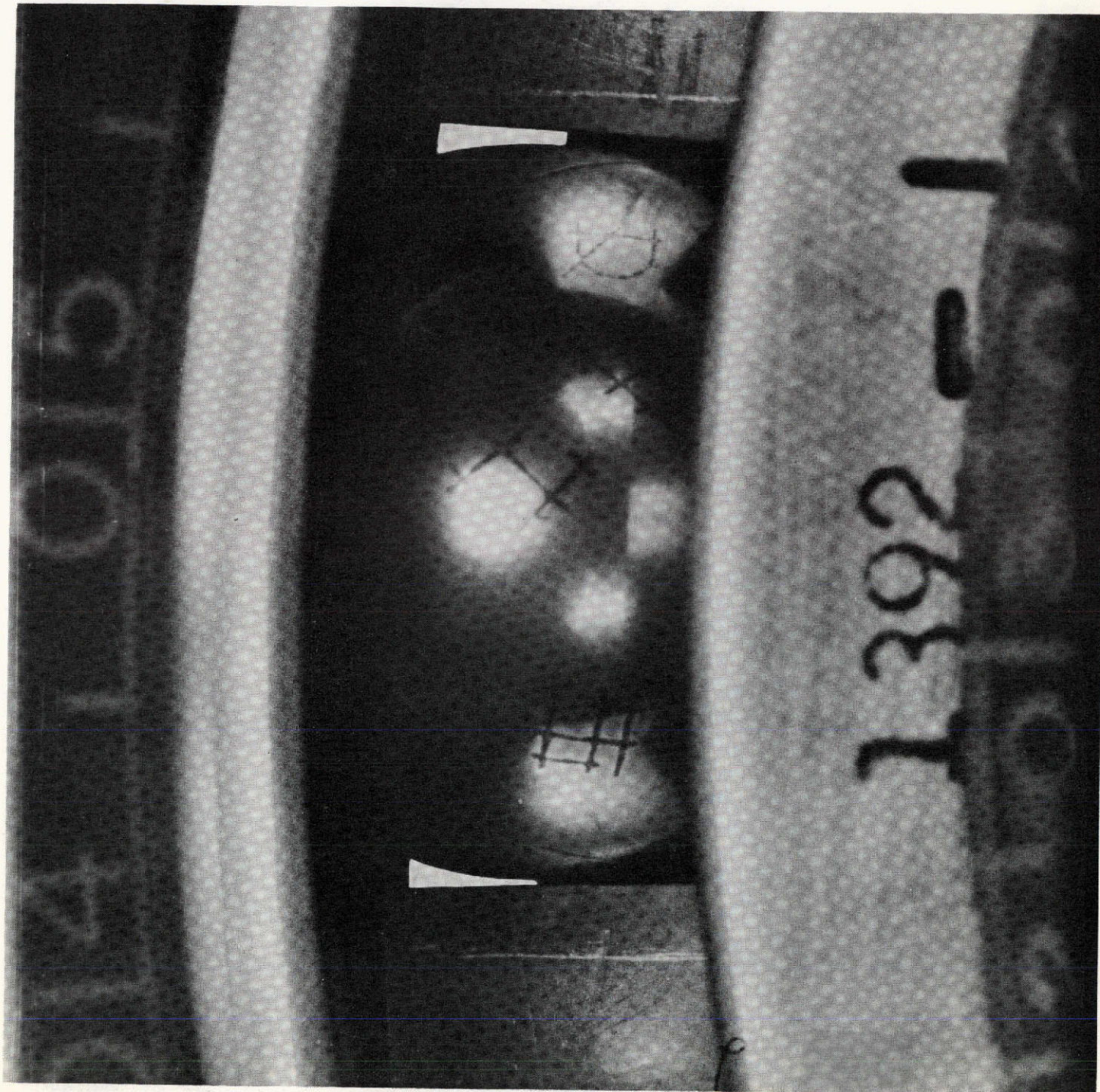
Surface trace of marked ball

Ball Marking by Electro-Chemical Etching

Figure -7-

Test Balls used in
Investigations of Bearing Kinematics

Figure -8-



High Speed Motion Picture
Ball Bearing Tests

Figure -9-

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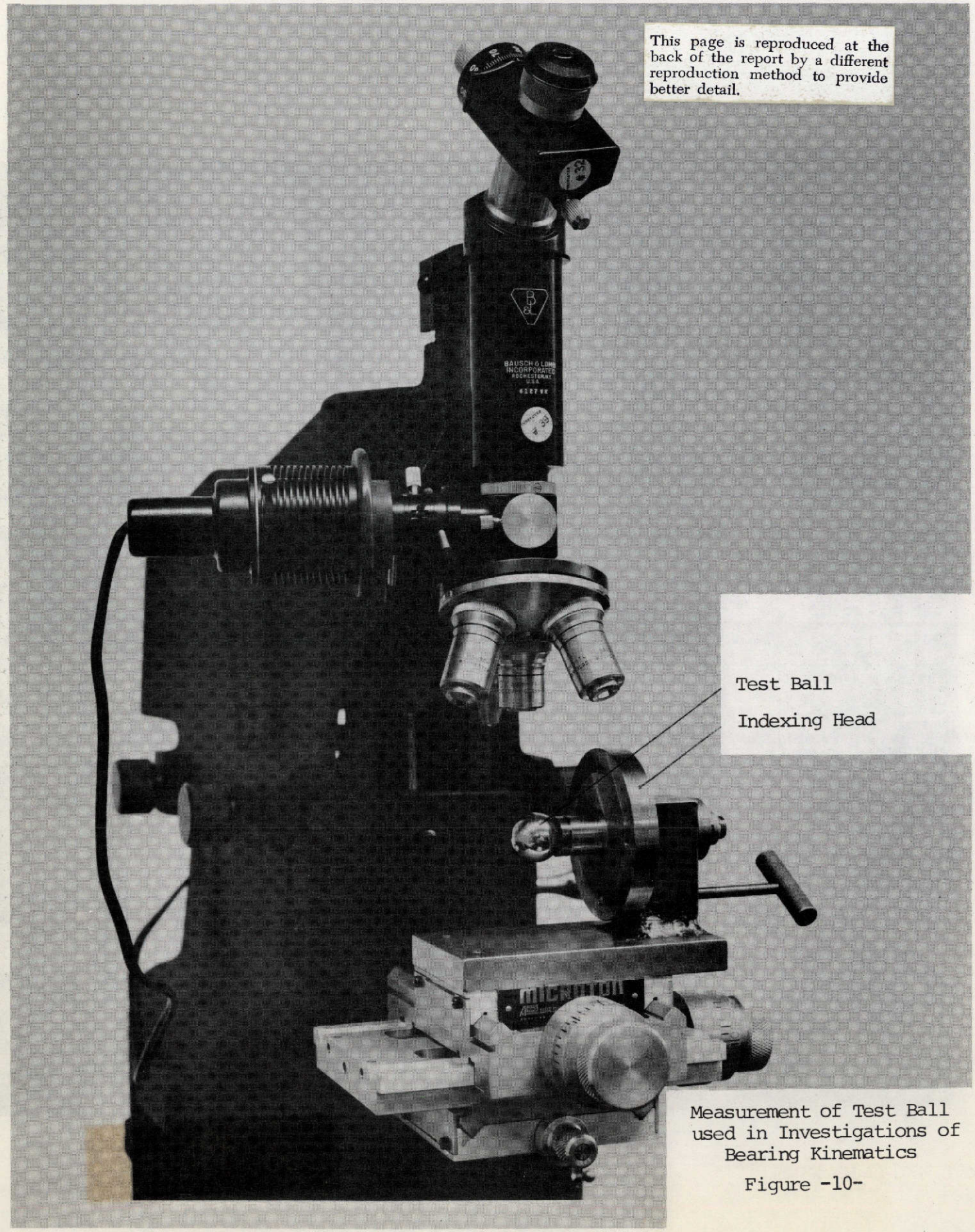
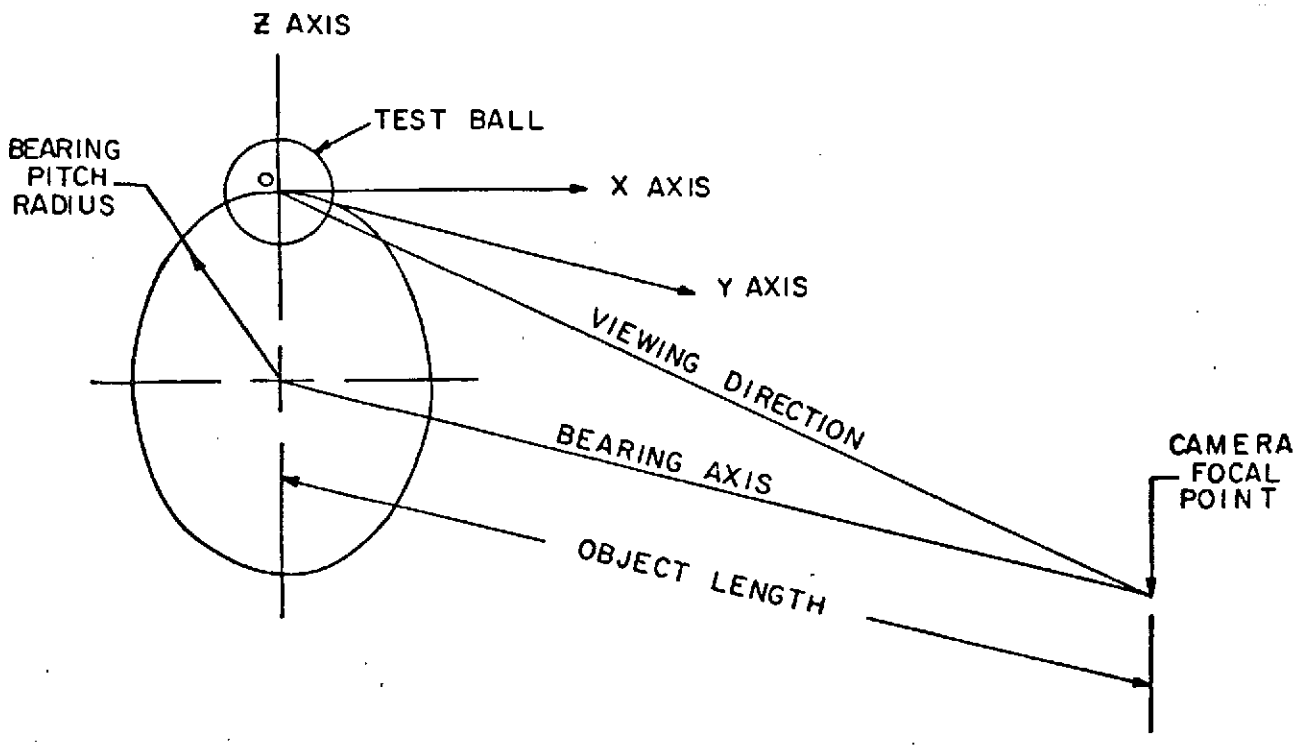
This page is reproduced at the back of the report by a different reproduction method to provide better detail.



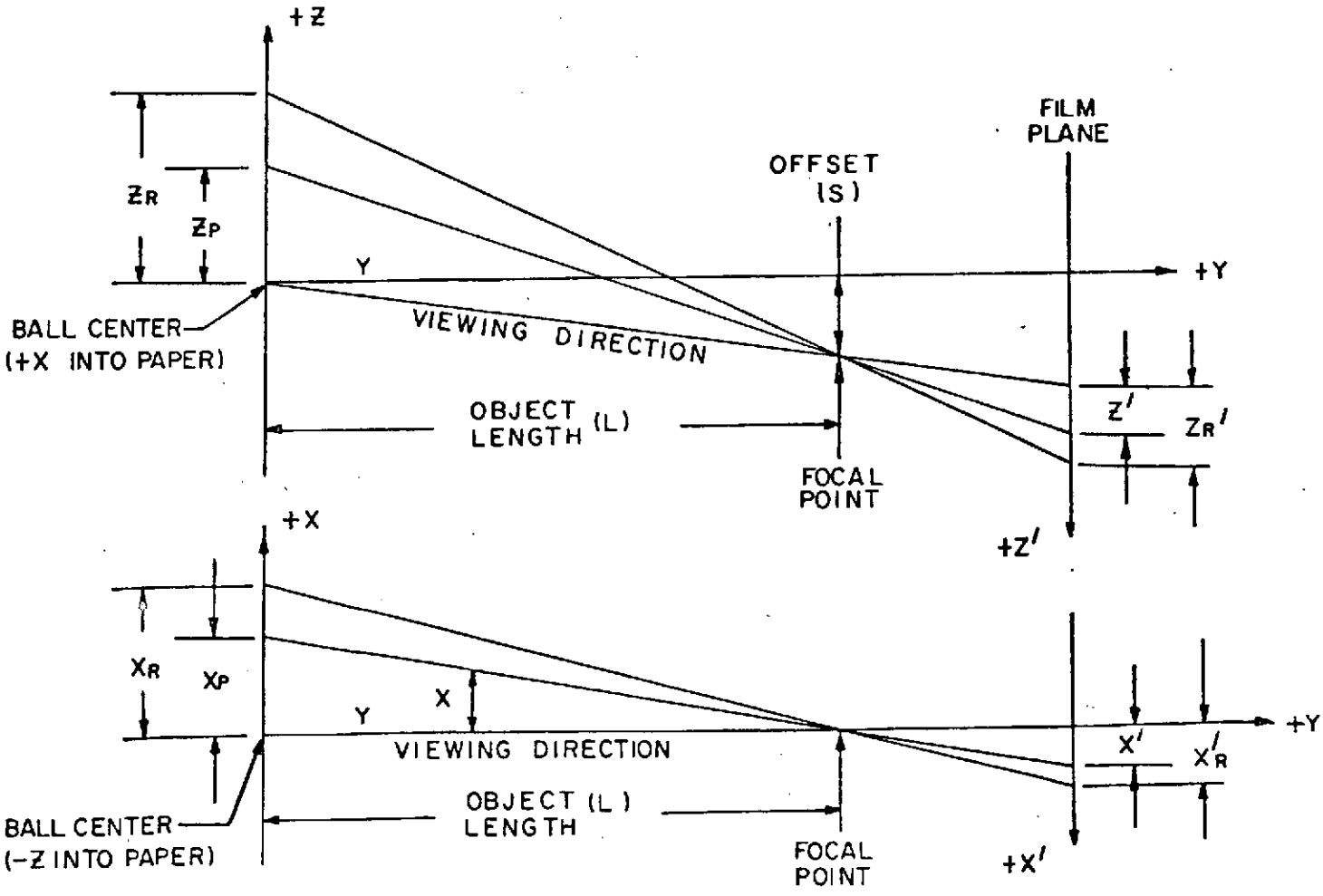
Measurement of Test Ball used in Investigations of Bearing Kinematics

Figure -10-



PITCH RADIUS COORDINATE SYSTEM

FIGURE 11A



DETERMINATION OF COORDINATES FROM FILM

FIGURE 11B

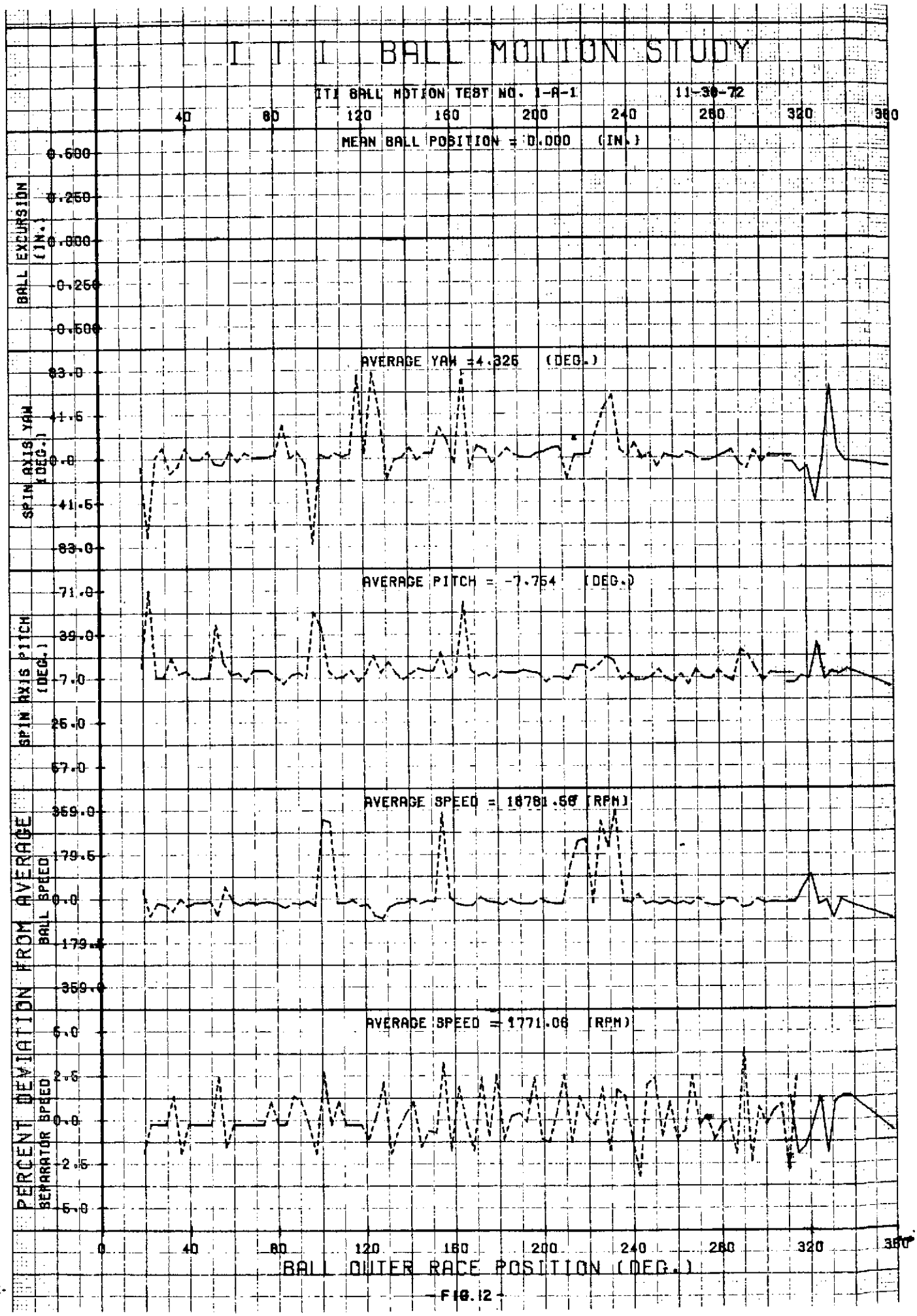
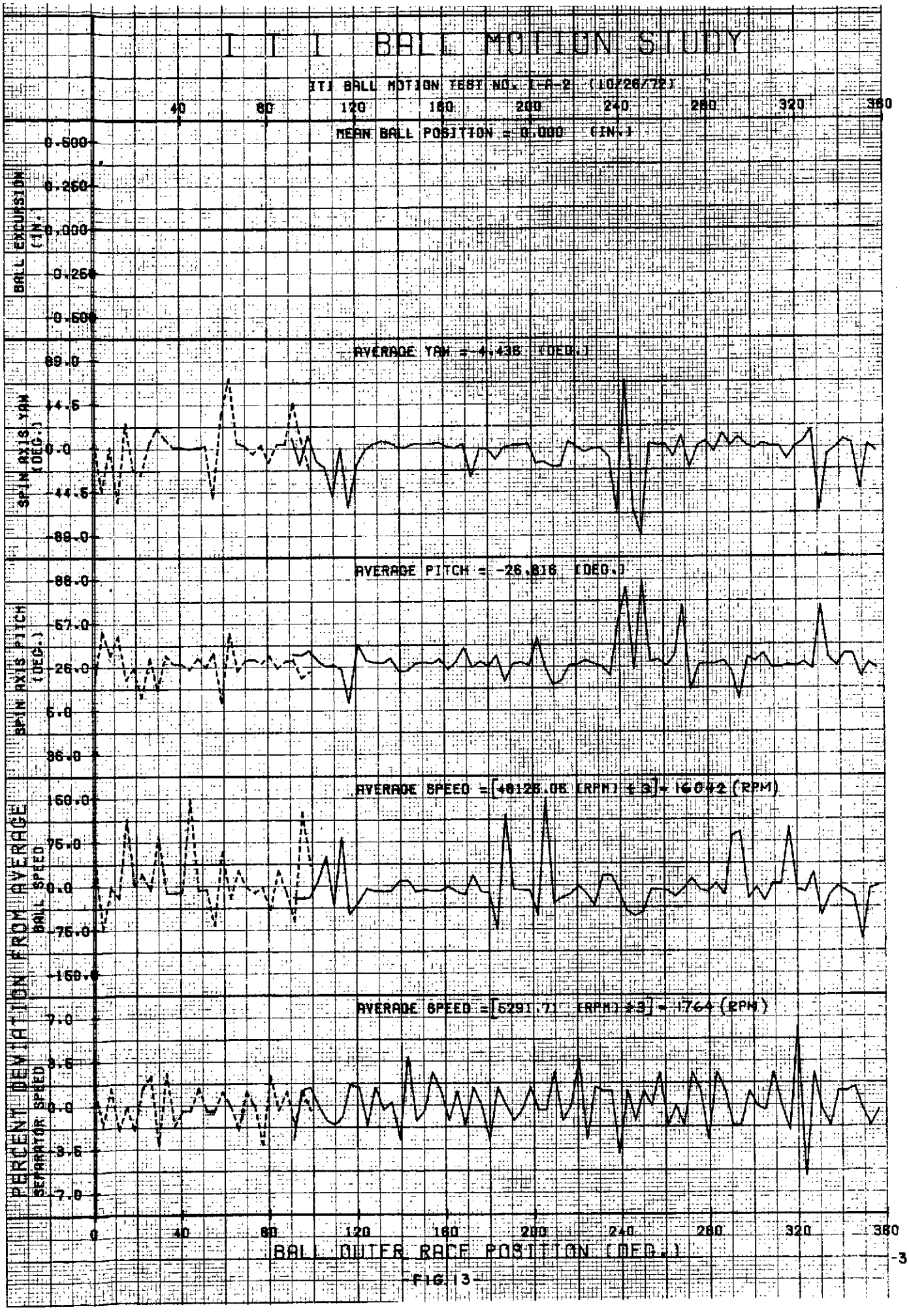
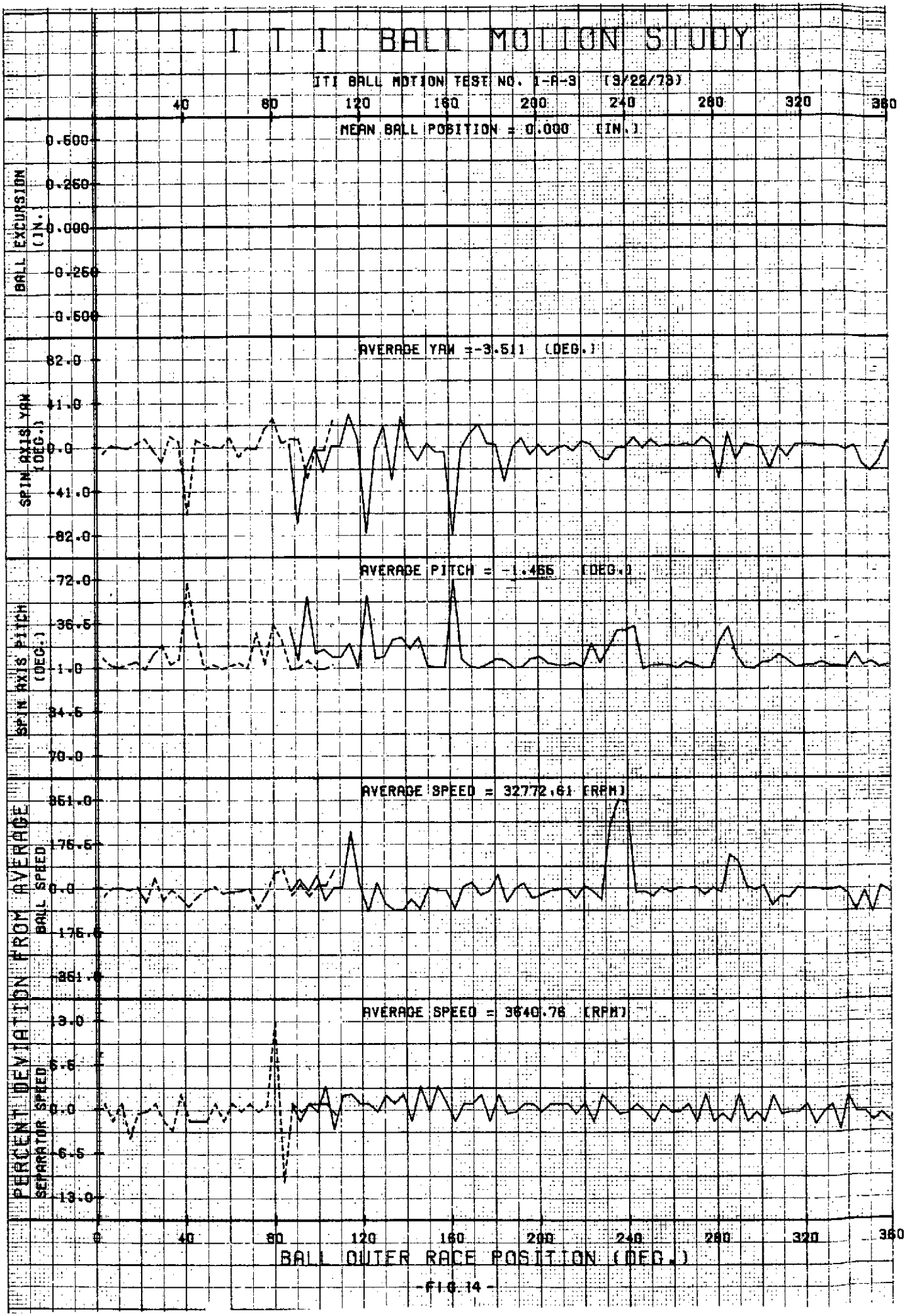

I T I BALL MOTION STUDY
ITI BALL MOTION TEST NO. 1-A-1
11-30-72
MEAN BALL POSITION = 0.000 (IN.)
AVERAGE YAW =4.326 (DEG.)
AVERAGE PITCH = -7.754 (DEG.)
AVERAGE SPEED = 18781.68 (RPM)
AVERAGE SPEED = 1771.08 (RPM)
BALL EXCURSION (IN.)
SPIN AXIS YAW (DEG.)
SPIN AXIS PITCH (DEG.)
PERCENT DEVIATION FROM AVERAGE
BALL SPEED
SEPARATOR SPEED
BALL OUTER RACE POSITION (DEG.)

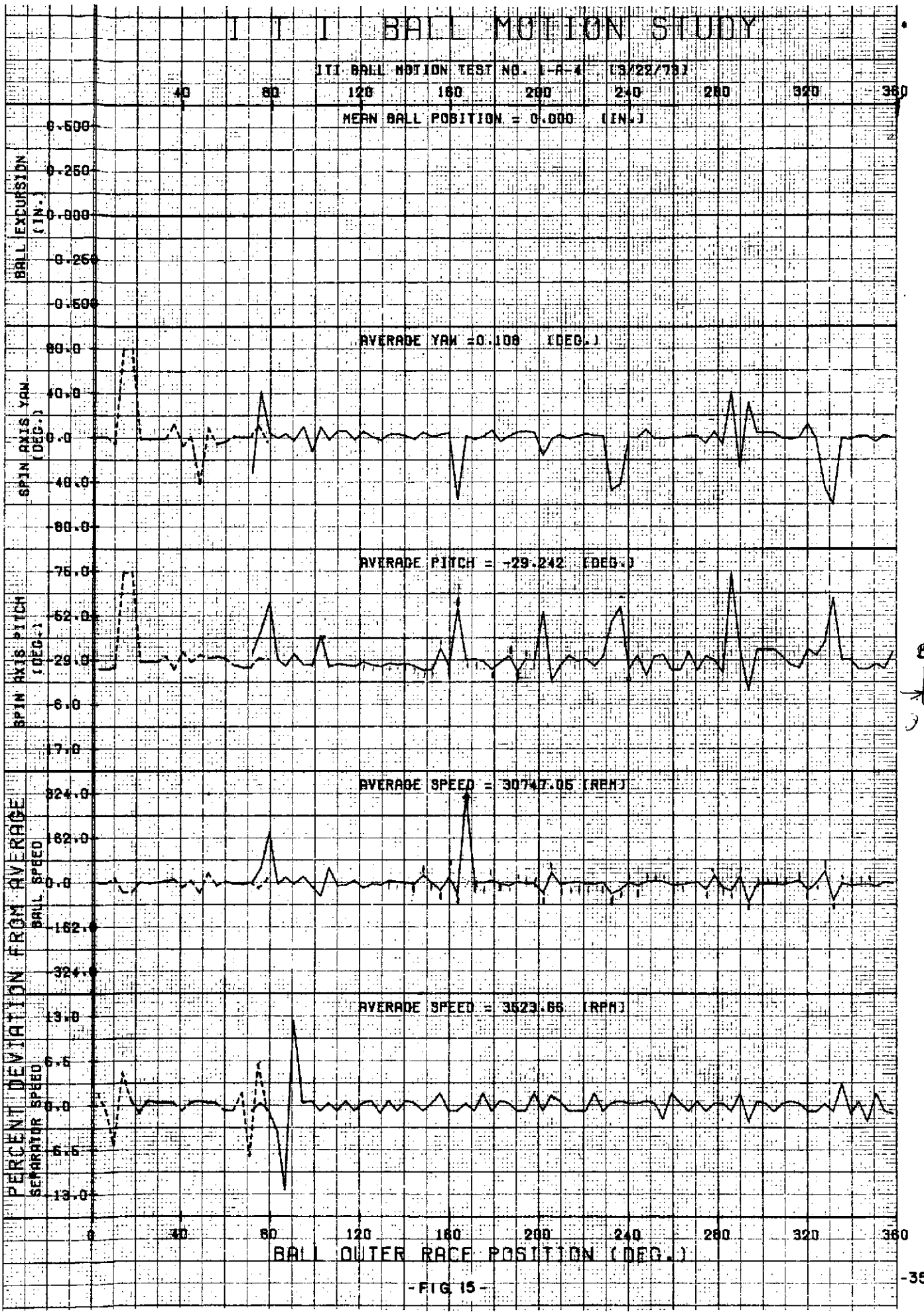
FIG. 12


ITI BALL MOTION STUDY
ITI BALL MOTION TEST NO. I-A-2 (10/26/72)
MEAN BALL POSITION = 0.000 (IN.)
BALL EXCURSION (IN.)
0.500
0.250
0.000
-0.250
-0.500
AVERAGE YAW = -4.438 (DEG.)
SPIN AXIS YAW (DEG.)
89.0
44.5
0.0
-44.5
-89.0
AVERAGE PITCH = -26.816 (DEG.)
SPIN AXIS PITCH (DEG.)
-88.0
-57.0
-26.0
5.0
36.0
AVERAGE SPEED =[48126.06 (RPM) ± 3] = 16042 (RPM)
PERCENT DEVIATION FROM AVERAGE
BALL SPEED
150.0
75.0
0.0
-75.0
-150.0
AVERAGE SPEED =[6291.71 (RPM) ±3] = 1764 (RPM)
SEPARATOR SPEED
7.0
3.5
0.0
-3.5
-7.0
0
40
80
120
160
200
240
280
320
360
BALL OUTER RACE POSITION (DEG.)

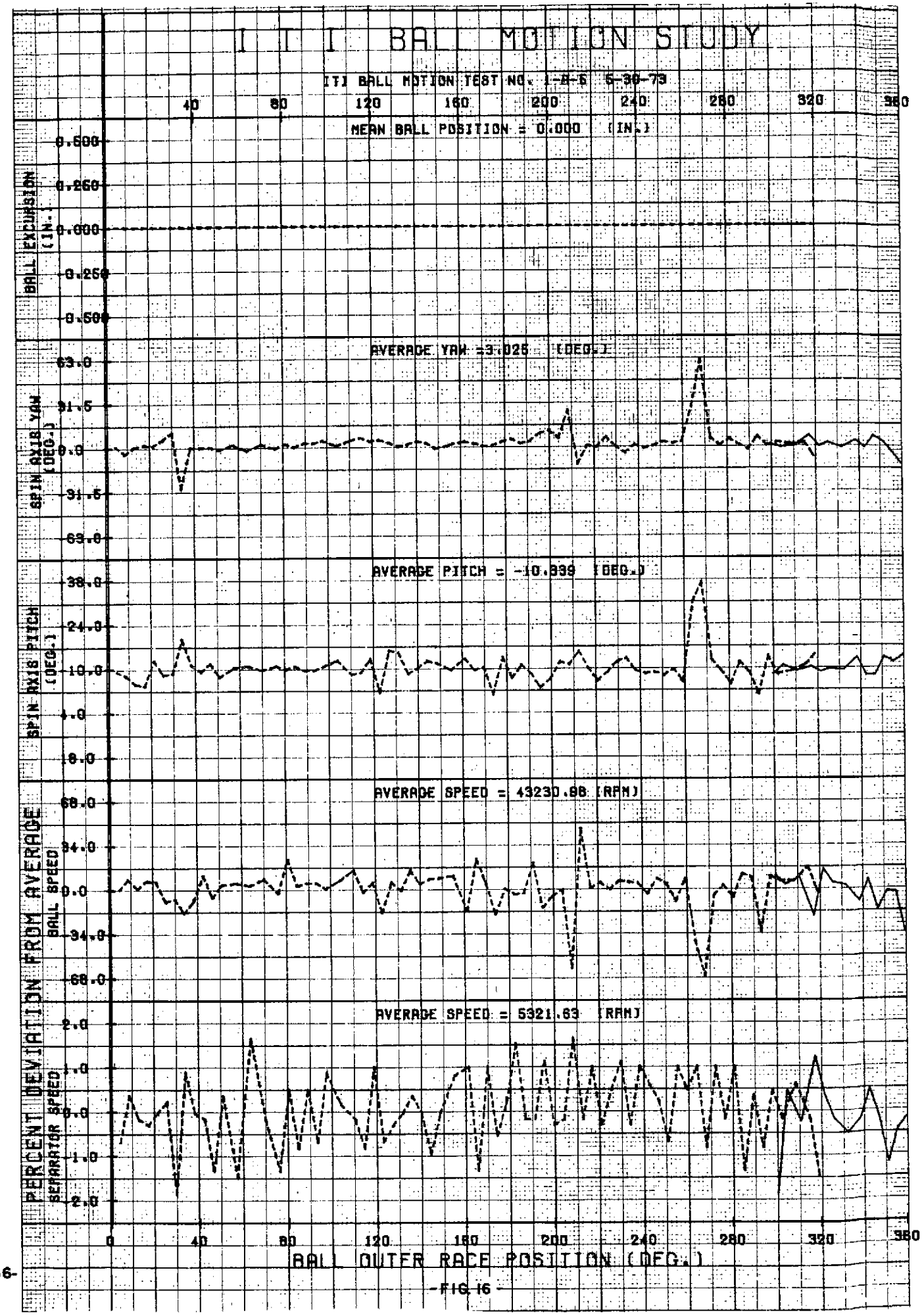
-FIG.13-


I T I BALL MOTION STUDY
ITI BALL MOTION TEST NO. 1-A-3 (3/22/78)
MEAN BALL POSITION = 0.000 (IN.)
BALL EXCURSION (IN.)
0.500
0.250
0.000
-0.250
-0.500
AVERAGE YAW = -3.511 (DEG.)
SPIN AXIS YAW (DEG.)
82.0
41.0
0.0
-41.0
-82.0
AVERAGE PITCH = -1.466 (DEG.)
SPIN AXIS PITCH (DEG.)
72.0
36.5
1.0
-34.5
-70.0
AVERAGE SPEED = 32772.61 (RPM)
PERCENT DEVIATION FROM AVERAGE BALL SPEED
351.0
176.5
0.0
-176.5
-351.0
AVERAGE SPEED = 3640.76 (RPM)
SEPARATOR SPEED
13.0
6.5
0.0
-6.5
-13.0
0
40
80
120
160
200
240
280
320
360
BALL OUTER RACE POSITION (DEG.)

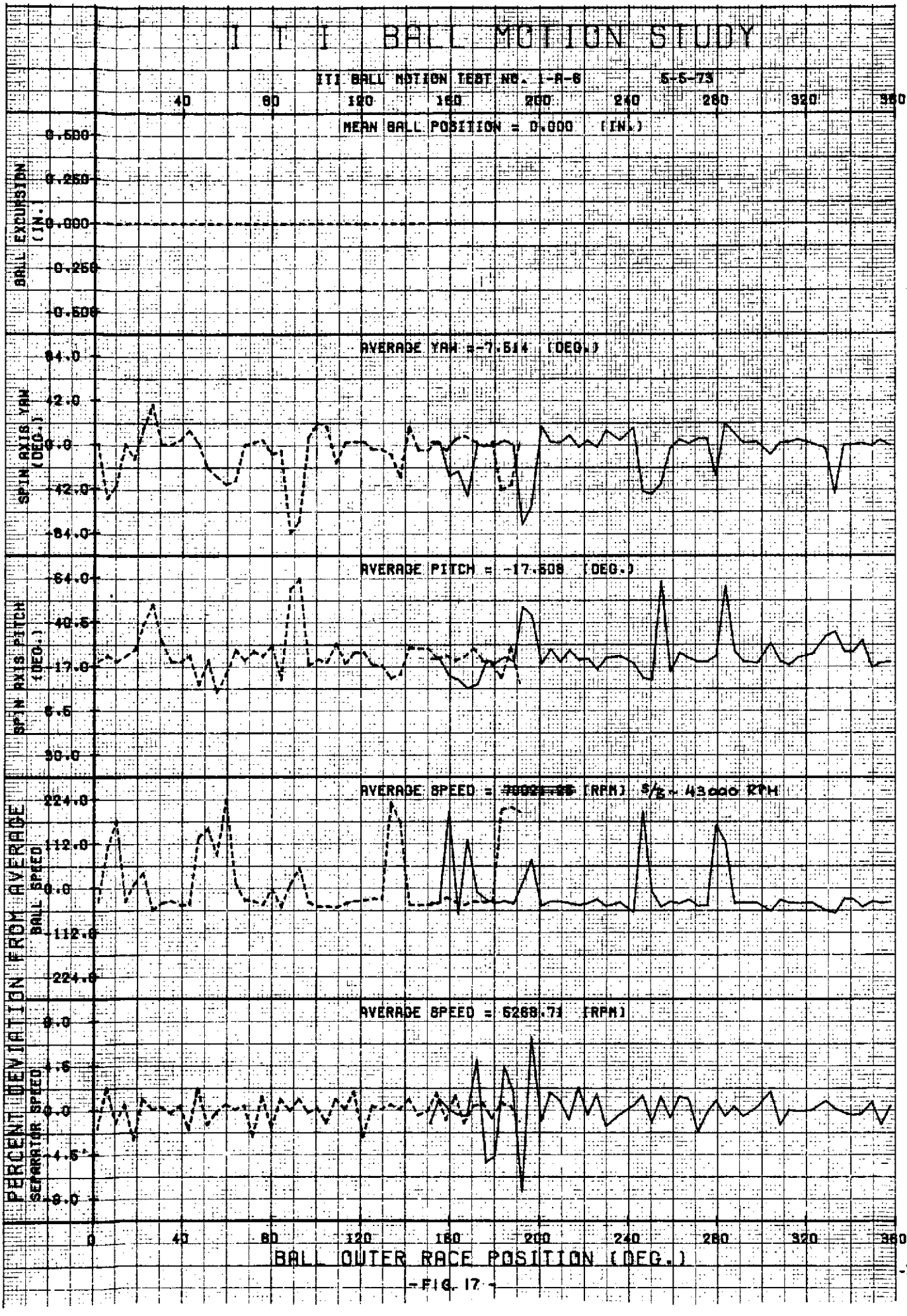
-FIG.14-


I I I BALL MOTION STUDY
III BALL MOTION TEST NO. 1-8-4 (3/22/79)
MEAN BALL POSITION = 0.000 (IN.)
BALL EXCURSION (IN.)
0.500
0.250
0.000
-0.250
-0.500
AVERAGE YAW =0.108 (DEG.)
SPIN AXIS YAW (DEG.)
80.0
40.0
0.0
-40.0
-80.0
AVERAGE PITCH = -29.242 (DEG.)
SPIN AXIS PITCH (DEG.)
-75.0
-52.0
-29.0
-6.0
-17.0
AVERAGE SPEED = 30740.05 (RPM)
PERCENT DEVIATION FROM AVERAGE
BALL SPEED
324.0
162.0
0.0
-162.0
-324.0
AVERAGE SPEED = 3523.66 (RPM)
SEPARATOR SPEED
13.0
6.5
0.0
-6.5
-13.0
0
40
80
120
160
200
240
280
320
360
BALL OUTER RACE POSITION (DEG.)

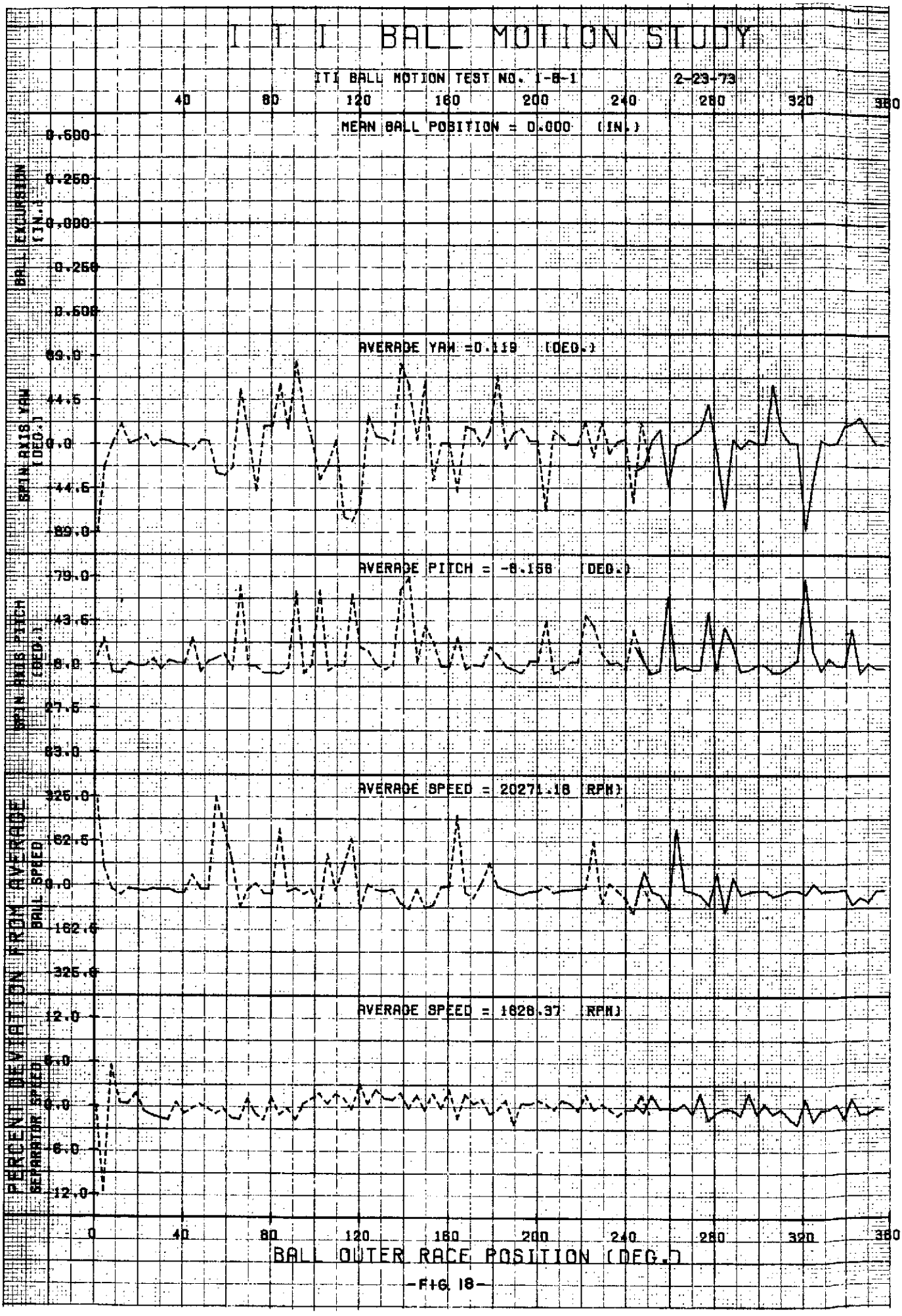
- FIG 15 -


I T I BALL MOTION STUDY
ITI BALL MOTION TEST NO. 1-8-6 5-30-73
MEAN BALL POSITION = 0.000 (IN.)
BALL EXPULSION (IN.)
AVERAGE YAW =3.025 (DEG.)
SPIN AXIS YAW (DEG.)
AVERAGE PITCH = -10.339 (DEG.)
SPIN AXIS PITCH (DEG.)
AVERAGE SPEED = 43230.98 (RPM)
BALL SPEED
AVERAGE SPEED = 5321.63 (RPM)
SEPARATOR SPEED
PERCENT DEVIATION FROM AVERAGE
BALL OUTER RACE POSITION (DEG.)

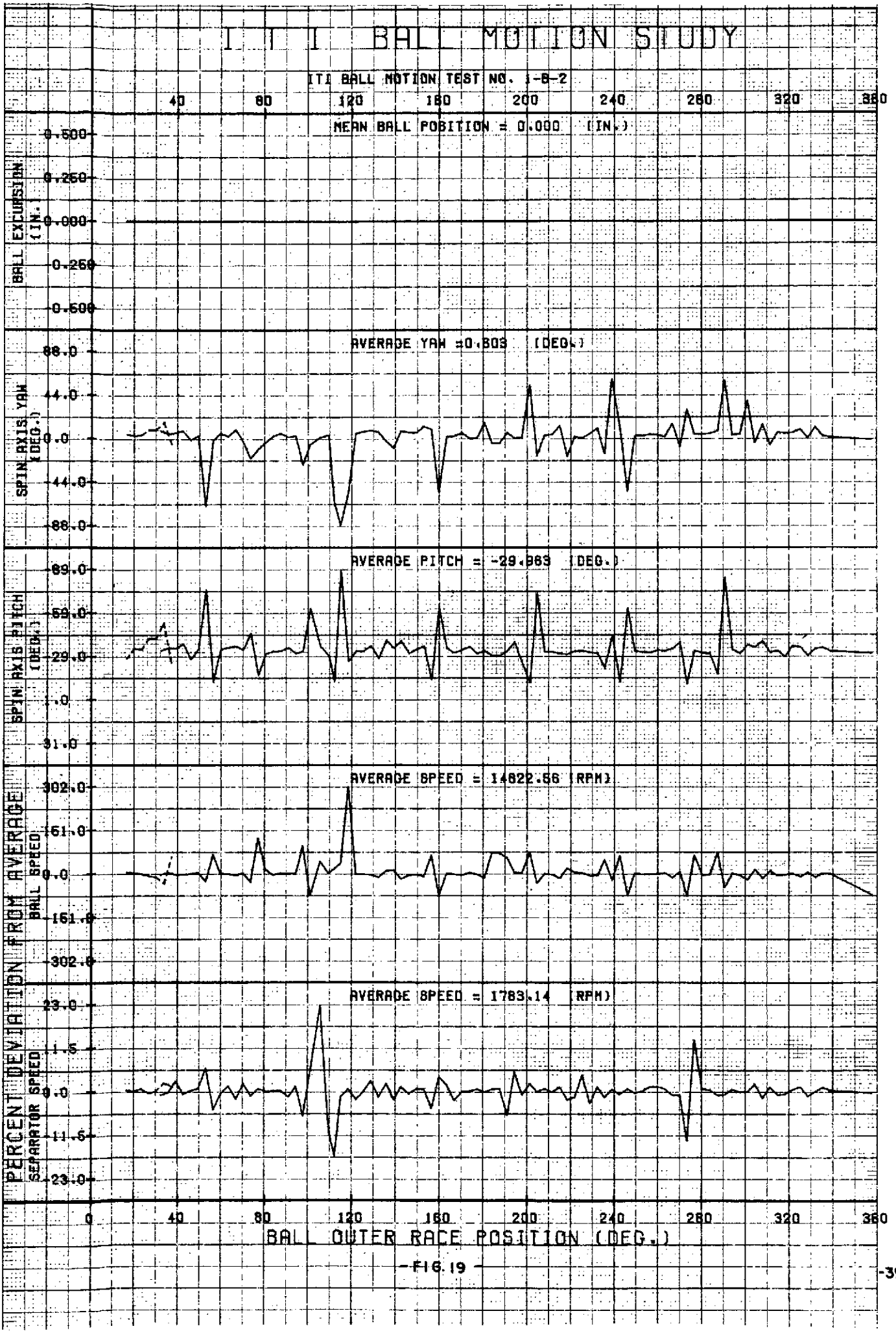
-FIG 16-


I I T I BALL MOTION STUDY
ITI BALL MOTION TEST NO. 1-A-6
5-5-73
MEAN BALL POSITION = 0.000 (IN.)
BALL EXCURSION (IN.)
0.500
0.250
0.000
0.250
0.500
AVERAGE YAW =-7.514 (DEG.)
SPIN AXIS YAW (DEG.)
84.0
42.0
0.0
42.0
84.0
AVERAGE PITCH = -17.608 (DEG.)
SPIN AXIS PITCH (DEG.)
64.0
40.5
17.0
6.5
30.0
AVERAGE SPEED = [illegible] (RPM) S/B - 43000 RPM
PERCENT DEVIATION FROM AVERAGE
BALL SPEED
224.0
112.0
0.0
112.0
224.0
AVERAGE SPEED = 6268.71 (RPM)
SEPARATOR SPEED
8.0
4.5
0.0
4.5
8.0
0
40
80
120
160
200
240
280
320
360
BALL OUTER RACE POSITION (DEG.)

-FIG. 17-


I T I BALL MOTION STUDY
ITI BALL MOTION TEST NO. 1-8-1
2-23-73
MEAN BALL POSITION = 0.000 (IN.)
AVERAGE YAW =0.119 (DEG.)
AVERAGE PITCH = -0.158 (DEG.)
AVERAGE SPEED = 20271.18 (RPM)
AVERAGE SPEED = 1828.37 (RPM)
BALL EXCURSION (IN.)
MAIN AXIS YAW (DEG.)
MAIN AXIS PITCH (DEG.)
BALL SPEED
SEPARATOR SPEED
PERCENT DEVIATION FROM AVERAGE
BALL OUTER RACE POSITION (DEG.)

-FIG. 18-


I T I BALL MOTION STUDY
ITI BALL MOTION TEST NO. 1-8-2
MEAN BALL POSITION = 0.000 (IN.)
BALL EXCURSION (IN.)
AVERAGE YAW =0.803 (DEG.)
SPIN AXIS YAW (DEG.)
AVERAGE PITCH = -29.963 (DEG.)
SPIN AXIS PITCH (DEG.)
AVERAGE SPEED = 14822.66 (RPM)
BALL SPEED
AVERAGE SPEED = 1783.14 (RPM)
SEPARATOR SPEED
PERCENT DEVIATION FROM AVERAGE
BALL OUTER RACE POSITION (DEG.)

-FIG.19-

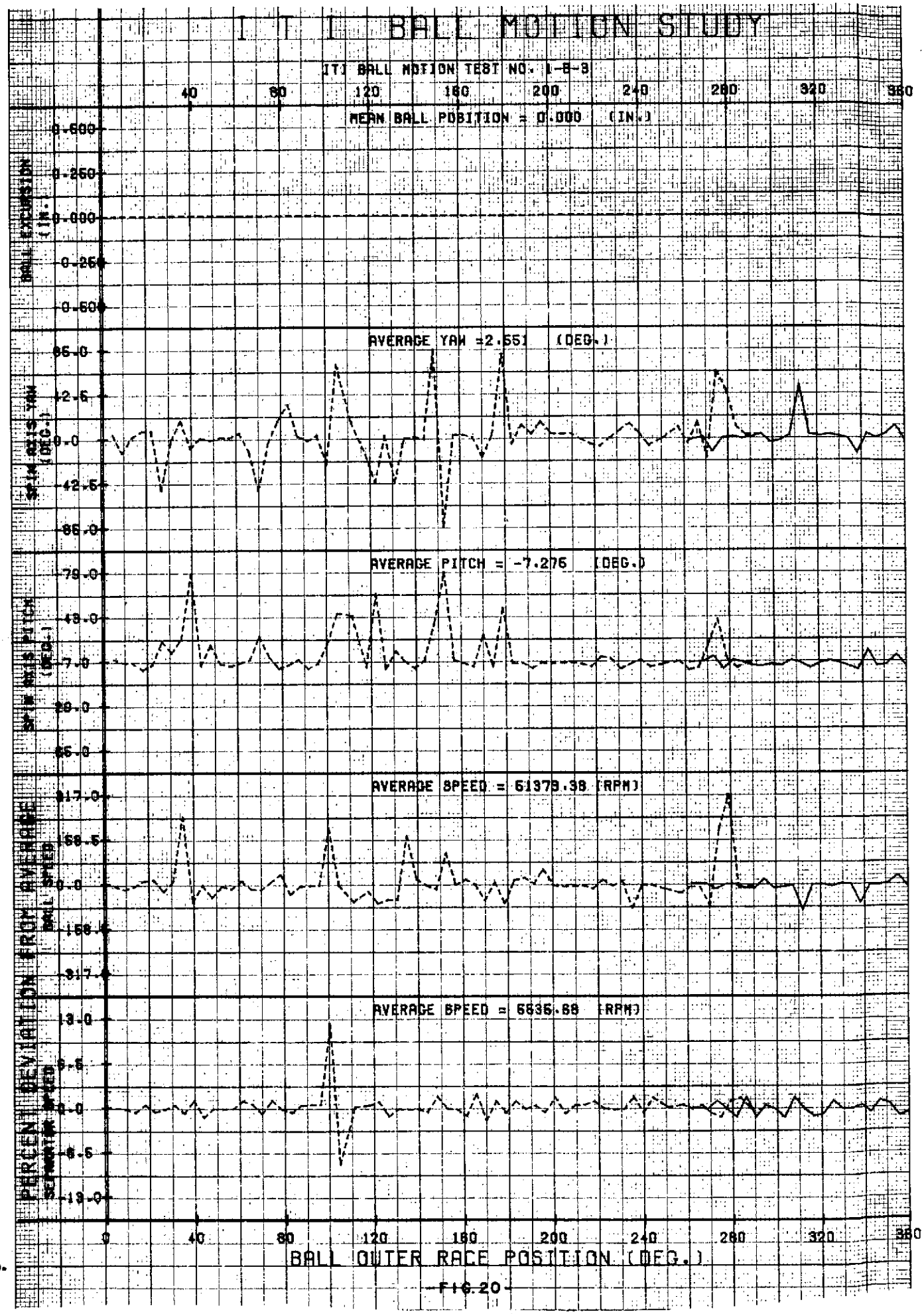
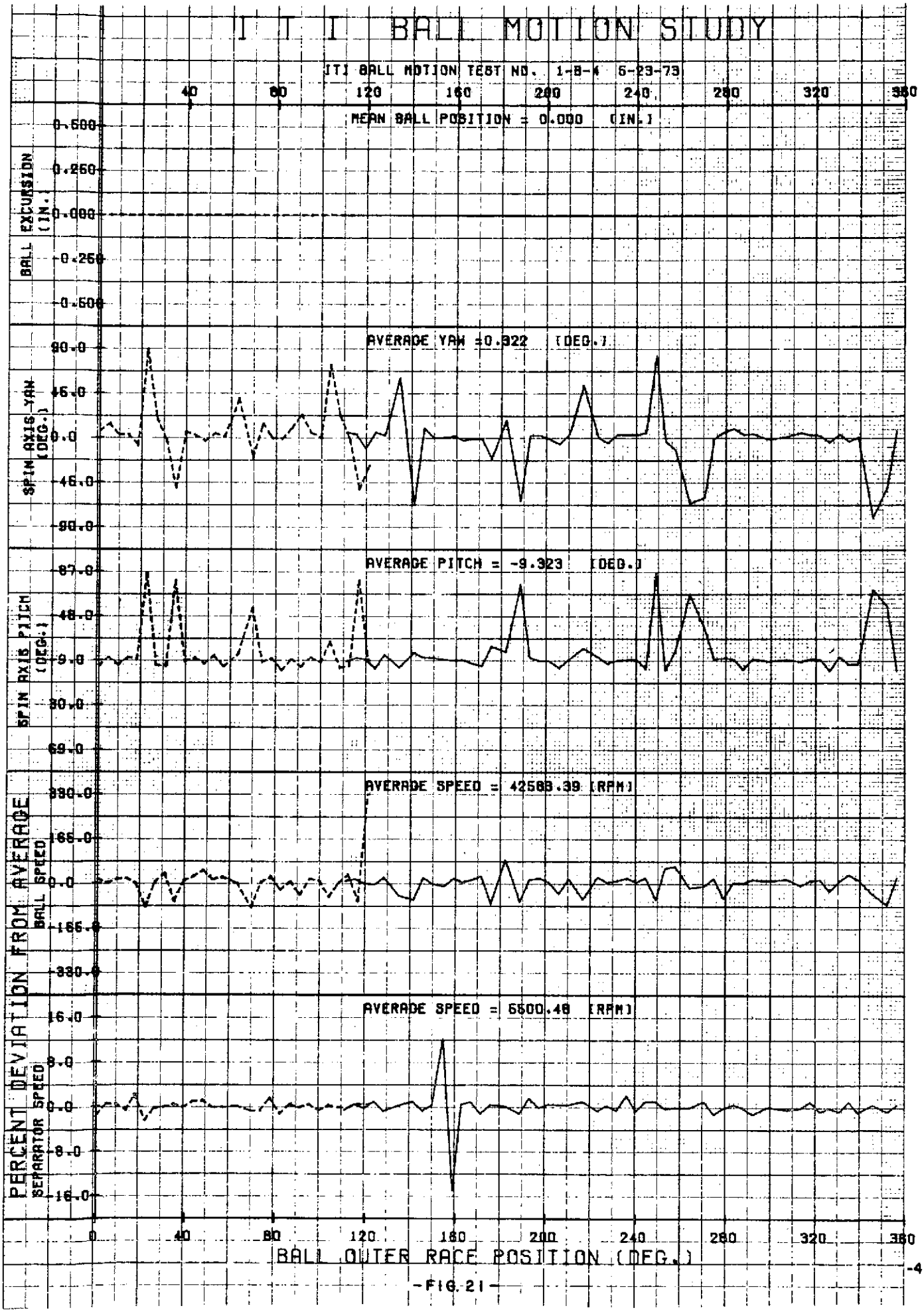

I T I BALL MOTION STUDY
ITI BALL MOTION TEST NO. 1-8-3
MEAN BALL POSITION = 0.000 (IN.)
BALL EXCURSION (IN.)
AVERAGE YAW =2.551 (DEG.)
SPIN AXIS YAW (DEG.)
AVERAGE PITCH = -7.276 (DEG.)
SPIN AXIS PITCH (DEG.)
AVERAGE SPEED = 61379.38 (RPM)
AVERAGE SPEED = 6836.68 (RPM)
PERCENT DEVIATION FROM AVERAGE BALL SPEED
0 40 80 120 160 200 240 280 320 360
BALL OUTER RACE POSITION (DEG.)

FIG.20


I T I BALL MOTION STUDY
ITI BALL MOTION TEST NO. 1-8-4 6-23-73
MEAN BALL POSITION = 0.000 (IN.)
BALL EXCURSION (IN.)
0.500
0.250
0.000
-0.250
-0.500
AVERAGE YAW =0.922 (DEG.)
SPIN AXIS YAW (DEG.)
90.0
45.0
0.0
-45.0
-90.0
AVERAGE PITCH = -9.323 (DEG.)
SPIN AXIS PITCH (DEG.)
-87.0
-48.0
-9.0
30.0
69.0
AVERAGE SPEED = 42588.39 (RPM)
BALL SPEED
330.0
165.0
0.0
-165.0
-330.0
AVERAGE SPEED = 6500.48 (RPM)
PERCENT DEVIATION FROM AVERAGE
SEPARATOR SPEED
16.0
8.0
0.0
-8.0
-16.0
0
40
80
120
160
200
240
280
320
360
BALL OUTER RACE POSITION (DEG.)

-FIG. 21-

Ball Rotational Speed vs. Inner Ring Speed

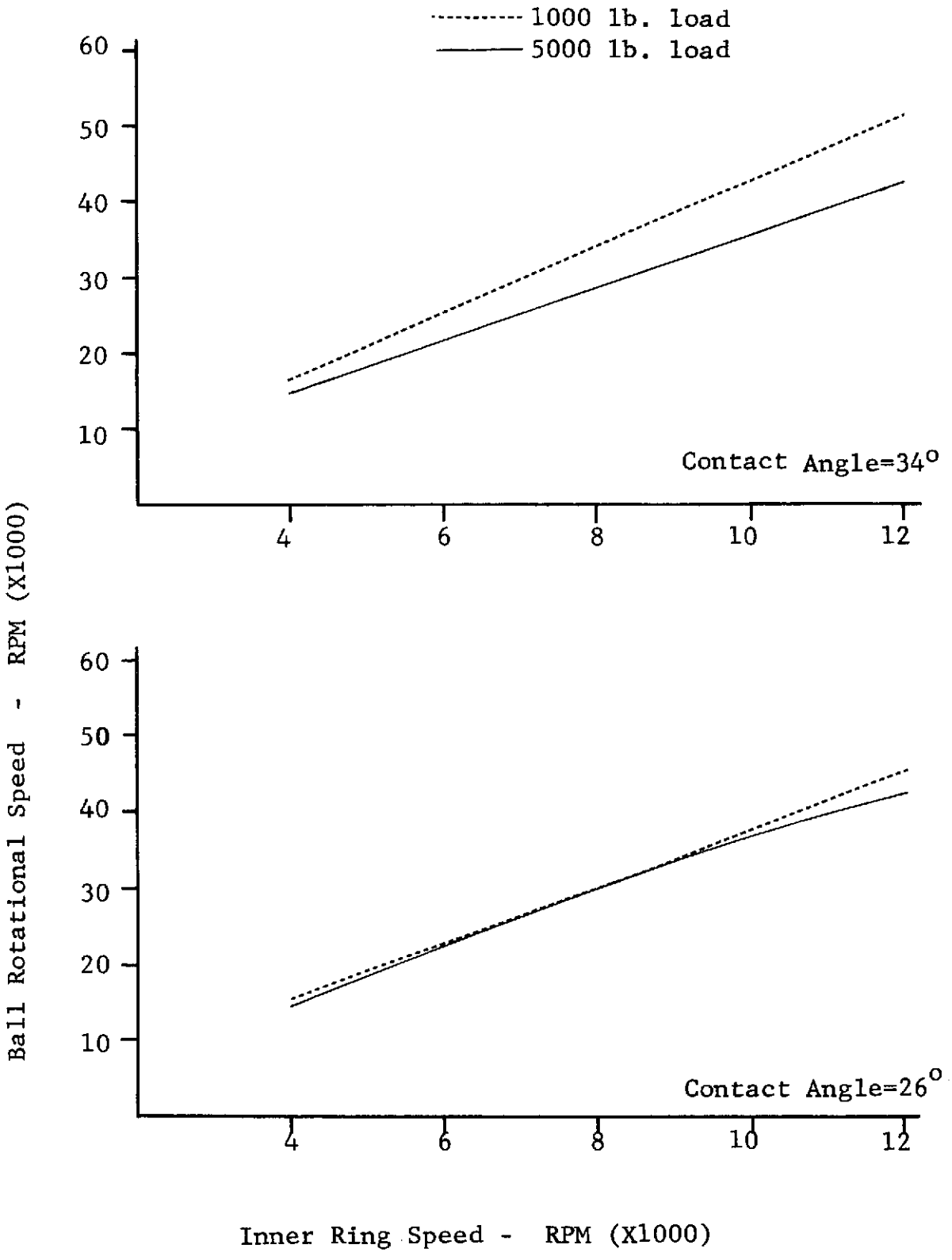


Figure -22-

Separator Speed vs. Inner Ring Speed

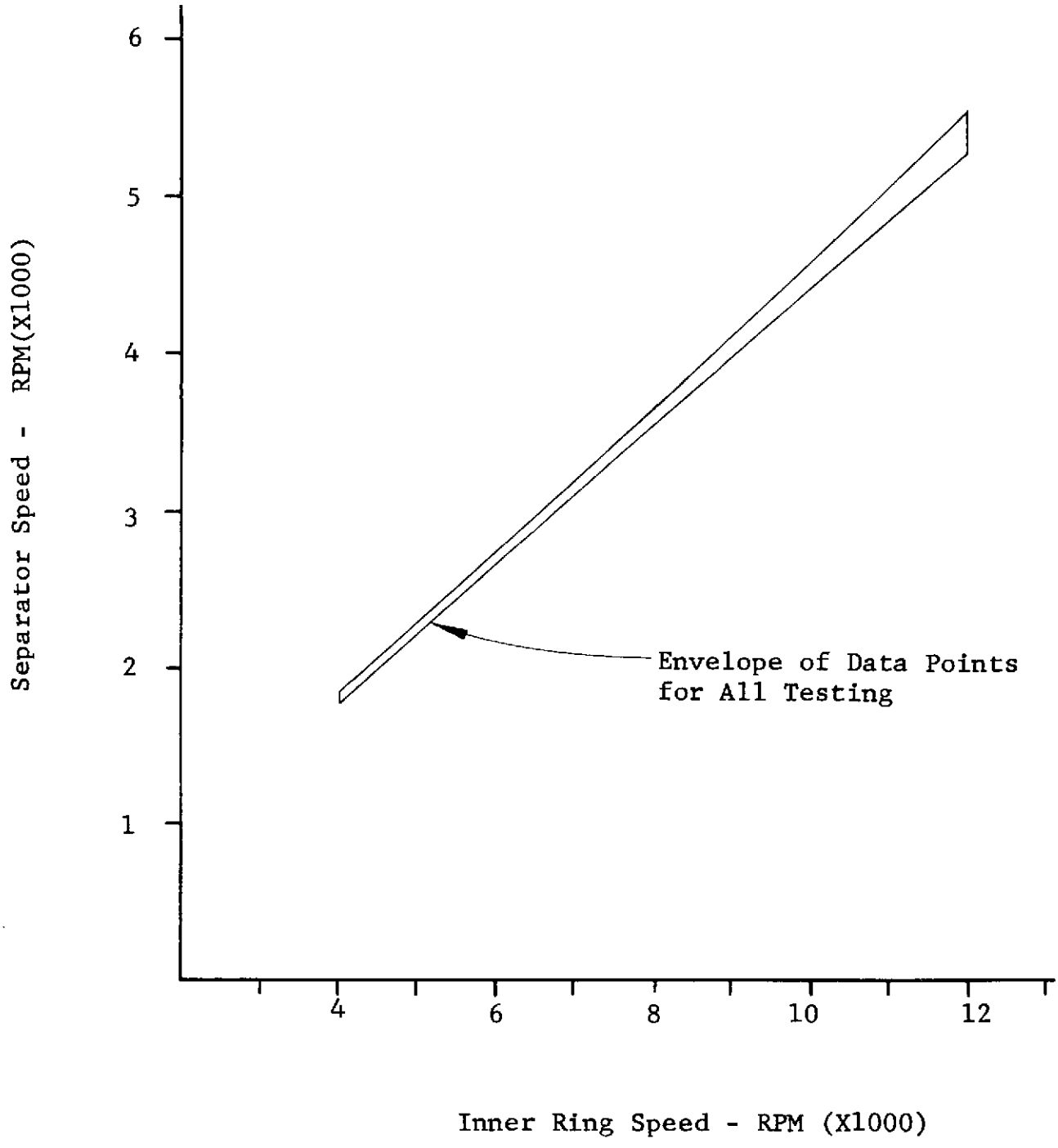


Figure -23-

Ball Attitude Angles as a Function of
Inner Ring Speed and Thrust Load

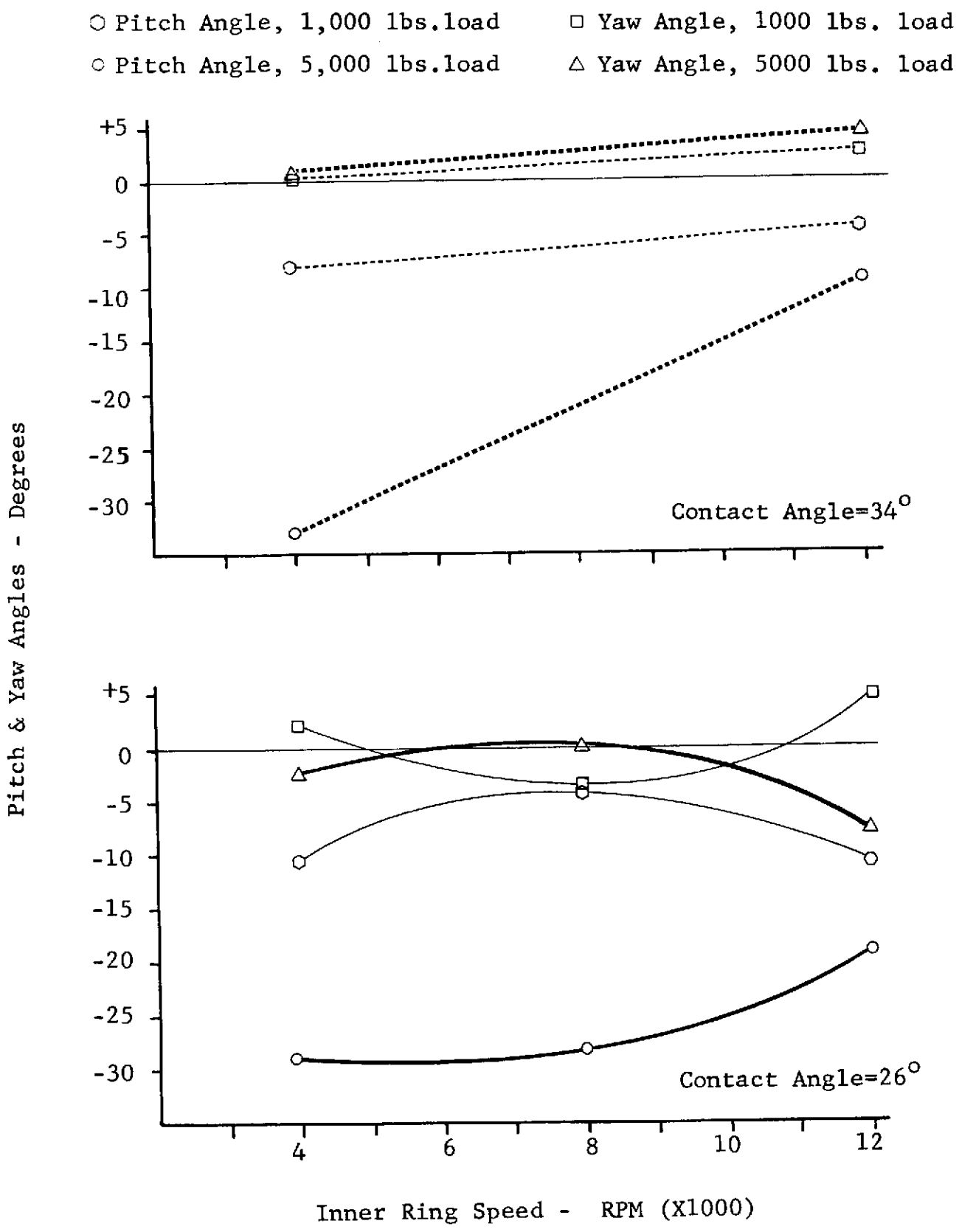


Figure -24-

A P P E N D I X 1

Ball Motion Printout for Tests IA-1 through IA-6

I T I BALL MOTION DATA REDUCTION

ITI BALL MOTION TEST NO. 1-A-1 11-30-72

SHAFT RPM	BALL DIA.	TEST BALL NO.	PITCH DIA.	SEPARATOR MEAN RAD	FILM MAGNIFICATION	OBJECT LENGTH
4000.	0.750	3	5.6350	2.8175	12.750	34.276

FRAME NO.	D.R. POSITION (DEG)	I.P. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	MEASURED COORDINATES RAD	SPIN AXIS DIRECTION X	SPIN AXIS DIRECTION Y	SPIN AXIS DIRECTION Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
1	309.200	63.600	0.0	29.2	2.981	-0.434										
				44.3	0.795	-0.148	-0.0764	0.9948	-0.0672	-3.863	-4.392	32.330	1795.	1.34	16579.	-11.73
2	312.700	59.300	0.0	43.3	-3.429	-0.473										
				43.5	-3.423	0.181	-0.0764	0.9948	-0.0672	-3.863	-4.392	32.330	1737.	-1.93	17016.	-9.40
3	316.000	55.000	0.0	21.3	3.476	-0.227										
				44.1	-1.636	-0.250	-0.2359	0.9602	0.1496	8.853	-13.801	54.532	1744.	-1.57	27965.	48.90
4	319.400	50.600	0.0	44.3	-0.210	0.351										
				40.3	-3.291	-0.660	-0.1453	0.9824	-0.1174	-6.813	-8.414	71.417	1766.	-0.27	37100.	97.54
5	322.800	46.300	0.0	44.3	-0.672	-0.896										
				29.1	-3.665	-0.690	-0.5876	0.6753	-0.4456	-33.420	-41.028	26.881	1795.	1.34	13785.	-26.60
6	326.300	42.000	0.0	42.2	3.514	0.692										
				31.2	0.474	0.937	0.0306	0.9937	-0.1076	-6.179	1.766	32.818	1737.	-1.93	17273.	-8.03
7	329.600	37.700	0.0	43.1	3.575	-0.860										
				44.2	0.070	-1.369	0.9266	0.3677	-0.0787	-12.078	68.353	7.174	1790.	1.04	3776.	-79.90
8	333.000	33.500	0.0	43.5	3.417	-0.902										
				44.3	-0.378	-1.036	0.1221	0.9770	-0.1749	-10.149	7.125	34.086	1795.	1.34	17480.	-6.93
9	336.500	29.200	0.0	43.6	3.684	-0.515										
				40.5	2.590	-0.609	-0.0522	0.9711	-0.2329	-13.485	-3.074	28.242	1795.	1.3	14483.	-22.89

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
10	340.000	24.900	0.0	40.1	3.944	-0.812										
				44.3	1.565	0.240	-0.1406	0.9898	-0.0224	-1.294	-8.087	61.896	1758.	-0.12	2933.	-84.38
11	17.100	337.600	0.0	43.1	3.453	0.277										
				44.2	0.788	-1.123	-0.1457	0.9548	-0.2590	-15.177	-8.674	49.092	1737.	-1.13	25838.	37.57
12	20.400	333.300	0.0	32.1	-3.090	-0.208										
				31.2	-1.360	-0.470	-0.7421	0.2121	0.6359	71.555	-74.050	10.447	1766.	-0.27	5427.	-71.11
13	23.800	329.000	0.0	30.4	3.245	-0.360										
				42.1	1.492	0.565	0.0069	0.9904	-0.1377	-7.916	0.397	29.096	1766.	-0.27	15114.	-19.53
14	27.200	324.700	0.0	42.2	-3.547	-0.475										
				44.3	0.608	1.110	0.1700	0.9754	-0.1404	-8.191	9.888	26.232	1766.	-0.27	13627.	-27.45
15	30.600	320.400	0.0	42.4	-3.693	-0.551										
				29.1	2.757	0.340	-0.2302	0.9009	-0.3679	-22.211	-14.332	17.813	1795.	1.34	9135.	-51.36
16	34.100	316.100	0.0	42.3	-2.210	-1.300										
				43.3	-3.307	0.387	-0.1299	0.9745	-0.1827	-10.621	-7.590	35.033	1737.	-1.93	18438.	-1.83
17	37.400	311.800	0.0	43.5	-3.360	-0.695										
				44.3	-1.511	0.114	0.1547	0.9640	-0.2161	-12.635	9.115	24.590	1766.	-0.27	12774.	-31.98
18	40.800	307.500	0.0	44.2	-0.858	-0.291										
				29.3	-0.120	1.520	-0.0239	0.9917	-0.1262	-7.252	-1.372	29.811	1766.	-0.27	15486.	-17.55
19	44.200	303.200	0.0	30.3	-3.557	0.401										
				40.2	-3.610	-0.394	-0.0238	0.9917	-0.1262	-7.252	-1.372	29.811	1766.	-0.27	15486.	-17.55
20	47.600	298.900	0.0	42.2	3.652	-0.378										
				31.2	0.880	0.685	0.1089	0.9832	-0.1465	-8.474	6.319	32.183	1766.	-0.27	16718.	-10.99
21	51.000	294.600	0.0	42.4	3.800	-0.277										
				31.2	0.260	0.940	-0.0681	0.6828	0.7274	46.809	-5.697	11.331	1813.	2.39	6044.	-67.82
22	54.400	290.500	0.0	31.2	-0.456	0.880										
				44.3	-0.546	-0.927	-0.1064	0.9422	-0.3178	-18.642	-6.443	53.990	1744.	-1.55	27687.	47.41
23	57.800	286.100	0.0	44.3	-0.275	-1.187										
				43.5	3.503	-0.208	0.1081	0.9790	-0.1729	-10.018	6.300	32.628	1766.	-0.27	16950.	-9.75
24	61.200	281.800	0.0	43.6	3.690	0.208										
				42.1	-0.553	1.338	-0.0532	0.9789	-0.1975	-11.405	-3.113	26.257	1766.	-0.27	13641.	-27.37
25	64.600	277.500	0.0	44.3	1.442	0.465										
				40.2	3.704	-0.460	0.0890	0.9918	-0.0914	-5.267	5.128	30.922	1766.	-0.27	16063.	-14.47
26	68.000	273.200	0.0	44.2	0.812	0.112										
				42.3	-1.477	1.245	0.0089	0.9741	-0.2260	-13.060	0.522	27.838	1766.	-0.27	14461.	-23.00
27	71.400	268.900	0.0	29.1	2.875	-0.025										
				44.1	0.844	-0.470	0.0217	0.9751	-0.2209	-12.766	1.277	30.889	1766.	-0.27	16046.	-14.56
28	74.800	264.600	0.0	29.2	3.001	-0.237										
				19.5	3.821	0.005	0.0217	0.9751	-0.2209	-12.766	1.277	30.889	1789.	1.04	16258.	-13.44
29	78.200	260.400	0.0	43.5	-3.395	-0.158										
				29.3	1.117	1.228	0.0546	0.9883	-0.1426	-8.210	3.161	28.128	1766.	-0.27	14612.	-22.20

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
30	81.600	256.100	0.0	43.6	-3.628	-0.492										
				21.4	4.050	-0.455	0.5204	0.8526	-0.0470	-3.153	31.396	22.297	1766.	-0.27	11583.	-38.33
31	85.000	251.800	0.0	30.4	-3.050	0.359										
				29.3	-0.850	1.320	0.0035	0.9858	-0.1682	-9.682	0.202	29.872	1795.	1.34	15319.	-18.44
32	88.500	247.500	0.0	30.3	-3.609	-0.936										
				31.2	1.061	0.534	0.0910	0.9760	-0.1976	-11.447	5.328	27.706	1789.	1.04	14582.	-22.36
33	91.900	243.300	0.0	29.1	-2.783	-0.523										
				44.1	-0.705	-0.455	-0.0800	0.9878	-0.1336	-7.702	-4.629	32.344	1766.	-0.27	16802.	-10.54
34	95.300	239.000	0.0	43.1	3.682	-0.592										
				19.5	-3.747	-0.259	-0.9594	0.1576	-0.2338	-56.017	-80.672	25.159	1737.	-1.93	13242.	-29.50
35	98.600	234.700	0.0	43.5	3.475	-0.747										
				42.1	0.697	1.324	0.0444	0.7125	-0.7003	-44.505	3.567	151.780	1818.	2.66	78847.	319.81
36	102.100	230.500	0.0	43.6	-3.701	-0.367										
				40.5	2.660	-0.533	0.0018	0.9762	-0.2170	-12.531	0.104	148.754	1766.	-0.27	77274.	311.44
37	105.500	226.200	0.0	40.2	3.627	-1.020										
				31.2	-1.363	-0.780	0.0849	0.9879	-0.1295	-7.468	4.910	29.058	1784.	1.04	15294.	-18.57
38	108.900	222.000	0.0	44.3	1.034	0.903										
				30.4	3.160	0.268	0.0239	0.9883	-0.1508	-8.678	1.386	29.584	1761.	-0.27	15368.	-18.17
39	112.300	217.700	0.0	44.3	0.221	1.209										
				29.1	2.876	-0.507	0.0727	0.9720	-0.2236	-12.953	4.275	33.777	1761.	-0.27	17547.	-6.58
40	115.700	213.400	0.0	29.2	2.955	-0.741										
				43.1	-3.536	0.369	0.9793	0.2018	0.0175	4.962	78.354	25.217	1766.	-0.27	13100.	-30.25
41	119.100	209.100	0.0	44.3	-1.279	0.553										
				43.3	-3.412	-0.242	0.0769	0.9783	-0.1922	-11.115	4.496	27.290	1752.	-1.10	14269.	-24.03
42	122.450	204.800	0.0	21.3	3.462	-0.598										
				44.3	-1.612	-0.221	0.9846	0.1595	0.0711	24.027	80.756	10.234	1775.	0.21	5422.	-71.13
43	125.800	200.600	0.0	31.2	1.440	-0.395										
				44.2	-1.019	-0.446	0.6784	0.7205	0.1437	11.276	43.274	6.728	1819.	2.14	3429.	-81.75
44	129.350	196.300	0.0	32.2	3.529	0.095										
				30.3	-3.675	-0.352	-0.3107	0.8964	-0.3160	-19.417	-19.118	24.062	1717.	-1.93	12664.	-32.57
45	132.650	192.000	0.0	42.2	3.571	0.211										
				31.1	-0.165	1.815	-0.0207	0.9824	-0.1856	-10.700	-1.209	28.956	1763.	-0.45	15240.	-18.86
46	136.000	187.750	0.0	42.4	3.711	0.356										
				31.2	-0.045	0.879	0.0178	0.9932	-0.1153	-6.619	1.024	29.799	1778.	0.38	15581.	-17.04
47	139.400	183.500	0.0	43.3	3.464	-0.787										
				31.2	-0.671	0.670	0.1724	0.9679	-0.1826	-10.686	10.101	35.257	1785.	1.04	18556.	-1.20
48	142.800	179.300	0.0	43.5	3.404	0.267										
				21.3	-3.341	0.181	-0.0268	0.9680	-0.2495	-14.453	-1.586	28.961	1744.	-1.55	14852.	-20.92
49	146.200	174.900	0.0	40.3	3.390	-0.654										
				44.3	1.692	-0.155	0.0825	0.9724	-0.2182	-12.647	4.847	32.012	1761.	-0.62	17073.	-9.10

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
50	149.500	170.700	0.0	30.3	3.705	-0.672										
				40.2	3.664	0.109	0.0825	0.9724	-0.2182	-12.647	4.847	32.012	1759.	-0.74	16312.	-13.15
51	152.950	166.300	0.0	44.2	0.756	0.158										
				42.2	-3.525	-0.634	0.4511	0.7996	-0.3964	-26.370	29.432	158.549	1828.	3.20	84000.	347.24
52	156.400	162.200	0.0	19.4	3.968	-0.533										
				0.0	0.0	0.0	0.2854	0.9505	-0.1230	-7.371	16.711	37.689	1740.	-1.74	19579.	4.24
53	159.750	157.950	0.0	19.5	3.742	0.538										
				43.3	-3.269	0.262	-0.0777	0.9739	-0.2132	-12.349	-4.559	27.380	1804.	1.86	14316.	-23.77
54	163.200	153.650	0.0	43.5	-3.343	-0.803										
				21.1	3.908	-0.255	0.9582	0.1290	0.2553	63.201	82.335	25.586	1746.	-0.27	13291.	-29.23
55	166.600	149.350	0.0	21.4	4.068	0.084										
				40.3	-3.212	0.136	-0.1654	0.9608	-0.2224	-13.035	-9.766	26.381	1740.	-1.74	13705.	-27.03
56	169.950	145.000	0.0	32.2	3.648	-0.604										
				31.2	1.409	0.0	0.1997	0.9676	-0.1545	-9.072	11.659	36.828	1813.	2.39	19641.	4.58
57	173.350	140.900	0.0	42.2	3.707	-0.462										
				31.2	0.993	0.571	0.1415	0.9713	-0.1912	-11.137	8.289	32.135	1755.	-0.92	16586.	-11.69
58	176.750	136.550	0.0	42.4	3.850	-0.385										
				31.1	-0.789	1.616	-0.0732	0.9896	-0.1234	-7.109	-4.231	29.773	1816.	2.53	15670.	-16.57
59	180.200	132.400	0.0	43.1	3.763	-0.192										
				31.2	-0.378	0.736	0.0297	0.9775	-0.2089	-12.062	1.680	26.657	1752.	-1.10	13938.	-25.79
60	183.550	128.100	0.0	43.5	3.616	-0.342										
				31.2	-0.910	0.251	0.1545	0.9698	-0.1889	-11.022	9.052	33.446	1775.	0.21	17720.	-5.65
61	186.900	123.900	0.0	40.5	2.802	-0.237										
				44.2	1.132	-0.884	0.0503	0.9792	-0.1965	-11.344	2.940	28.671	1778.	0.38	14992.	-20.18
62	190.300	119.650	0.0	40.4	2.679	0.090										
				42.1	-1.156	0.724	0.0103	0.9746	-0.2239	-12.936	0.605	28.224	1769.	-0.10	14474.	-22.94
63	193.750	115.300	0.0	30.4	2.184	0.631										
				44.1	0.871	-0.968	0.0030	0.9789	-0.2043	-11.737	0.173	27.502	1813.	2.39	14668.	-21.90
64	197.150	111.200	0.0	29.1	3.054	-0.213										
				44.3	0.223	1.104	0.0769	0.9798	-0.1845	-10.665	4.485	35.188	1752.	-1.10	18399.	-2.04
65	200.500	106.900	0.0	29.2	3.222	-0.213										
				44.2	0.222	0.434	0.1046	0.9914	-0.0790	-4.557	6.025	29.772	1748.	-1.28	15773.	-16.02
66	203.800	102.650	0.0	43.3	-3.123	-0.817										
				44.3	-1.068	0.302	0.1640	0.9766	-0.1393	-8.116	9.534	27.715	1778.	0.38	14491.	-22.84
67	207.200	98.400	0.0	43.6	-3.385	-0.493										
				44.3	-1.282	-0.510	0.1823	0.9738	-0.1363	-7.967	10.604	27.449	1816.	2.53	14447.	-23.08
68	210.650	94.250	0.0	40.1	-3.693	-0.111										
				29.3	-0.361	1.264	-0.3406	0.9352	0.0963	5.881	-20.013	81.764	1748.	-1.28	43319.	130.64
69	213.950	90.000	0.0	32.2	-3.715	0.509										
				30.3	-3.340	-0.831	0.0426	0.9584	-0.2821	-16.403	2.548	121.722	1795.	1.34	62421.	232.35

FRAME NO.	O.P. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
70	217.450	85.700	0.0	29.1	-2.500	-0.453										
				29.3	-1.517	-0.213	0.0426	0.9584	-0.2821	-16.403	2.548	121.722	1775.	0.21	64489.	243.36
71	220.800	81.500	0.0	19.5	-3.475	-0.110										
				44.1	-0.205	-0.750	0.0714	0.9738	-0.2158	-12.495	4.192	29.829	1766.	-0.27	15495.	-17.50
72	224.200	77.200	0.0	43.3	3.754	-0.165										
				44.1	0.0	-0.997	0.4950	0.8354	-0.2597	-17.205	30.138	148.979	1804.	1.86	77898.	314.75
73	227.650	73.000	0.0	40.5	3.010	-0.514										
				44.1	3.516	-1.099	0.7234	0.6344	0.2725	23.249	48.752	111.875	1740.	-1.74	58117.	209.44
74	231.000	68.650	0.0	40.3	3.616	0.0										
				94.2	1.368	-0.302	0.8462	0.4998	0.1947	20.291	59.431	162.376	1801.	1.71	86027.	358.04
75	234.400	64.500	0.0	30.4	3.431	0.296										
				44.2	1.212	0.167	0.1272	0.9864	-0.1041	-6.025	7.350	32.383	1795.	1.34	16607.	-11.58
76	237.900	60.200	0.0	29.1	3.088	-0.441										
				44.1	1.061	-0.402	0.0331	0.9818	-0.1871	-10.788	1.929	30.173	1752.	-1.10	15777.	-16.00
77	241.250	55.900	0.0	29.2	3.123	-0.656										
				44.1	0.998	0.0	0.2413	0.9654	-0.0989	-5.850	14.032	40.123	1714.	-3.21	21836.	16.26
78	244.400	51.700	0.0	20.3	4.068	-0.570										
				44.2	-0.183	0.624	-0.0026	0.9947	-0.1025	-5.886	-0.151	27.989	1806.	2.00	14446.	-23.09
79	247.900	47.450	0.0	21.3	3.581	-0.589										
				31.1	2.566	0.0	0.0712	0.9866	-0.1467	-8.456	4.127	30.395	1813.	2.39	16211.	-13.69
80	251.300	43.350	0.0	40.3	-3.200	-0.084										
				32.1	4.164	0.161	-0.1375	0.9629	-0.2323	-13.564	-8.124	27.131	1755.	-0.92	14003.	-25.44
81	254.700	39.000	0.0	32.2	3.621	0.189										
				44.1	-0.461	0.333	0.0541	0.9918	-0.1161	-6.677	3.124	31.403	1789.	1.04	16528.	-12.00
82	258.100	34.800	0.0	42.2	3.650	0.314										
				44.2	-0.517	-0.986	0.0165	0.9965	-0.0825	-4.734	0.948	27.198	1752.	-1.10	14221.	-24.28
83	261.450	30.500	0.0	19.4	-3.969	-0.090										
				44.1	-0.710	-0.434	-0.0066	0.9839	-0.1787	-10.295	-0.383	29.964	1760.	-0.62	15981.	-14.91
84	264.750	26.300	0.0	43.3	3.418	-0.707										
				44.1	-0.577	-0.790	0.0926	0.9946	-0.0477	-2.745	5.318	26.255	1816.	2.52	13818.	-26.43
85	268.200	22.150	0.0	43.6	3.584	-1.402										
				44.2	0.729	-0.887	0.0363	0.9704	-0.2388	-13.826	2.142	36.819	1766.	-0.27	19127.	1.84
86	271.600	17.850	0.0	40.3	3.282	-0.554										
				44.2	0.875	-0.512	-0.0407	0.9905	-0.1315	-7.565	-2.353	27.505	1775.	0.21	14572.	-22.41
87	274.950	13.650	0.0	30.3	3.670	-0.669										
				44.1	0.453	-0.969	-0.0418	0.9926	-0.1137	-6.532	-2.414	25.473	1752.	-1.10	13320.	-29.08
88	278.300	9.350	0.0	44.1	0.689	-0.702										
				44.2	0.641	0.274	0.0112	0.9739	-0.2267	-13.102	0.656	26.210	1766.	-0.27	13615.	-27.51
89	281.700	5.050	0.0	29.1	2.759	0.359										
				44.2	0.248	0.531	0.0653	0.9883	-0.1378	-7.937	3.780	34.5[illegible]	772.	0.04	18574.	-1.11

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
90	285.000	0.900	0.0	29.2	2.955	0.213										
				44.1	0.681	0.078										
							0.1329	0.9869	-0.0916	-5.302	7.671	33.853	1737.	-1.94	17818.	-5.13
91	288.300	356.600	0.0	29.3	0.851	1.405										
				44.3	-1.497	0.185										
							-0.0786	0.8772	-0.4737	-28.370	-5.121	22.077	1842.	4.01	11620.	-38.13
92	291.900	352.500	0.0	21.3	3.429	0.514										
				44.1	-0.864	-0.278										
							-0.1630	0.8991	-0.4062	-24.311	-10.278	25.035	1729.	-2.37	12921.	-31.20
93	295.150	348.100	0.0	32.2	3.630	-0.510										
				31.1	1.478	1.245										
							0.1176	0.9618	-0.2473	-14.418	6.970	33.156	1784.	0.72	17922.	-4.58
94	298.450	344.000	0.0	42.2	3.655	-0.406										
				31.2	0.904	0.275										
							-0.0696	0.9934	-0.0915	-5.262	-4.007	28.902	1766.	-0.27	15014.	-20.06
95	301.850	339.700	0.0	31.2	0.266	1.084										
				44.1	-0.755	-0.409										
							0.0448	0.9797	-0.1954	-11.282	2.616	31.300	1781.	0.54	16155.	-13.98
96	305.300	335.400	0.0	43.1	3.604	-0.160										
				44.2	0.197	-1.319										
							0.0399	0.9817	-0.1864	-10.753	2.326	29.228	1787.	0.88	15588.	-17.00
97	308.650	331.250	0.0	43.5	3.454	-0.250										
				43.3	3.375	0.414										
							0.0399	0.9817	-0.1864	-10.753	2.326	29.228	1722.	-2.78	15485.	-17.55
98	311.900	326.950	0.0	44.2	0.877	-0.812										
				44.3	1.635	-0.356										
							0.0399	0.9817	-0.1864	-10.753	2.326	29.228	1813.	2.38	15588.	-17.00
99	315.300	322.850	0.0	40.3	3.252	0.426										
				40.2	3.688	-0.571										

	AVG. SPEED (RPM)	AVG. ABS(SPEED ERROR) (PERCENT)	AVERAGE YAW (DEG.)	AVERAGE PITCH (DEG.)	MEAN BALL POSITION (DEG.)
SEPARATOR	1771.06	1.1407			
BALL	18781.57	46.4449	4.325	-7.754	0.0

I T I BALL MOTION DATA REDUCTION

ITI BALL MOTION TEST NO. I-A-2 (10/26/72)

SHAFT RPM	BALL DIA.	TEST BALL NO.	PITCH DIA.	SEPARATOR MEAN RAD	FILM MAGNIFICATION	OBJECT LENGTH
4000 ~~12000~~	0.750	2	5.6350	2.8175	12.750	34.276

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL SEP POS (IN.)	TC POINT NO.	MEASURED COORDINATES TANG	MEASURED COORDINATES RAD	SPIN AXIS DIRECTION X	SPIN AXIS DIRECTION Y	SPIN AXIS DIRECTION Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM) (3x)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM) (3x)	BALL PERCENT ERROR
1	89.000	77.100	0.0	3.2	-1.476	0.438										
				2.3	0.892	-0.997	0.1363	0.8041	-0.5787	-35.744	9.622	27.062	5143.	-2.81	38660.	-19.67
2	92.600	72.300	0.0	43.2	3.815	0.165										
				5.3	-3.480	-1.103	-0.2564	0.7960	-0.5482	-34.556	-17.855	26.111	5349.	1.09	37751.	-21.56
3	96.300	67.700	0.0	3.5	-3.006	-0.763										
				30.3	0.384	0.418	0.1732	0.7738	-0.6093	-38.215	12.616	27.190	5365.	1.38	38386.	-20.24
4	100.100	63.000	0.0	36.5	-2.978	0.027										
				12.1	3.817	-1.179	-0.2028	0.8366	-0.5089	-31.309	-13.623	36.217	5286.	-0.11	51738.	7.51
5	103.800	58.300	0.0	6.1	1.000	-0.883										
				11.1	3.700	-0.613	-0.3108	0.8481	-0.4291	-26.838	-20.125	51.108	5224.	-1.29	72153.	49.92
6	107.500	53.500	0.0	43.3	-3.600	-0.192										
				6.3	-0.627	0.835	-0.7247	0.6092	-0.3221	-27.867	-49.947	21.904	5205.	-1.64	31669.	-34.20
7	111.100	48.800	0.0	43.2	-4.040	0.725										
				6.5	0.689	-0.817	-0.0061	0.9089	-0.4169	-24.641	-0.387	51.980	5239.	-0.99	87854.	82.55
8	114.200	44.800	0.0	4.5	2.690	-0.290										
				5.1	3.854	-0.495	-0.8748	0.4844	-0.0066	-0.784	-61.025	19.298	5375.	1.57	24123.	-49.88
9	118.500	39.500	0.0	12.2	-3.375	-0.643										
				5.3	2.915	0.400	-0.2278	0.7180	-0.6578	-42.494	-17.602	24.348	5365.	1.38	34373.	-28.58

NOTE: FOR ACTUAL SPEED VALUES IN THIS RUN I-A-2 DIVIDE PRINTED FIGURES OF SEPARATOR- AND BALL SPEEDS BY 3. OTHER VALUES ARE CORRECT.

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO POS SEP (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
10	122.300	34.800	0.0	11.3	-4.096	-0.147										
				3.5	2.895	-0.389	-0.0334	0.8552	-0.5173	-31.168	-2.234	31.520	5205.	-1.64	45571.	-5.31
11	125.900	30.100	0.0	10.5	-3.821	-0.425										
				4.3	-0.624	-0.467	0.0532	0.8679	-0.4938	-29.638	3.507	30.747	5365.	1.38	43407.	-9.81
12	129.700	25.400	0.0	9.1	-3.445	0.233										
				4.4	-1.564	-0.075	0.0996	0.8702	-0.4825	-29.008	6.526	29.507	5268.	-0.44	43182.	-10.27
13	133.300	20.800	0.0	5.1	-3.774	-0.219										
				3.1	-1.599	-0.204	0.0772	0.8382	-0.5399	-32.790	5.264	31.136	5302.	0.20	43446.	-9.72
14	137.100	16.000	0.0	41.2	3.518	-0.528										
				2.3	-0.152	-0.648	0.0014	0.9190	-0.3942	-23.215	0.088	36.322	5143.	-2.81	51888.	7.82
15	140.700	11.200	0.0	30.1	-0.815	-0.210										
				2.3	-0.780	-0.871	0.0014	0.9190	-0.3942	-23.215	0.088	36.322	5494.	3.82	52513.	9.12
16	144.500	366.700	0.0	36.5	-3.281	-0.655										
				1.2	-0.450	-0.216	0.0576	0.8755	-0.4798	-28.723	3.762	30.266	5223.	-1.29	42728.	-11.22
17	148.200	361.900	0.0	36.6	-3.953	0.161										
				1.1	-0.675	0.340	0.0499	0.8662	-0.4972	-29.857	3.299	30.448	5268.	-0.44	44558.	-7.41
18	151.800	357.300	0.0	43.3	-3.813	-1.005										
				6.1	-0.096	-0.462	0.0545	0.8761	-0.4791	-28.673	3.561	30.618	5429.	2.59	43741.	-9.11
19	155.600	352.700	0.0	41.2	-3.534	-0.626										
				6.3	-0.447	-0.675	0.0764	0.8465	-0.5268	-31.856	5.159	30.228	5349.	1.09	43703.	-9.19
20	159.300	348.100	0.0	5.1	3.576	0.363										
				4.2	0.924	-0.020	0.0115	0.9107	-0.4128	-24.383	0.725	33.329	5224.	-1.29	47052.	-2.23
21	163.000	343.300	0.0	4.4	1.486	0.095										
				3.2	2.578	-0.330	-0.0139	0.8663	-0.4994	-29.961	-0.919	29.700	5349.	1.09	42941.	-10.77
22	166.700	338.700	0.0	4.1	-0.412	-0.745										
				3.1	1.352	0.090	0.0478	0.7655	-0.6417	-39.973	3.574	27.922	5205.	-1.64	40370.	-16.12
23	170.300	334.000	0.0	10.4	-3.480	0.298										
				2.4	-0.955	0.520	-0.4581	0.7985	-0.3906	-26.065	-29.846	40.095	5365.	1.38	56604.	17.62
24	174.100	329.300	0.0	3.2	-1.472	0.656										
				7.3	1.324	0.712	-0.0125	0.8637	-0.5038	-30.252	-0.827	29.917	5286.	-0.11	42739.	-11.19
25	177.800	324.600	0.0	30.2	1.202	0.962										
				43.2	3.907	0.162	-0.0207	0.8931	-0.4495	-26.716	-1.326	29.677	5143.	-2.81	42396.	-11.91
26	181.400	319.800	0.0	30.3	0.484	0.598										
				41.2	3.232	0.298	-0.1731	0.8085	0.5625	34.826	-12.082	8.506	5365.	1.38	12008.	-75.05
27	185.200	315.100	0.0	12.2	3.479	-0.812										
				1.3	0.596	1.207	0.0040	0.9623	-0.2721	-15.789	0.240	74.453	5266.	-0.11	106362.	121.01
28	189.900	310.400	0.0	1.3	-0.967	1.049										
				24.2	1.124	0.812	0.0343	0.8792	-0.4752	-28.391	2.237	31.641	5223.	-1.29	44669.	-7.18
29	192.600	305.600	0.0	43.5	-3.199	-0.286										
				6.3	0.688	-0.687	0.0360	0.8681	-0.4951	-29.658	2.375	30.337	5268.	-0.44	44396.	-7.75

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
30	196.200	301.000	0.0	41.2	-3.191	0.363										
				6.6	0.771	0.910	0.0641	0.8863	-0.4586	-27.357	4.138	30.934	5365.	1.38	43671.	-9.26
31	200.000	296.300	0.0	24.1	-3.943	-0.055										
				4.5	2.743	-0.254	-0.1908	0.6671	-0.7201	-47.187	-15.961	15.898	5268.	-0.44	23266.	-51.66
32	203.600	291.700	0.0	12.4	-3.838	0.556										
				4.2	0.436	0.250	-0.2242	0.8724	-0.4342	-26.461	-14.412	81.527	5268.	-0.44	119306.	147.90
33	207.200	287.100	0.0	10.2	-3.611	-0.128										
				4.2	-0.663	0.150	-0.3213	0.9213	-0.2190	-13.372	-19.224	23.353	5429.	2.59	33361.	-30.68
34	211.000	282.500	0.0	10.3	-3.776	-0.120										
				4.2	-1.566	-0.424	-0.3182	0.9094	-0.2676	-16.398	-19.286	27.061	5223.	-1.29	38203.	-20.62
35	214.700	277.700	0.0	10.4	-3.767	-0.475										
				2.4	0.417	-0.765	0.1005	0.8819	-0.4607	-27.582	6.499	28.608	5286.	-0.11	40869.	-15.08
36	218.400	273.000	0.0	43.5	3.258	-0.300										
				5.1	-3.732	0.095	0.0048	0.8822	-0.4708	-28.086	0.314	32.086	5481.	3.58	47534.	-1.23
37	222.100	268.600	0.0	41.2	3.571	-0.663										
				3.2	-2.700	-0.885	-0.0702	0.8527	-0.5177	-31.266	-4.705	28.817	5143.	-2.81	41166.	-14.46
38	225.700	263.800	0.0	24.1	3.763	0.420										
				1.1	1.738	-0.195	-0.0192	0.8797	-0.4751	-28.374	-1.251	22.357	5365.	1.38	31563.	-34.42
39	229.500	259.100	0.0	12.1	3.764	-0.424										
				1.3	-0.072	1.209	-0.0151	0.8954	-0.4450	-26.426	-0.965	39.107	5349.	1.09	56542.	17.49
40	233.200	254.500	0.0	1.1	-0.508	0.460										
				11.1	3.523	0.091	-0.1591	0.9274	-0.3385	-20.051	-9.735	39.232	5349.	1.09	56721.	17.86
41	236.900	249.900	0.0	43.3	-3.765	-0.660										
				10.3	3.575	0.296	-0.7721	0.3383	-0.5380	-57.841	-66.342	30.795	5082.	-3.96	43476.	-9.66
42	240.500	245.000	0.0	24.1	-3.471	-0.318										
				6.4	-0.485	0.937	0.3182	0.1215	-0.9402	-82.639	69.109	18.771	5349.	1.09	27138.	-43.61
43	244.200	240.400	0.0	5.3	3.451	-0.598										
				4.2	1.114	-0.065	-0.8749	0.4404	0.2016	24.596	-63.281	16.120	5224.	-1.29	22758.	-52.71
44	247.900	235.600	0.0	12.2	-3.454	-1.066										
				3.2	2.504	-0.663	-0.8726	0.0162	-0.4881	-88.101	-88.937	17.985	5349.	1.09	26002.	-45.97
45	251.600	231.000	0.0	11.1	-3.721	-0.927										
				4.1	-0.295	-0.723	0.0637	0.8635	-0.5004	-30.093	4.219	31.288	5286.	-0.11	44697.	-7.13
46	255.300	226.300	0.0	10.1	-2.838	0.126										
				4.4	-0.757	0.395	0.0335	0.8522	-0.5222	-31.501	2.249	31.077	5428.	2.58	44397.	-7.75
47	259.100	221.700	0.0	3.2	-1.210	0.750										
				36.6	3.994	0.116	0.0447	0.8902	-0.4535	-26.996	2.874	30.196	5205.	-1.64	43656.	-9.29
48	262.700	217.000	0.0	5.1	-3.900	-0.727										
				43.5	2.940	0.221	-0.1297	0.8187	-0.5594	-34.342	-9.000	27.139	5286.	-0.11	38770.	-19.44
49	266.400	212.300	0.0	41.2	3.393	-0.045										
				1.2	1.102	-0.492	0.0730	0.3397	-0.9377	-70.086	12.129	31.187	5205.	-1.64	45089.	-6.31

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP. POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
50	270.000	207.600	0.0	7.1	-3.830	-0.937										
				30.3	-0.636	0.470	-0.3407	0.9263	0.1609	9.852	-20.193	37.652	5428.	2.58	53789.	11.77
51	273.800	203.000	0.0	36.5	-3.401	-1.051										
				1.3	-0.723	1.037	0.0249	0.8836	-0.4675	-27.882	1.615	30.643	5350.	1.09	44302.	-7.95
52	277.500	198.400	0.0	36.6	-4.096	-0.310										
				1.1	-1.034	0.231	0.1045	0.8730	-0.4763	-28.617	6.824	29.759	5143.	-2.82	42514.	-11.66
53	281.100	193.600	0.0	43.2	-3.942	-0.107										
				6.6	1.027	0.686	-0.0661	0.8780	-0.4741	-28.368	-4.303	34.791	5429.	2.59	49702.	3.27
54	284.900	189.000	0.0	24.1	-3.826	0.316										
				41.2	-3.608	-1.056	0.2128	0.8396	-0.4997	-30.761	14.225	27.825	5349.	1.09	40229.	-16.41
55	288.600	184.400	0.0	12.4	-3.787	-0.275										
				4.1	0.728	-0.973	0.0293	0.9144	-0.4038	-23.827	1.835	61.724	5205.	-1.64	89239.	85.43
56	292.200	179.700	0.0	4.1	0.150	-0.755										
				7.2	3.078	-0.829	0.1780	0.9823	0.0582	3.394	10.273	63.749	5205.	-1.64	92169.	91.52
57	295.800	175.000	0.0	3.2	1.133	0.734										
				4.2	1.437	-0.425	0.0326	0.8362	-0.5474	-33.208	2.231	25.827	5350.	1.09	37339.	-22.41
58	299.500	170.400	0.0	10.4	-3.648	-0.180										
				3.5	0.804	1.229	-0.0178	0.8617	-0.5071	-30.474	-1.181	32.546	5286.	-0.11	46495.	-3.39
59	303.200	165.700	0.0	3.1	-1.293	-0.005										
				5.1	-3.550	0.327	0.0544	0.8115	-0.5819	-35.643	3.835	24.169	5268.	-0.44	35370.	-26.50
60	306.800	161.100	0.0	30.2	0.866	0.960										
				7.2	-0.416	0.879	0.0143	0.9007	-0.4341	-25.733	0.907	34.717	5429.	2.59	49595.	3.05
61	310.600	156.500	0.0	30.3	0.163	0.437										
				1.2	0.856	-0.368	0.0143	0.9007	-0.4341	-25.733	0.907	34.717	5286.	-0.11	49596.	3.05
62	314.300	151.800	0.0	12.2	3.372	-0.571										
				36.5	-3.114	-0.128	-0.1871	0.8700	-0.4562	-27.669	-12.139	64.648	5185.	-2.01	95775.	99.01
63	317.800	147.200	0.0	11.1	3.634	-0.390										
				1.1	-0.235	0.349	0.0086	0.8951	-0.4458	-26.476	0.551	29.331	5620.	6.21	44552.	-7.43
64	321.500	143.000	0.0	43.3	-3.699	-0.325										
				24.2	-0.605	0.771	0.0879	0.8672	-0.4901	-29.471	5.787	31.631	4989.	-5.73	42649.	-11.38
65	325.200	137.800	0.0	41.2	-3.322	-0.049										
				6.6	-0.421	0.769	0.2869	0.8695	-0.4020	-24.810	18.262	40.834	5429.	2.59	58334.	21.21
66	329.000	133.200	0.0	4.2	1.289	-0.318										
				5.3	3.824	-0.366	-0.5718	0.2821	-0.7704	-69.890	-63.743	16.060	5268.	-0.44	23504.	-51.16
67	332.600	128.600	0.0	12.1	-3.551	0.067										
				5.3	2.848	0.459	-0.1032	0.8347	-0.5410	-32.949	-7.052	27.555	5205.	-1.64	39838.	-17.22
68	336.200	123.900	0.0	4.1	-0.150	-0.813										
				4.4	0.825	0.260	-0.0097	0.8929	-0.4502	-26.758	-0.624	32.727	5349.	1.09	47317.	-1.68
69	339.900	119.300	0.0	4.1	-0.740	-1.052										
				10.3	-3.375	0.045	0.1159	0.8078	-0.5780	-35.583	8.163	29.977	5349.	1.09	43341.	-9.94

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
70	343.600	114.700	0.0	3.2	-0.880	0.729										
				7.2	1.361	0.367	0.0598	0.8162	-0.5747	-35.151	4.191	27.324	5365.	1.38	38575.	-19.85
71	347.400	110.000	0.0	5.4	-2.949	-0.290										
				2.3	-0.430	-0.603	-0.6601	0.7091	-0.2479	-19.273	-42.952	2.608	5268.	-0.44	3817.	-92.07
72	351.000	105.400	0.0	41.2	3.455	-0.517										
				30.3	0.955	0.249	0.0465	0.8751	-0.4818	-28.835	3.043	31.360	5205.	-1.64	45341.	-5.79
73	354.600	100.700	0.0	24.1	3.633	0.570										
				2.3	-0.851	-1.008	-0.0652	0.9028	-0.4251	-25.215	-4.133	32.407	5268.	-0.44	47425.	-1.46
74	358.200	96.100	0.0	36.8	-3.006	0.379										
				30.4	-1.416	0.482	0.0869	0.9598	-0.2670	-15.545	5.172	48.151	5349.	1.09	69616.	44.65
75	1.900	91.500	0.0	10.3	3.970	-0.117										
				1.1	-0.765	0.192	-0.5291	0.5272	0.6649	51.590	-45.106	7.902	5205.	-1.64	11424.	-76.26
76	5.500	86.800	0.0	6.4	0.780	0.666										
				43.3	-3.784	-1.035	0.0070	0.8249	-0.5653	-34.422	0.487	33.029	5365.	1.38	46630.	-3.11
77	9.300	82.100	0.0	10.1	2.846	-0.053										
				6.5	0.397	-0.791	-0.6893	0.4792	-0.5434	-48.592	-55.192	25.745	5185.	-2.01	38140.	-20.75
78	12.800	77.500	0.0	5.4	3.359	-0.462										
				4.4	0.911	-0.613	0.4126	0.8693	-0.2721	-17.377	25.390	72.422	5286.	-0.11	103460.	114.98
79	16.500	72.800	0.0	4.1	0.377	-0.895										
				10.2	-3.180	0.998	-0.3346	0.8506	-0.4055	-25.488	-21.474	32.928	5185.	-2.01	48783.	1.36
80	20.000	68.200	0.0	10.2	-3.975	-0.259										
				4.2	-1.147	-0.354	-0.4635	0.8836	-0.0662	-4.283	-27.679	40.189	5365.	1.38	56737.	17.89
81	23.800	63.500	0.0	10.1	-2.880	-0.201										
				4.4	-0.868	0.190	0.0690	0.8386	-0.5403	-32.791	4.703	30.425	5415.	2.32	44525.	-7.48
82	27.500	59.000	0.0	3.2	-1.314	0.500										
				2.4	0.138	-0.927	0.3459	0.9248	0.1583	9.712	20.507	61.071	5122.	-3.21	89372.	85.70
83	31.000	54.300	0.0	4.5	2.896	0.254										
				5.3	-3.397	-0.858	0.1296	0.8149	-0.5649	-34.731	9.037	29.378	5429.	2.59	41969.	-12.79
84	34.800	49.700	0.0	41.2	3.308	0.030										
				30.3	0.578	0.389	0.0088	0.8792	-0.4764	-28.454	0.575	29.143	5205.	-1.64	42134.	-12.45
85	38.400	45.000	0.0	1.3	0.744	0.966										
				30.4	-0.435	0.822	0.0088	0.8792	-0.4764	-28.454	0.575	29.143	5268.	-0.44	42648.	-11.38
86	42.000	40.400	0.0	12.2	3.471	0.278										
				1.1	0.137	0.362	-0.0121	0.9115	-0.4112	-24.282	-0.763	81.916	5268.	-0.44	119878.	149.09
87	45.600	35.800	0.0	24.2	-0.148	0.784										
				1.1	-1.152	0.037	0.0061	0.8391	-0.5440	-32.956	0.418	31.299	5365.	1.38	44187.	-8.19
88	49.400	31.100	0.0	10.3	3.392	0.059										
				6.4	0.301	0.815	0.0312	0.8986	-0.4377	-25.971	1.987	30.873	5268.	-0.44	45179.	-6.12
89	53.000	26.500	0.0	24.1	-3.817	0.145										
				6.6	-0.491	0.742	-0.7008	0.5760	-0.4208	-36.152	-50.582	10.663	5268.	-0.44	15604.	-67.58

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	MEASURED COORDINATES RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
90	56.600	21.900	0.0	12.2	-3.234	-0.270										
				6.5	-0.565	-0.800										
							0.5470	0.8370	0.0157	1.078	33.163	52.816	5349.	1.09	76361.	58.67
91	60.300	17.300	0.0	11.1	-3.470	-0.056										
				2.1	0.099	-0.817										
							0.8776	0.3064	-0.3686	-50.269	70.755	26.408	5286.	-0.11	37726.	-21.61
92	64.000	12.600	0.0	3.1	1.092	0.085										
				4.1	-0.548	-0.944										
							0.0835	0.9152	-0.3943	-23.309	5.214	41.029	5185.	-2.01	60784.	26.30
93	67.500	8.000	0.0	36.8	3.554	-0.619										
				10.4	-3.620	-0.282										
							0.0282	0.8564	-0.5156	-31.052	1.885	32.421	5349.	1.09	46874.	-2.60
94	71.200	3.400	0.0	5.3	-2.974	0.205										
				43.3	3.749	-0.438										
							-0.0926	0.8440	-0.5283	-32.047	-6.264	29.424	5286.	-0.11	42034.	-12.66
95	74.900	358.700	0.0	41.2	3.632	-1.073										
				30.3	1.397	0.100										
							0.0410	0.8731	-0.4858	-29.091	2.685	31.824	5122.	-3.21	46573.	-3.23
96	78.400	354.000	0.0	24.1	3.940	0.040										
				2.3	-0.584	-0.820										
							-0.2112	0.8080	-0.5500	-34.245	-14.648	19.253	5415.	2.32	28175.	-41.46
97	82.100	349.500	0.0	12.1	3.845	-0.865										
				1.1	1.019	0.228										
							0.0526	0.9026	-0.4273	-25.333	3.338	41.589	5268.	-0.44	60861.	26.46
98	85.700	344.900	0.0	36.8	-3.440	-0.561										
				1.1	-0.275	0.393										
							0.0591	0.8582	-0.5100	-30.721	3.939	29.387	5349.	1.09	42487.	-11.72
99	89.400	340.300	0.0	43.3	-3.689	-0.331										
				24.2	-0.609	0.789										
							0.6550	0.6471	0.3902	31.092	45.347	12.930	5205.	-1.64	18694.	-61.16
100	93.000	335.600	0.0	10.2	3.120	-0.439										
				6.5	0.658	-0.746										
							0.1494	0.9398	-0.3074	-18.114	9.032	75.108	5349.	1.09	108592.	125.64
101	96.700	331.000	0.0	24.1	-3.981	-0.380										
				6.6	-0.930	0.685										
							-0.3217	0.8745	-0.3629	-22.540	-20.199	44.315	5268.	-0.44	64851.	34.75
102	100.300	326.400	0.0	12.4	-3.823	-0.936										
				3.2	2.859	0.472										

	AVG. SPEED (RPM)	AVG. ABS(SPEED ERROR) (PERCENT)	AVERAGE YAW (DEG.)	AVERAGE PITCH (DEG.)	MEAN BALL POSITION (DEG.)
SEPARATOR	5291.71	1.4605			
BALL	48126.06	28.7947	-4.437	-26.816	0.0

I T I BALL MOTION DATA REDUCTION

ITI BALL MOTION TEST NO. 1-A-3 (3/22/73)

SHAFT RPM	BALL DIA.	TEST BALL NO.	PITCH DIA.	SEPARATOR MEAN RAD	FILM MAGNIFICATION	OBJECT LENGTH
8000.	0.750	2	5.6350	2.8175	12.750	34.276

[HC251I SQRT NEGATIVE ARGUMENT=-0.8125009E 02

TRACEBACK	ROUTINE	CALLED FROM ISN	REG. 14	REG. 15	REG. 0	REG. 1
	SQRT	C008	52040C08	00056680	0004B91C	00040B04
	CNVRT		6204C888	00040A90	0004B91C	00049ADC
	MAIN		00015354	C1049648	FDC00008	00081FF8

ENTRY POINT= 01049648

STANDARD FIXUP TAKEN , EXECUTION CONTINUING

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO POINT SEP POS (IN.)	NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
1	85.100	102.500	0.0	15.4	3.926	-0.637										
				10.4	3.455	0.440	0.0351	0.8319	-0.5538	-33.651	2.414	31.935	3671.	0.82	30057.	-8.29
2	89.000	97.900	0.0	16.3	3.331	-0.876										
				5.3	1.235	0.190	-0.9467	0.3196	-0.0398	-7.106	-71.345	47.581	3576.	-1.77	44783.	36.65
3	92.800	93.200	0.0	30.1	-3.180	-0.650										
				4.3	0.007	-1.600	-0.1788	0.5143	-0.8388	-58.484	-19.169	31.286	3671.	0.82	29446.	-10.15
4	96.700	88.600	0.0	6.1	-3.910	-0.075										
				3.1	-6.700	-0.368	0.0005	0.9750	-0.2222	-12.836	0.029	53.738	3628.	-0.35	49989.	52.53
5	100.600	83.900	0.0	22.2	3.375	0.411										
				3.5	0.940	-0.869	-0.3876	0.8869	0.2512	15.815	-23.604	17.696	3765.	3.40	16655.	-49.18
6	104.600	79.400	0.0	3.1	0.182	-0.749										
				10.3	-3.700	-0.357	0.0117	0.9853	-0.1706	-9.826	0.683	35.950	3535.	-2.91	33442.	2.04
7	108.400	74.600	0.0	36.5	3.398	0.196										
				7.3	2.903	-0.330	0.0117	0.9853	-0.1706	-9.826	0.683	35.950	3714.	2.02	34239.	4.47
8	112.300	70.100	0.0	16.0	-4.013	-0.363										
				5.3	-0.988	-0.458	0.4792	0.8224	0.3067	20.453	30.231	114.314	3721.	2.20	106339.	224.47
9	116.300	65.500	0.0	3.1	0.918	0.385										
				2.2	3.103	-0.194	0.1259	0.9919	-0.0170	-0.980	7.232	39.665	3671.	0.82	37332.	13.91

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
10	120.200	60.900	0.0	4.2	2.796	-0.399										
				5.4	0.304	-0.561	-0.9476	0.1615	-0.2756	-59.632	-80.328	2.780	3671.	0.82	2617.	-92.02
11	124.100	56.300	0.0	10.3	3.360	-0.818										
				3.5	1.096	0.120	-0.0293	0.9894	0.1424	8.189	-1.699	42.642	3628.	-0.35	39667.	21.04
12	128.000	51.600	0.0	3.1	-0.309	0.922										
				5.3	1.217	-0.246	0.3272	0.9300	-0.1674	-10.203	19.385	13.465	3714.	2.02	12824.	-60.87
13	131.900	47.100	0.0	16.3	3.475	-0.160										
				30.2	-3.640	-0.328	-0.4806	0.8031	-0.3522	-23.679	-30.898	4.255	3671.	0.82	4005.	-87.78
14	135.800	42.500	0.0	5.4	0.400	0.787										
				3.2	-0.205	0.585	0.4228	0.8194	0.3871	25.284	27.291	4.379	3721.	2.20	4074.	-87.57
15	139.800	37.900	0.0	22.2	3.289	-0.764										
				5.3	0.205	1.329	-0.0081	0.9611	0.2760	16.021	-0.482	19.559	3576.	-1.77	18408.	-43.83
16	143.600	33.200	0.0	3.1	-0.144	-0.686										
				5.3	-0.469	1.206	-0.1987	0.8836	0.4241	25.639	-12.673	6.197	3765.	3.40	5832.	-82.20
17	147.600	28.700	0.0	36.3	3.583	-0.301										
				5.3	-0.948	0.694	0.0521	0.9978	-0.0417	-2.396	2.988	36.482	3628.	-0.35	33936.	3.55
18	151.500	24.000	0.0	30.2	3.732	-0.154										
				3.1	0.759	-0.340	-0.0871	0.9960	0.0217	1.249	-4.999	31.577	3765.	3.40	29720.	-9.32
19	155.500	19.500	0.0	3.1	0.972	0.110										
				5.4	-0.385	-0.398	-0.0871	0.9960	0.0217	1.249	-4.999	31.577	3671.	0.82	29720.	-9.32
20	159.400	14.900	0.0	6.2	3.390	-0.562										
				4.4	1.058	-0.523	-0.9028	0.1311	0.4096	72.248	-81.736	6.278	3576.	-1.77	5909.	-81.97
21	163.200	10.200	0.0	22.1	-3.265	-0.283										
				5.4	-0.540	-0.541	-0.0363	0.9903	-0.1342	-7.716	-2.100	36.465	3671.	0.82	34320.	4.72
22	167.100	5.600	0.0	10.4	3.452	-0.065										
				4.4	1.067	0.833	0.2070	0.9779	0.0292	1.708	11.950	42.823	3671.	0.82	40304.	22.98
23	171.000	1.000	0.0	36.5	-3.269	-0.104										
				5.3	1.278	0.086	0.3544	0.9351	0.0090	0.554	20.755	25.228	3721.	2.20	23468.	-28.39
24	175.000	356.400	0.0	3.1	-0.768	0.438										
				5.4	0.624	0.651	0.0489	0.9966	-0.0661	-3.793	2.809	30.840	3576.	-1.77	29026.	-11.43
25	178.800	351.700	0.0	4.4	-0.820	1.051										
				5.3	0.608	1.202	0.0304	0.9900	-0.1380	-7.935	1.758	53.793	3721.	2.20	50040.	52.69
26	182.800	347.100	0.0	22.2	3.332	-0.005										
				3.5	0.723	-0.869	-0.5306	0.8421	0.0965	6.535	-32.214	15.457	3619.	-0.59	14721.	-55.08
27	186.600	342.500	0.0	36.1	3.611	-0.990										
				3.5	1.187	-0.373	-0.0115	0.9998	0.0135	0.774	-0.661	33.934	3628.	-0.36	31566.	-3.68
28	190.500	337.800	0.0	3.5	1.256	0.420										
				36.5	3.310	-0.217	0.1346	0.9906	0.0253	1.463	7.739	41.346	3671.	0.82	38914.	18.74
29	194.400	333.200	0.0	3.5	0.860	1.090										
				5.3	-1.120	-0.225	-0.1262	0.9821	-0.1396	-8.092	-7.322	20.860	3671.	0.82	19633.	-40.09

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
30	198.300	328.600	0.0	3.1	0.886	0.332										
				4.4	0.725	-0.837	0.0297	0.9850	-0.1701	-9.798	1.730	25.394	3628.	-0.35	23622.	-27.92
31	202.200	323.900	0.0	6.5	3.454	0.223										
				5.4	0.142	-0.549	-0.1457	0.9865	-0.0754	-4.373	-8.400	31.248	3671.	0.82	29410.	-10.26
32	206.100	319.300	0.0	10.1	2.995	-0.537										
				3.1	0.270	1.007	-0.0336	0.9982	0.0498	2.854	-1.926	32.785	3671.	0.82	30857.	-5.85
33	210.000	314.700	0.0	3.5	-1.247	0.228										
				36.1	-3.783	-0.283	0.0118	0.9989	-0.0446	-2.558	0.675	33.683	3671.	0.82	31701.	-3.27
34	213.900	310.100	0.0	5.4	0.695	0.462										
				3.1	-0.618	0.710	-0.0757	0.9940	-0.0794	-4.566	-4.354	20.322	3619.	-0.59	19355.	-40.94
35	217.700	305.500	0.0	5.4	0.474	0.801										
				16.5	3.457	0.005	0.0829	0.9963	0.0241	1.383	4.755	38.773	3678.	1.02	35653.	8.79
36	221.700	300.800	0.0	3.5	0.256	-1.024										
				5.3	0.315	1.350	0.0294	0.9378	-0.3459	-20.246	1.793	30.068	3576.	-1.77	28299.	-13.65
37	225.500	296.100	0.0	22.2	3.338	0.680										
				3.1	-0.343	-0.563	-0.1677	0.9823	0.0835	4.860	-9.698	19.366	3721.	2.20	18015.	-45.03
38	229.500	291.500	0.0	36.1	3.792	-0.195										
				3.1	0.136	-0.656	-0.2087	0.9354	-0.2853	-16.960	-12.578	121.888	3671.	0.82	114717.	250.04
39	233.400	286.900	0.0	4.4	-0.403	-0.945										
				9.3	2.821	-0.241	-0.0169	0.8569	-0.5152	-31.018	-1.131	155.125	3619.	-0.60	147736.	350.79
40	237.200	282.300	0.0	30.1	3.321	0.437										
				1.2	3.832	-0.539	-0.0169	0.8569	-0.5152	-31.018	-1.131	155.125	3628.	-0.35	144303.	340.32
41	241.100	277.600	0.0	5.3	-0.450	-0.922										
				6.4	3.717	-0.518	0.1176	0.8179	0.5632	34.547	8.181	28.775	3671.	0.82	27083.	-17.36
42	245.000	273.000	0.0	4.2	2.731	-0.194										
				3.5	-0.692	1.235	-0.0323	0.9995	-0.0018	-0.105	-1.852	30.335	3628.	-0.36	28218.	-13.90
43	249.900	268.300	0.0	3.5	-1.117	0.684										
				4.4	1.154	0.670	0.1145	0.9922	-0.0494	-2.853	6.585	23.455	3576.	-1.77	22075.	-32.64
44	252.700	263.600	0.0	9.3	3.490	-0.705										
				5.4	0.772	0.156	-0.0072	0.9983	0.0586	3.360	-0.415	35.531	3671.	0.82	33442.	2.04
45	256.600	259.000	0.0	3.5	-0.806	-0.721										
				3.1	-0.714	0.598	0.0222	0.9984	-0.0515	-2.955	1.271	29.950	3628.	-0.35	27860.	-14.99
46	260.500	254.300	0.0	3.1	-0.830	0.147										
				5.4	0.310	0.856	0.0020	0.9999	-0.0106	-0.605	0.117	35.695	3628.	-0.35	33205.	1.32
47	264.400	249.600	0.0	3.5	0.567	-0.983										
				6.3	-3.700	-0.689	0.0402	0.9948	-0.0933	-5.357	2.312	34.083	3671.	0.82	32079.	-2.12
48	268.300	245.000	0.0	3.5	1.076	-0.517										
				5.3	-0.627	1.177	0.0032	0.9986	-0.0528	-3.029	0.186	36.266	3576.	-1.77	34132.	4.15
49	272.100	240.300	0.0	3.5	1.256	0.239										
				5.3	-1.075	0.689	0.1463	0.9892	0.0083	0.480	8.411	25.759	3721.	2.20	23962.	-26.88

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO POINT SEP POS (IN.)	MEASURED COORDINATES NO.	TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
50	276.100	235.700	0.0	3.5	1.010	0.926										
				7.2	2.831	0.511	0.0349	0.9992	0.0189	1.084	2.003	35.215	3576.	-1.77	33143.	1.13
51	279.900	231.000	0.0	16.4	-3.349	-0.590										
				5.3	-0.856	-0.648	-0.4612	0.8174	0.3452	22.894	-29.435	28.864	3619.	-0.60	27490.	-16.12
52	283.700	226.400	0.0	10.3	-4.077	-0.350										
				4.4	1.060	-0.498	0.1787	0.8169	0.5485	33.879	12.338	80.717	3576.	-1.77	75969.	131.81
53	287.500	221.700	0.0	6.1	2.803	0.353										
				5.3	0.465	-0.942	-0.2002	0.9622	0.1846	10.860	-11.751	72.505	3721.	2.20	67446.	105.80
54	291.500	217.100	0.0	10.4	3.454	0.092										
				4.4	0.983	0.884	0.0382	0.9992	-0.0154	-0.880	2.189	36.540	3576.	-1.77	34391.	4.94
55	295.300	212.400	0.0	9.2	3.008	-0.145										
				5.4	0.737	0.294	0.0057	1.0000	-0.0051	-0.291	0.325	32.526	3628.	-0.35	30256.	-7.68
56	299.200	207.700	0.0	30.1	-3.298	-0.167										
				5.4	0.605	0.684	-0.0263	0.9954	-0.0924	-5.305	-1.513	38.334	3576.	-1.77	36079.	10.09
57	303.000	203.000	0.0	3.5	0.100	-1.069										
				3.1	-0.774	-0.144	-0.3520	0.9301	0.1055	6.470	-20.728	10.631	3714.	2.02	10125.	-69.10
58	306.900	198.500	0.0	22.2	3.350	0.123										
				5.4	-0.167	0.376	0.0027	0.9792	0.2028	11.658	0.156	23.358	3619.	-0.60	22245.	-32.12
59	310.700	193.900	0.0	3.1	0.015	-0.708										
				3.5	1.214	-0.261	-0.1679	0.9783	-0.1212	-7.062	-9.736	21.560	3628.	-0.35	20056.	-38.80
60	314.600	189.200	0.0	36.5	3.340	-0.115										
				4.4	-0.577	-0.857	0.0338	0.9991	0.0253	1.452	1.938	36.055	3628.	-0.35	33539.	2.34
61	318.500	184.500	0.0	4.4	0.095	-1.043										
				5.3	-1.112	-0.243	0.0314	0.9980	-0.0552	-3.168	1.802	33.803	3671.	0.82	31815.	-2.92
62	322.400	179.900	0.0	3.5	0.260	1.390										
				3.2	0.292	0.273	0.0314	0.9980	-0.0552	-3.168	1.802	33.803	3566.	-2.05	32581.	-0.58
63	326.100	175.300	0.0	3.5	-0.404	1.302										
				5.3	-1.060	0.020	0.0037	0.9947	-0.1024	-5.879	0.214	32.973	3628.	-0.35	30672.	-6.41
64	330.000	170.600	0.0	3.1	0.230	0.975										
				4.4	1.247	0.403	0.0114	0.9987	-0.0489	-2.803	0.654	32.658	3671.	0.82	30737.	-6.21
65	333.900	166.000	0.0	3.1	-0.224	0.946										
				5.3	1.131	-0.390	0.0084	0.9989	-0.0467	-2.676	0.479	36.232	3535.	-2.91	33704.	2.84
66	337.700	161.200	0.0	3.1	-0.604	0.676										
				5.3	1.210	0.410	-0.0521	0.9982	-0.0301	-1.728	-2.990	27.344	3714.	2.02	26042.	-20.54
67	341.600	156.700	0.0	3.1	-0.804	0.241										
				4.4	-0.505	1.272	0.0230	0.9741	0.2249	13.002	1.355	4.519	3628.	-0.35	4203.	-87.17
68	345.500	152.000	0.0	8.6	3.976	-0.358										
				4.4	-1.014	0.783	-0.2718	0.9609	0.0539	3.209	-15.794	31.233	3628.	-0.35	29054.	-11.35
69	349.400	147.300	0.0	3.1	-0.400	-0.587										
				4.2	-2.760	-0.088	-0.3750	0.9215	-0.1007	-6.236	-22.146	1.209	3576.	-1.77	1138.	-96.53

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP. POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
70	-353.200	142.600	0.0	36.1	3.750	-0.125										
				4.4	-0.959	-0.544										
							-0.2228	0.9742	0.0351	2.061	-12.881	36.703	3619.	-0.60	34955.	6.66
71	357.000	138.000	0.0	9.2	-2.950	0.427										
				4.4	-0.496	-0.551										
							0.0962	0.9933	-0.0635	-3.660	5.533	29.965	3576.	-1.77	28202.	-13.95
72	0.800	133.300	0.0	5.3	-0.998	-0.486										
				3.5	0.725	1.160										
							-0.1004	0.9821	-0.1597	-9.234	-5.835	23.083	3671.	0.82	21725.	-33.71
73	4.700	128.700	0.0	3.1	0.837	0.435										
				4.4	0.886	-0.694										
							0.0230	0.9983	-0.0534	-3.062	1.318	33.940	3576.	-1.77	31943.	-2.53
74	8.500	124.000	0.0	3.1	0.545	0.793										
				4.2	2.720	-0.258										
							-0.0012	0.9995	-0.0324	-1.857	-0.071	34.723	3671.	0.82	32681.	-0.28
75	12.400	119.400	0.0	4.4	1.145	0.623										
				10.1	3.070	0.065										
							-0.0242	0.9971	-0.0718	-4.116	-1.388	31.249	3482.	-4.35	29411.	-10.26
76	16.100	114.600	0.0	36.3	-3.495	-0.390										
				3.5	-1.196	-0.135										
							0.0566	0.9922	-0.1110	-6.384	3.265	35.485	3619.	-0.60	33795.	3.12
77	19.900	110.000	0.0	3.1	-0.754	0.429										
				5.3	1.183	0.542										
							0.1379	0.9904	0.0001	0.007	7.929	15.105	3628.	-0.35	14051.	-57.13
78	23.800	105.300	0.0	3.4	2.725	0.184										
				3.5	-0.120	-1.085										
							-0.0592	0.9752	-0.2134	-12.346	-3.473	48.368	3671.	0.82	45523.	38.91
79	27.700	100.700	0.0	22.2	3.304	-0.584										
				3.5	0.533	-1.044										
							-0.2242	0.9187	0.3250	19.483	-13.713	17.078	3576.	-1.77	16074.	-50.95
80	31.500	96.000	0.0	3.1	-0.133	-0.745										
				4.4	-1.179	-0.193										
							0.1734	0.9821	-0.0731	-4.259	10.010	31.757	3524.	-3.21	30244.	-7.71
81	35.200	91.300	0.0	36.5	3.575	-0.160										
				3.1	0.350	-0.662										
							0.0779	0.9874	-0.1380	-7.954	4.509	21.849	3721.	2.20	20325.	-37.98
82	39.200	86.700	0.0	3.1	0.734	-0.418										
				4.4	-0.129	-1.104										
							-0.5645	0.2920	-0.7720	-69.285	-62.653	8.463	3576.	-1.77	7965.	-75.70
83	43.000	82.000	0.0	3.4	-3.431	0.225										
				3.5	0.550	1.421										
							0.0989	0.8760	0.4720	28.317	6.439	22.734	3576.	-1.77	21396.	-34.71
84	46.800	77.300	0.0	6.5	3.432	-0.500										
				5.3	-0.188	-1.065										
							0.0446	0.9990	-0.0068	-0.388	2.553	31.414	3576.	-1.77	29566.	-9.79
85	50.600	72.600	0.0	3.5	-0.777	0.968										
				5.4	0.407	-0.533										
							-0.0026	0.9977	-0.0678	-3.885	-0.147	36.682	3671.	0.82	34524.	5.34
86	54.500	68.000	0.0	3.5	-1.162	0.331										
				5.3	1.070	-0.572										
							-0.0156	0.9998	-0.0088	-0.503	-0.896	27.197	3576.	-1.77	25597.	-21.90
87	58.300	63.300	0.0	36.5	-3.245	-0.238										
				3.1	-0.447	0.743										
							0.1425	0.9885	-0.0512	-2.967	8.204	29.487	3671.	0.82	27752.	-15.32
88	62.200	58.700	0.0	16.5	3.417	-0.746										
				3.5	-0.578	-0.995										
							-0.1611	0.9829	-0.0895	-5.205	-9.311	30.858	3628.	-0.35	28705.	-12.41
89	66.100	54.000	0.0	8.1	3.612	-0.435										
				3.5	0.151	-1.202										
							-0.0127	0.9998	0.0172	0.986	-0.727	33.880	3671.	0.82	31887.	-2.70

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP. POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
90	70.000	49.400	0.0	5.4	-0.192	0.817										
				3.1	-0.440	-0.574	-0.0347	0.8713	0.4895	29.329	-2.279	6.267	3628.	-0.35	5830.	-82.21
91	73.900	44.700	0.0	36.1	3.700	-0.960										
				10.1	-2.980	0.144	0.2906	0.9540	-0.0736	-4.413	16.944	25.356	3663.	0.60	24439.	-25.43
92	77.700	40.200	0.0	36.8	3.927	-0.865										
				3.5	1.313	0.324	0.3665	0.7502	-0.5504	-36.269	26.037	48.245	4108.	12.84	52157.	59.15
93	81.500	36.600	0.0	43.3	3.872	-0.321										
				5.4	-0.538	-0.379	0.0578	0.9169	0.3950	23.305	3.605	68.210	3250.	-10.73	56842.	73.44
94	85.400	30.900	0.0	5.3	-0.646	-0.868										
				4.4	0.870	-0.561	0.1242	0.9923	0.0028	0.161	7.133	24.527	3671.	0.82	23084.	-29.56
95	89.300	26.300	0.0	3.1	0.712	0.631										
				6.5	3.465	0.181	0.1158	0.9930	-0.0234	-1.347	6.653	39.901	3628.	-0.35	37117.	13.26
96	93.200	21.600	0.0	10.3	3.740	-0.768										
				4.4	1.258	0.363	-0.4866	0.8669	0.1081	7.106	-29.307	23.550	3671.	0.82	22165.	-32.37
97	97.100	17.000	0.0	15.4	3.970	-0.403										
				9.2	2.780	-0.975	-0.0571	0.9983	-0.0077	-0.445	-3.274	38.172	3671.	0.82	35926.	9.62
98	101.000	12.400	0.0	16.3	3.411	-0.644										
				9.2	3.061	0.328	-0.0571	0.9983	-0.0077	-0.445	-3.274	38.172	3671.	0.82	35926.	9.62
99	104.900	7.800	0.0	5.4	0.572	0.649										
				16.5	3.537	-0.053	0.4064	0.9117	0.0613	3.849	24.024	58.808	3619.	-0.60	56007.	70.90
100	108.700	3.200	0.0	6.1	-3.837	-0.322										
				5.4	0.200	0.819	0.1494	0.9398	-0.3074	-18.114	9.032	75.108	5349.	1.09	108592.	125.64
100	108.700	3.200	0.0	6.1	-3.837	-0.322										
				5.4	0.200	0.819										

	AVG. SPEED (RPM)	AVG. ABS(SPEED ERROR) (PERCENT)	AVERAGE YAW (DEG.)	AVERAGE PITCH (DEG.)	MEAN BALL POSITION (DEG.)
SEPARATOR	3640.76	1.4530			
BALL	32772.62	39.3231	-3.511	-1.465	0.0

ITI BALL MOTION DATA REDUCTION

ITI BALL MOTION TEST NO. 1-A-4 (3/22/73)

APP. -1-

	SHAFT RPM	BALL DIA.	TEST BALL NO.	PITCH DIA.	SEPARATOR MEAN RAD	FILM MAGNIFICATION	OBJECT LENGTH
•	8000.	0.750	2	5.6350	2.8175	12.750	34.276

FRAME NO.	C.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
1	69.600	334.100	0.0	16.4	3.591	-0.165										
				6.6	-2.985	-0.832	-0.4567	0.7485	-0.4809	-32.718	-31.388	32.712	3494.	-0.83	30080.	-2.17
2	73.400	329.200	0.0	11.4	-3.609	-1.148										
				15.4	-0.572	1.176	0.5344	0.6025	-0.5928	-44.534	41.568	49.449	3535.	0.32	45999.	49.60
3	77.200	324.400	0.0	12.2	-4.089	-0.593										
				9.3	-0.567	1.234	0.0347	0.5122	-0.8582	-59.169	3.879	94.308	3494.	-0.83	86721.	182.04
4	81.000	319.500	0.0	7.2	3.544	-0.562										
				3.5	-2.612	0.148	-0.0085	0.8727	-0.4881	-29.219	-0.556	32.640	3391.	-3.76	28383.	-7.69
5	84.900	314.200	0.0	30.1	3.578	-0.100										
				5.2	-1.470	0.295	0.0530	0.8956	-0.4416	-26.248	3.385	31.474	3086.	-12.43	35970.	16.99
6	87.600	309.900	0.0	16.5	-3.953	-0.258										
				2.4	1.482	0.390	-0.0393	0.8431	-0.5363	-32.461	-2.667	34.638	3959.	12.35	28568.	-7.09
7	92.400	305.000	0.0	6.4	3.451	-0.886										
				4.1	0.720	-0.761	0.1558	0.8826	-0.4436	-26.684	10.013	39.830	3535.	0.32	37051.	20.50
8	96.200	300.200	0.0	11.3	3.984	-0.617										
				3.5	-2.971	-0.625	-0.1980	0.8751	-0.4416	-26.775	-12.751	28.159	3545.	0.62	25599.	-16.74
9	100.100	295.300	0.0	7.3	-3.737	-0.393										
				2.2	-1.183	0.290	0.1238	0.7410	-0.6600	-41.692	9.484	16.333	3494.	-0.83	15019.	-51.15

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
10	103.900	290.400	0.0	30.1	-3.737	-0.085										
				6.4	-0.764	1.751	-0.0376	0.9001	-0.4341	-25.749	-2.392	49.896	3535.	0.32	46415.	50.96
11	107.700	285.600	0.0	6.3	-2.695	-0.680										
				10.1	0.700	-0.905	0.0972	0.8856	-0.4542	-27.156	6.261	29.475	3494.	-0.83	27104.	-11.85
12	111.500	280.700	0.0	6.4	-3.342	-0.697										
				10.1	0.095	-0.720	0.0880	0.8903	-0.4468	-26.651	5.646	30.307	3545.	0.62	27551.	-10.39
13	115.400	275.800	0.0	11.1	-3.551	-0.849										
				10.3	-1.440	-0.211	-0.0333	0.8991	-0.4365	-25.894	-2.121	35.695	3494.	-0.83	32824.	6.75
14	119.200	270.900	0.0	13.1	-3.521	-0.554										
				4.5	0.450	-1.081	0.0870	0.8773	-0.4720	-28.281	5.666	25.875	3535.	0.32	24069.	-21.72
15	123.000	266.100	0.0	15.4	-2.823	-0.588										
				7.2	3.585	-0.658	0.0110	0.8943	-0.4474	-26.576	0.704	31.756	3545.	0.62	28869.	-6.11
16	126.900	261.200	0.0	2.3	3.198	-0.640										
				4.4	0.540	-0.936	-0.0402	0.8991	-0.4359	-25.866	-2.563	29.195	3482.	-1.17	27477.	-10.63
17	130.600	256.400	0.0	3.5	-0.166	1.625										
				4.4	-0.060	-0.841	0.0424	0.8859	-0.4619	-27.534	2.743	35.512	3545.	0.62	32284.	5.00
18	134.500	251.500	0.0	6.4	3.443	-1.060										
				4.3	0.240	-0.866	0.0474	0.8915	-0.4506	-26.813	3.042	34.141	3494.	-0.83	31394.	2.11
19	138.300	246.600	0.0	11.1	3.596	-0.691										
				2.2	0.283	0.557	0.0229	0.8879	-0.4595	-27.360	1.479	32.658	3545.	0.62	29689.	-3.44
20	142.200	241.700	0.0	11.4	3.345	0.156										
				6.3	-0.106	1.148	-0.0233	0.8986	-0.4382	-25.994	-1.486	30.885	3535.	0.32	28730.	-6.56
21	146.000	236.900	0.0	4.2	-0.165	-1.060										
				10.2	1.370	0.184	0.0778	0.9117	-0.4035	-23.874	4.878	42.182	3494.	-0.83	38789.	26.15
22	149.800	232.000	0.0	15.3	3.910	-0.486										
				10.3	0.990	0.090	0.0103	0.9118	-0.4106	-24.242	0.645	31.971	3535.	0.32	29740.	-3.27
23	153.600	227.200	0.0	10.1	0.120	-0.734										
				6.4	-3.311	-0.477	0.0386	0.8157	-0.5771	-35.280	2.711	23.813	3586.	1.78	21897.	-28.78
24	157.500	222.400	0.0	10.1	-0.485	-0.853										
				15.4	-0.110	1.255	0.0702	0.8968	-0.4369	-25.976	4.479	39.592	3494.	-0.83	36406.	18.41
25	161.300	217.500	0.0	13.3	-3.296	0.360										
				9.3	-0.518	1.347	-0.6347	0.4303	0.6419	56.162	-55.863	19.592	3494.	-0.83	18015.	-41.41
26	165.100	212.600	0.0	7.2	-3.585	-1.030										
				9.2	-1.203	0.665	0.0238	0.8730	-0.4871	-29.160	1.562	140.112	3535.	0.32	130337.	323.90
27	168.900	207.800	0.0	5.2	-1.132	0.477										
				3.2	0.996	0.125	-0.0235	0.8678	-0.4963	-29.766	-1.551	33.522	3494.	-0.83	30825.	0.25
28	172.700	202.900	0.0	3.1	0.426	0.275										
				2.1	2.577	-0.628	0.0164	0.8787	-0.4772	-28.504	1.070	32.701	3586.	1.77	30070.	-2.20
29	176.600	198.100	0.0	6.3	2.649	-0.434										
				4.4	-0.578	-1.001	0.1099	0.9045	-0.4121	-24.498	6.929	36.028	3494.	-0.83	33129.	7.75

FRAME NO.	O.S. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
30	180.400	193.200	0.0	3.5	-2.807	-0.188										
				6.4	2.970	0.356										
							-0.0519	0.8804	-0.4715	-28.171	-3.374	31.649	3545.	0.62	28772.	-6.42
31	184.300	188.300	0.0	2.2	-0.883	0.425										
				6.5	0.316	0.364										
							0.0227	0.8528	-0.5217	-31.458	1.527	28.725	3535.	0.32	26721.	-13.09
32	188.100	183.500	0.0	6.5	-0.933	0.162										
				13.1	3.186	0.438										
							0.0957	0.9155	-0.3930	-23.234	5.347	34.138	3494.	-0.83	31391.	2.09
33	191.900	178.600	0.0	1.1	-3.982	-0.116										
				10.1	0.856	-1.012										
							0.0924	0.8649	-0.4953	-29.699	6.100	31.910	3494.	-0.83	29342.	-4.57
34	195.700	173.700	0.0	6.2	-3.764	-0.389										
				10.2	-1.028	0.295										
							0.0715	0.8722	-0.4839	-29.021	4.684	31.957	3586.	1.77	29386.	-4.43
35	199.600	168.900	0.0	11.3	-3.723	0.326										
				10.3	-1.188	-0.070										
							-0.1637	0.5732	-0.8029	-54.480	-15.939	20.110	3494.	-0.83	18492.	-39.86
36	203.400	164.000	0.0	9.2	0.502	0.920										
				10.1	-1.247	-0.440										
							-0.0205	0.9467	-0.3213	-18.748	-1.241	44.077	3576.	1.50	41484.	34.92
37	207.200	159.300	0.0	5.2	0.440	0.740										
				3.5	2.962	-0.350										
							0.0413	0.8946	-0.4451	-26.451	2.644	31.402	3545.	0.62	28547.	-7.15
38	211.100	154.400	0.0	15.3	-3.766	-0.137										
				4.4	0.677	-1.011										
							-0.0147	0.8516	-0.5240	-31.607	-0.989	32.801	3494.	-0.83	30162.	-1.90
39	214.900	149.500	0.0	4.4	0.121	-0.831										
				5.3	-1.263	-0.412										
							0.0180	0.8772	-0.4798	-28.677	1.172	34.393	3494.	-0.83	31626.	2.86
40	218.700	144.600	0.0	4.3	0.412	-0.904										
				2.4	0.687	0.786										
							0.0535	0.8650	-0.4990	-29.980	3.542	31.323	3494.	-0.83	28803.	-6.32
41	222.500	139.700	0.0	6.4	3.112	0.171										
				2.1	0.736	1.270										
							0.0282	0.8970	-0.4411	-26.188	1.799	31.295	3586.	1.77	28777.	-6.41
42	226.400	134.900	0.0	7.3	-3.472	0.385										
				6.3	0.315	1.160										
							0.0237	0.8531	-0.5212	-31.422	1.591	32.937	3494.	-0.83	30287.	-1.50
43	230.200	130.000	0.0	13.1	3.283	0.295										
				4.2	-0.070	-1.030										
							-0.5805	0.5332	-0.6155	-49.098	-47.433	19.087	3535.	0.32	17756.	-42.25
44	234.000	125.200	0.0	15.4	2.859	-0.504										
				4.2	-1.533	-1.249										
							-0.4342	0.4896	-0.7561	-57.078	-41.572	24.843	3545.	0.62	22584.	-26.55
45	237.900	120.300	0.0	10.1	0.325	-0.745										
				16.3	3.545	-0.836										
							0.0088	0.9092	-0.4163	-24.602	0.553	32.959	3535.	0.32	30660.	-0.28
46	241.700	115.500	0.0	10.1	-0.325	-0.775										
				9.1	0.868	-0.414										
							-0.0004	0.8514	-0.5245	-31.636	-0.028	29.305	3535.	0.32	27260.	-11.34
47	245.500	110.700	0.0	5.1	1.358	-0.085										
				3.6	3.600	0.120										
							0.1196	0.9242	-0.3626	-21.423	7.375	34.693	3545.	0.62	31539.	2.57
48	249.400	105.800	0.0	13.3	-3.681	-0.910										
				5.4	1.247	-0.469										
							-0.0113	0.8560	-0.5169	-31.128	-0.758	34.533	3535.	0.32	32123.	4.48
49	253.200	101.000	0.0	5.2	-0.789	0.655										
				9.3	-2.817	-0.252										
							-0.0121	0.8468	-0.5318	-32.130	-0.820	34.736	3455.	-1.96	31578.	2.70

FRAME NO.	C.F. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	PERCENT ERROR	BALL SPEED (RPM)	PERCENT ERROR
50	257.000	96.000	0.0	3.1	0.721	0.197										
				1.2	3.778	-0.230	0.0036	0.9129	-0.4081	-24.087	0.229	30.132	3586.	1.77	27708.	-9.88
51	260.900	91.200	0.0	3.2	-1.065	0.143										
				4.4	-0.417	-0.896	0.0036	0.9129	-0.4081	-24.087	0.229	30.132	3535.	0.32	28029.	-8.84
52	264.700	86.400	0.0	3.6	-3.785	-1.196										
				2.4	-0.530	0.811	0.0278	0.8332	-0.5522	-33.534	1.912	32.441	3494.	-0.83	29830.	-2.98
53	268.500	81.500	0.0	4.1	-0.392	-0.631										
				6.5	0.666	0.280	0.0287	0.9132	-0.4065	-23.994	1.802	34.377	3545.	0.62	31253.	1.64
54	272.400	76.600	0.0	2.3	-3.037	-0.405										
				6.3	-1.023	0.955	-0.0744	0.8513	-0.5193	-31.384	-4.996	24.901	3494.	-0.83	22897.	-25.53
55	276.200	71.700	0.0	10.1	0.569	-1.131										
				15.4	2.924	-0.700	0.0855	0.8687	-0.4880	-29.324	5.624	41.887	3535.	0.32	38965.	26.73
56	280.000	66.900	0.0	9.3	2.915	-0.322										
				6.4	-3.006	0.217	-0.0964	0.9171	-0.3867	-22.865	-6.002	26.376	3535.	0.32	24537.	-20.20
57	283.800	62.100	0.0	10.3	-0.908	0.126										
				12.1	-4.088	-0.247	0.2316	0.2607	-0.9372	-74.458	41.620	23.881	3494.	-0.83	21960.	-28.58
58	287.600	57.200	0.0	10.4	-1.030	-0.247										
				9.3	0.853	0.845	-0.3843	0.7590	-0.5256	-34.706	-26.852	41.256	3586.	1.78	37936.	23.38
59	291.500	52.400	0.0	3.5	3.110	-0.781										
				5.3	0.450	0.324	0.5107	0.8359	-0.2013	-13.539	31.423	9.376	3442.	-2.32	8722.	-71.63
60	295.200	47.500	0.0	15.3	-3.514	0.337										
				5.1	-0.783	0.168	0.0642	0.8190	-0.5702	-34.847	4.480	31.546	3545.	0.62	28678.	-6.73
61	299.100	42.600	0.0	3.2	0.320	0.339										
				4.4	0.290	-0.887	0.0642	0.8190	-0.5702	-34.847	4.480	31.546	3535.	0.32	29345.	-4.56
62	302.900	37.800	0.0	3.2	-0.911	0.139										
				4.4	-0.272	-0.876	0.0642	0.8190	-0.5702	-34.847	4.480	31.546	3494.	-0.83	29007.	-5.66
63	306.700	32.900	0.0	3.1	-1.369	-0.221										
				4.1	0.483	-0.632	-0.0046	0.8564	-0.5163	-31.084	-0.305	30.542	3535.	0.32	28411.	-7.60
64	310.500	28.100	0.0	4.1	-0.257	-0.580										
				2.1	-0.407	1.341	-0.0200	0.8932	-0.4492	-26.695	-1.286	33.978	3545.	0.62	30890.	0.46
65	314.400	23.200	0.0	4.2	0.070	-1.007										
				6.5	-0.400	0.349	0.0061	0.9037	-0.4281	-25.346	0.386	35.846	3535.	0.32	33345.	8.45
66	318.200	18.400	0.0	6.5	-1.501	-0.247										
				3.2	-0.400	-1.143	0.1810	0.8047	-0.5654	-35.095	12.680	24.235	3494.	-0.83	22285.	-27.52
67	322.000	13.500	0.0	10.4	1.148	-0.314										
				6.4	-2.869	0.427	-0.0152	0.8509	-0.5252	-31.683	-1.021	33.247	3494.	-0.84	30572.	-0.57
68	325.800	8.600	0.0	10.1	-0.137	-0.757										
				16.4	3.438	0.129	-0.6101	0.6176	-0.4963	-39.786	-44.646	47.109	3535.	0.32	43822.	42.53
69	329.600	3.800	0.0	3.5	3.751	-0.438										
				15.4	-0.811	1.200	-0.6399	0.3689	0.6741	61.310	-60.037	12.149	3494.	-0.83	11172.	-63.67

FRAME NO.	C.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
70	333.400	358.900	0.0	9.2	-0.408	0.926										
				5.3	1.158	-0.320	-0.0109	0.8707	-0.4917	-29.453	-0.714	33.026	3636.	3.20	30024.	-2.35
71	337.400	354.100	0.0	3.2	1.527	-0.180										
				5.1	-0.615	0.272	-0.0238	0.8698	-0.4929	-29.539	-1.571	29.273	3482.	-1.17	27551.	-10.39
72	341.100	349.300	0.0	3.1	1.004	0.080										
				30.1	3.450	0.254	0.0249	0.9094	-0.4153	-24.544	1.571	31.156	3546.	0.62	28323.	-7.88
73	345.000	344.400	0.0	3.2	-0.758	0.230										
				4.4	-0.270	-0.872	0.0249	0.9094	-0.4153	-24.544	1.571	31.156	3442.	-2.32	28983.	-5.74
74	348.700	339.500	0.0	4.4	-0.751	-1.149										
				6.4	3.341	-0.565	-0.0554	0.8879	-0.4566	-27.214	-3.567	29.295	3586.	1.77	26938.	-12.39
75	352.600	334.700	0.0	4.3	-0.545	-1.001										
				6.5	0.948	0.146	0.0371	0.9063	-0.4210	-24.915	2.342	33.911	3494.	-0.84	31181.	1.41
76	356.400	329.800	0.0	2.3	-2.870	0.035										
				4.1	-0.849	-0.884	-0.0011	0.8330	-0.5532	-33.590	-0.078	31.717	3482.	-1.17	29852.	-2.91
77	0.100	325.000	0.0	10.2	0.968	0.377										
				13.3	3.131	0.693	0.0030	0.9112	-0.4120	-24.329	0.188	32.170	3586.	1.77	29581.	-3.79
78	4.000	320.200	0.0	10.1	0.605	-0.888										
				10.3	0.630	0.211	0.0030	0.9112	-0.4120	-24.329	0.188	32.170	3494.	-0.84	29581.	-3.79
79	7.800	315.300	0.0	6.4	-3.720	-0.969										
				10.5	-1.267	0.759	-0.0957	0.9009	-0.4233	-25.166	-6.066	35.414	3317.	-5.86	34551.	12.37
80	11.200	310.500	0.0	9.3	0.700	1.330										
				3.4	3.291	0.308	0.8277	0.1490	-0.5410	-74.600	79.794	21.631	3692.	4.78	19016.	-38.15
81	15.400	305.600	0.0	13.1	-3.559	-0.826										
				13.2	-4.074	-0.161	0.8277	0.1490	-0.5410	-74.600	79.794	21.631	3545.	0.62	19665.	-36.04
82	19.300	300.700	0.0	3.5	2.642	0.186										
				5.1	-0.464	0.259	-0.0224	0.8818	-0.4710	-28.109	-1.455	32.191	3482.	-1.17	30297.	-1.46
83	23.000	295.900	0.0	3.2	0.675	0.272										
				4.4	0.456	-0.928	-0.0224	0.8818	-0.4710	-28.109	-1.455	32.191	3545.	0.62	29265.	-4.82
84	26.900	291.000	0.0	3.2	-0.571	0.273										
				4.4	-0.095	-0.858	-0.0224	0.8818	-0.4710	-28.109	-1.455	32.191	3535.	0.32	29945.	-2.61
85	30.700	286.200	0.0	3.2	-1.575	-0.318										
				4.1	0.641	-0.730	-0.0108	0.8562	-0.5165	-31.098	-0.720	34.605	3535.	0.32	32190.	4.69
86	34.500	281.400	0.0	4.1	-0.065	-0.537										
				11.1	3.514	-0.460	0.1917	0.8943	-0.4042	-24.321	12.101	36.058	3535.	0.32	33542.	9.09
87	38.300	276.600	0.0	7.3	-3.757	-0.370										
				11.4	3.197	0.332	-0.1136	0.8302	-0.5458	-33.323	-7.789	27.214	3494.	-0.83	25024.	-18.61
88	42.100	271.700	0.0	6.6	-0.357	1.307										
				13.3	3.300	0.420	0.0135	0.8815	-0.4720	-28.164	0.877	34.579	3535.	0.32	32167.	4.62
89	45.900	266.900	0.0	15.3	3.802	-0.250										
				6.3	-2.723	-0.680	-0.6010	0.6788	-0.4219	-31.862	-41.524	20.235	3545.	0.62	18396.	-40.17

FRAME NO.	C.P. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
90	49.800	262.000	0.0	16.3	3.666	-0.417										
				10.1	0.075	-0.740	0.1336	0.8574	-0.4970	-30.102	8.855	43.882	3535.	0.32	40820.	32.76
91	53.600	257.200	0.0	3.4	3.428	0.025										
				11.4	-3.329	0.090	-0.0915	0.8552	-0.5102	-30.820	-6.104	28.830	3535.	0.32	26819.	-12.78
92	57.400	252.400	0.0	5.2	1.388	0.368										
				9.3	-0.693	1.320	-0.0548	0.8639	-0.5006	-30.091	-3.630	34.137	3494.	-0.83	31391.	2.09
93	61.200	247.500	0.0	5.4	0.956	-0.292										
				7.2	3.595	-0.802	0.0128	0.8950	-0.4459	-26.483	0.821	31.464	3494.	-0.83	28932.	-5.90
94	65.000	242.600	0.0	3.2	0.865	0.170										
				30.1	3.660	-0.355	0.0067	0.9039	-0.4276	-25.317	0.426	30.761	3586.	1.77	28286.	-8.00
95	68.900	237.800	0.0	3.2	-0.375	0.299										
				4.4	-0.670	-0.855	0.0067	0.9039	-0.4276	-25.317	0.426	30.761	3259.	-7.50	30381.	-1.19
96	72.200	233.000	0.0	4.4	-0.630	-1.046										
				6.4	3.423	-1.117	0.1627	0.8533	-0.4953	-30.132	10.795	26.645	3733.	5.95	23685.	-22.97
97	76.400	228.200	0.0	3.5	-2.890	-0.369										
				2.4	-1.071	0.368	-0.0652	0.8674	-0.4933	-29.624	-4.301	37.671	3494.	-0.83	34640.	12.66
98	80.200	223.300	0.0	2.2	-0.974	0.267										
				4.1	-0.643	-0.796										

	AVG. SPEED (RPM)	AVG. ABS(SPEED ERROR) (PERCENT)	AVERAGE YAW (DEG.)	AVERAGE PITCH (DEG.)	MEAN BALL POSITION (DEG.)
SEPARATOR	3523.66	1.3394			
BALL	30747.05	19.1033	0.108	-29.242	0.0

I T I BALL MOTION DATA REDUCTION

ITI BALL MOTION TEST NO. 1-A-5 5-30-73

APP. -1-

SHAFT RPM	BALL DIA.	TEST BALL NO.	PITCH DIA.	SEPARATOR MEAN RAD	FILM MAGNIFICATION	OBJECT LENGTH
12000.	0.750	3	5.6350	2.8175	12.750	34.276

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	MEASURED COORDINATES RAD	SPIN AXIS DIRECTION X	SPIN AXIS DIRECTION Y	SPIN AXIS DIRECTION Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
1	298.000	334.850	0.0	43.1	0.246	1.454										
				43.3	0.741	0.397	0.0196	0.9898	-0.1409	-8.099	1.133	38.197	5223.	-1.86	47500.	9.87
2	302.200	329.400	0.0	43.3	0.138	0.656										
				43.5	0.680	0.345	-0.0089	0.9811	-0.1933	-11.145	-0.520	35.868	5347.	0.48	44602.	3.17
3	306.500	324.050	0.0	43.5	0.106	0.594										
				40.2	3.417	-0.403	0.0155	0.9871	-0.1592	-9.162	0.899	74.776	5309.	-0.24	46980.	8.67
4	314.950	313.400	0.0	40.5	0.602	0.671										
				44.3	1.499	0.077	0.1398	0.9734	-0.1815	-10.564	8.170	27.871	5388.	1.24	34128.	-21.06
5	319.350	308.000	0.0	31.2	3.583	0.203										
				40.5	0.108	0.787	0.0025	0.9881	-0.1536	-8.836	0.145	39.622	5340.	0.35	49787.	15.17
6	323.600	302.700	0.0	40.5	-0.790	0.457										
				44.3	0.0	1.108	0.0461	0.9841	-0.1718	-9.901	2.682	36.231	5312.	-0.17	45289.	4.76
7	327.850	297.350	0.0	36.5	3.818	-0.824										
				44.3	-0.890	0.782	-0.0175	0.9864	-0.1633	-9.401	-1.016	70.535	5295.	-0.50	44199.	2.24
8	336.300	286.650	0.0	43.3	1.109	-0.113										
				42.3	-0.550	1.248	0.0717	0.9699	-0.2327	-13.489	4.230	31.175	5312.	-0.17	38968.	-9.86
9	340.550	281.300	0.0	38.4	3.753	0.688										
				43.5	1.043	-0.137	-0.0183	0.9908	-0.1340	-7.704	-1.060	37.196	5347.	0.48	46255.	6.99

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
10	344.850	275.950	0.0	43.1	-0.981	1.172										
				43.5	0.701	0.354	0.1340	0.9820	-0.1334	-7.735	7.769	28.825	5312.	-0.17	36031.	-16.65
11	349.100	270.600	0.0	42.4	-2.988	-0.571										
				43.3	-0.585	0.420	0.0641	0.9700	-0.2345	-13.590	3.781	34.070	5258.	-1.20	42149.	-2.50
12	353.350	265.150	0.0	40.5	1.158	0.140										
				43.5	-0.525	0.360	-0.0698	0.9758	-0.2071	-11.982	-4.090	32.955	5298.	-0.44	42070.	-2.69
13	357.500	259.900	0.0	44.3	1.449	0.152										
				44.1	3.040	-0.179	-0.2082	0.9489	-0.2370	-14.022	-12.376	22.726	5313.	-0.17	28407.	-34.29
14	361.750	254.550	0.0	43.3	-0.883	-0.745										
				44.3	0.874	0.856	0.0233	0.9866	-0.1615	-9.294	1.350	34.695	5285.	-0.69	43144.	-0.20
15	6.000	249.150	0.0	40.5	-0.848	0.381										
				42.2	3.851	-0.722	-0.0741	0.9878	-0.1367	-7.880	-4.288	37.015	5340.	0.35	46511.	7.59
16	10.250	243.850	0.0	40.5	-1.162	-0.277										
				44.3	-0.945	0.720	0.0130	0.9956	-0.0926	-5.313	0.746	34.806	5313.	-0.17	43507.	0.64
17	14.500	238.500	0.0	36.6	4.056	-0.897										
				42.3	0.471	1.301	0.0401	0.9958	-0.0818	-4.698	2.305	36.462	5305.	-0.31	46057.	6.54
18	18.700	233.200	0.0	44.1	-2.963	-0.546										
				43.1	1.189	1.033	0.0274	0.9744	-0.2231	-12.894	1.610	37.004	5320.	-0.04	45778.	5.89
19	23.000	227.800	0.0	42.3	-1.455	0.462										
				43.3	0.678	0.411	0.1020	0.9842	-0.1446	-8.359	5.914	30.817	5333.	0.22	39133.	-9.48
20	27.200	222.550	0.0	42.2	-3.763	0.151										
				43.3	0.030	0.620	0.1906	0.9703	-0.1491	-8.735	11.112	32.188	5223.	-1.86	40027.	-7.41
21	31.400	217.100	0.0	36.5	-3.765	0.142										
				40.2	3.400	-0.210	-0.4611	0.8357	-0.2984	-19.648	-28.890	28.009	5368.	0.88	35380.	-18.16
22	35.650	211.850	0.0	43.3	-1.018	-0.188										
				43.6	0.353	1.404	0.0052	0.9799	-0.1995	-11.509	0.304	31.882	5320.	-0.04	39442.	-8.76
23	39.950	206.450	0.0	43.5	-0.931	-0.212										
				40.5	0.535	0.630	0.0026	0.9868	-0.1617	-9.304	0.150	38.279	5312.	-0.17	47849.	10.68
24	44.200	201.100	0.0	40.5	-0.202	0.737										
				44.3	0.794	0.860	0.0125	0.9784	-0.2062	-11.901	0.731	32.423	5250.	-1.35	40528.	-6.25
25	48.400	195.700	0.0	44.3	-0.092	1.029										
				42.2	3.849	-0.626	-0.0219	0.9911	-0.1312	-7.539	-1.265	35.608	5340.	0.35	44743.	3.50
26	52.650	190.400	0.0	30.4	-3.157	0.192										
				40.5	-1.208	-0.356	0.0363	0.9822	-0.1845	-10.638	2.117	71.725	5242.	-1.49	45300.	4.79
27	60.950	179.700	0.0	42.3	-0.694	1.127										
				43.3	1.081	-0.126	-0.0312	0.9807	-0.1930	-11.134	-1.820	35.775	5409.	1.65	44487.	2.90
28	65.300	174.400	0.0	43.5	1.009	-0.145										
				39.3	3.965	-0.660	0.0397	0.9845	-0.1707	-9.834	2.307	74.689	5313.	-0.17	46681.	7.98
29	73.800	163.700	0.0	43.3	-0.641	0.313										
				43.6	1.362	0.828	-0.0115	0.9812	-0.1925	-11.098	-0.669	33.509	5250.	-1.35	41886.	-3.11

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
30	78.000	156.300	0.0	43.5	-0.592	0.242										
				40.5	1.114	0.140										
							0.0445	0.9838	-0.1739	-10.027	2.589	42.789	5347.	0.48	53209.	23.08
31	82.300	152.950	0.0	43.6	-0.801	1.177										
				44.3	1.435	0.151										
							0.0073	0.9816	-0.1909	-11.004	0.424	35.380	5277.	-0.83	44456.	2.83
32	86.500	147.600	0.0	43.5	-0.831	-0.893										
				40.5	-0.273	0.653										
							0.0508	0.9843	-0.1688	-9.733	2.955	36.496	5347.	0.48	45384.	4.98
33	90.800	142.250	0.0	40.4	-1.198	1.006										
				40.5	-0.879	0.245										
							0.0508	0.9843	-0.1688	-9.733	2.955	36.496	5285.	-0.69	45384.	4.98
34	95.050	136.850	0.0	30.3	-3.690	-0.162										
				42.3	1.332	0.793										
							0.0873	0.9782	-0.1882	-10.891	5.100	34.356	5368.	0.88	43397.	0.38
35	99.300	131.600	0.0	29.1	-3.988	-0.166										
				44.3	-1.391	-0.253										
							0.0213	0.9747	-0.2226	-12.867	1.251	73.972	5330.	0.15	46113.	6.67
36	107.850	120.900	0.0	43.3	0.641	0.396										
				39.3	3.997	-0.497										
							0.0864	0.9857	-0.1450	-8.368	5.012	39.685	5312.	-0.17	49606.	14.75
37	112.100	115.550	0.0	42.2	-3.767	-0.225										
				43.3	0.0	0.550										
							0.1193	0.9807	-0.1546	-8.960	6.938	33.542	5277.	-0.83	42147.	-2.51
38	116.300	110.200	0.0	36.5	-3.756	-0.223										
				43.5	0.018	0.480										
							0.0757	0.9700	-0.2309	-13.390	4.460	36.409	5375.	1.00	45511.	5.27
39	120.600	104.900	0.0	43.6	0.299	1.365										
				43.3	-0.969	-0.334										
							0.0947	0.9945	-0.0449	-2.584	5.437	28.448	5285.	-0.69	35375.	-18.17
40	124.850	99.500	0.0	38.4	-3.590	0.518										
				40.5	0.506	0.608										
							0.0548	0.9599	-0.2748	-15.978	3.270	36.042	5305.	-0.31	45527.	5.31
41	129.050	94.200	0.0	40.4	-0.134	1.481										
				44.3	0.752	0.840										
							0.0101	0.9646	-0.2637	-15.291	0.603	34.520	5320.	-0.04	42705.	-1.22
42	133.350	88.800	0.0	44.3	-0.142	0.969										
				42.3	1.792	-0.162										
							0.0374	0.9882	-0.1486	-8.553	2.165	39.372	5340.	0.35	49473.	14.44
43	137.600	83.500	0.0	30.3	-3.663	-0.312										
				40.5	-1.138	-0.474										
							0.0741	0.9805	-0.1818	-10.503	4.321	36.309	5320.	-0.04	44919.	3.90
44	141.900	78.100	0.0	29.3	-3.583	0.346										
				42.3	0.283	1.283										
							0.0529	0.9747	-0.2172	-12.565	3.105	36.733	5270.	-0.97	46645.	7.90
45	146.050	72.800	0.0	42.3	-0.724	1.018										
				43.3	1.144	-0.065										
							-0.0140	0.9783	-0.2068	-11.936	-0.821	37.803	5320.	-0.04	46766.	8.18
46	150.350	67.400	0.0	43.1	-0.083	1.380										
				43.5	1.048	-0.099										
							0.0310	0.9849	-0.1703	-9.811	1.801	76.922	5364.	0.80	47704.	10.35
47	159.000	56.700	0.0	43.3	-0.650	0.261										
				43.5	-0.082	0.516										
							0.0700	0.9705	-0.2309	-13.381	4.128	28.782	5375.	1.00	35978.	-16.78
48	163.300	51.400	0.0	43.5	-0.575	0.214										
				40.5	1.122	0.230										
							0.0483	0.9842	-0.1701	-9.804	2.812	42.557	5250.	-1.35	53196.	23.05
49	167.500	46.000	0.0	43.6	-0.878	1.123										
				44.3	1.448	0.276										
							0.0134	0.9825	-0.1860	-10.721	0.782	36.044	5375.	1.00	45055.	4.22

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
50	171.800	40.700	0.0	43.5	-0.738	-0.940										
				40.5	-0.313	0.672	0.0217	0.9992	-0.0347	-1.990	1.243	28.343	5292.	-0.55	34884.	-19.31
51	176.100	35.250	0.0	40.1	-3.199	0.424										
				40.5	-0.883	0.199	0.0694	0.9690	-0.2372	-13.756	4.097	34.109	5333.	0.22	43314.	0.19
52	180.300	30.000	0.0	30.4	-3.102	-0.201										
				44.3	-1.013	0.515	0.1044	0.9868	-0.1240	-7.160	6.038	33.101	5403.	1.53	41593.	-3.79
53	184.600	24.750	0.0	29.1	-3.946	-0.489										
				43.5	0.828	-1.137	0.0477	0.9792	-0.1970	-11.376	2.786	33.451	5312.	-0.17	41814.	-3.28
54	188.850	19.400	0.0	43.3	1.063	0.112										
				43.4	2.643	-0.202	0.0776	0.9856	-0.1499	-8.648	4.503	41.423	5313.	-0.17	51779.	19.77
55	193.100	14.050	0.0	42.1	-2.647	-0.172										
				43.3	0.610	0.517	0.1717	0.9826	-0.0711	-4.138	9.912	29.961	5381.	1.12	37065.	-14.26
56	197.450	8.700	0.0	42.2	-3.708	-0.501										
				43.1	-1.225	0.850	0.2068	0.9715	-0.1163	-6.826	12.017	32.403	5305.	-0.31	40930.	-5.32
57	201.650	3.400	0.0	36.5	-3.716	-0.525										
				43.3	-0.712	0.255	0.1105	0.9708	-0.2128	-12.364	6.494	34.345	5312.	-0.17	42931.	-0.69
58	205.900	358.050	0.0	43.3	-0.969	-0.338										
				40.5	1.067	0.384	0.4419	0.8791	0.1787	11.488	26.686	13.684	5409.	1.65	17017.	-60.64
59	210.250	352.750	0.0	38.4	-3.650	0.229										
				43.5	-0.910	-0.343	-0.1983	0.9437	-0.2648	-15.674	-11.866	50.590	5312.	-0.17	63236.	46.28
60	214.500	347.400	0.0	40.5	-0.300	0.710										
				44.3	0.613	1.015	0.0190	0.9833	-0.1810	-10.429	1.107	34.797	5375.	1.00	43496.	0.61
61	218.800	342.100	0.0	40.5	-1.001	0.126										
				44.3	-0.340	1.038	-0.0002	0.9939	-0.1100	-6.315	-0.014	35.850	5305.	-0.31	45284.	4.75
62	223.000	336.800	0.0	30.3	-3.682	-0.585										
				40.5	-1.156	-0.479	0.1215	0.9806	-0.1540	-8.924	7.063	34.635	5347.	0.48	43071.	-0.37
63	227.300	331.450	0.0	29.3	-3.632	0.083										
				44.3	-1.408	-0.401	0.0076	0.9767	-0.2146	-12.395	0.444	37.105	5381.	1.12	45903.	6.18
64	231.650	326.100	0.0	31.2	-3.396	0.458										
				43.3	1.039	0.106	-0.0719	0.9700	-0.2324	-13.475	-4.241	35.930	5305.	-0.31	45386.	4.98
65	235.850	320.800	0.0	43.1	-0.281	1.453										
				43.5	0.980	-0.075	0.0279	0.9857	-0.1664	-9.582	1.618	36.030	5375.	1.00	45039.	4.18
66	240.150	315.500	0.0	43.3	-0.176	0.636										
				40.1	3.466	-0.850	-0.0161	0.9889	-0.1478	-8.498	-0.934	33.683	5354.	0.60	41455.	-4.11
67	244.500	310.100	0.0	43.5	-0.167	0.565										
				40.5	1.308	-0.271	0.0163	0.9874	-0.1571	-9.040	0.944	36.768	5333.	0.22	46689.	8.00
68	248.700	304.850	0.0	43.5	-0.663	0.245										
				40.5	1.033	0.437	0.0639	0.9884	-0.1377	-7.932	3.698	36.083	5285.	-0.69	44871.	3.79
69	252.950	299.450	0.0	43.6	-1.055	1.058										
				44.3	1.330	0.520	0.0410	0.9840	-0.1734	-9.995	2.384	31.271	5375.	1.00	39088.	-9.58

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
70	257.250	294.150	0.0	39.3	-3.854	-0.653										
				40.5	-0.428	0.709										
							0.0699	0.9922	-0.1035	-5.957	4.027	37.487	5347.	0.48	46616.	7.83
71	261.550	288.800	0.0	40.1	-3.306	0.201										
				40.5	-0.995	0.210										
							0.4229	0.7742	-0.4710	-31.319	28.644	20.808	5375.	1.01	26010.	-39.83
72	265.850	283.500	0.0	44.3	-1.186	0.484										
				43.1	0.957	-1.021										
							0.8375	0.4336	-0.3326	-37.489	62.627	11.177	5277.	-0.83	14044.	-67.51
73	270.050	278.150	0.0	43.5	0.857	-0.991										
				44.1	-2.831	0.530										
							0.1084	0.9687	-0.2234	-12.989	6.387	32.799	5375.	1.00	40998.	-5.17
74	274.350	272.850	0.0	42.3	-1.073	1.011										
				43.3	0.914	0.242										
							0.0203	0.9861	-0.1650	-9.499	1.177	35.458	5313.	-0.17	44324.	2.53
75	278.600	267.500	0.0	42.1	-2.749	-0.390										
				43.3	0.404	0.628										
							0.0973	0.9911	-0.0906	-5.221	5.609	32.329	5375.	1.00	40411.	-6.52
76	282.900	262.200	0.0	42.2	-3.757	-0.865										
				43.5	0.351	0.557										
							0.0247	0.9769	-0.2122	-12.254	1.451	38.515	5250.	-1.35	48144.	11.36
77	287.100	256.800	0.0	43.3	-0.855	0.218										
				43.6	0.941	1.257										
							-0.0346	0.9873	-0.1551	-8.927	-2.008	37.304	5340.	0.35	46875.	8.43
78	291.350	251.500	0.0	43.3	-1.056	-0.400										
				43.5	-0.820	0.178										
							0.1262	0.9915	0.0325	1.877	7.254	23.120	5277.	-0.83	29052.	-32.80
79	295.550	246.150	0.0	38.4	-3.756	-0.127										
				43.5	-0.985	-0.428										
							0.0174	0.9700	-0.2427	-14.046	1.030	38.077	5347.	0.48	47350.	9.53
80	299.850	240.800	0.0	44.3	0.426	1.064										
				42.1	2.844	-0.191										
							0.0516	0.9879	-0.1463	-8.421	2.991	36.679	5313.	-0.17	45849.	6.06
81	304.100	235.450	0.0	40.1	-3.394	0.0										
				40.5	-1.085	0.077										
							0.0251	0.9865	-0.1619	-9.319	1.458	72.651	5354.	0.61	45764.	5.86
82	312.600	224.900	0.0	29.3	-3.673	-0.278										
				42.3	-0.120	1.400										
							0.0437	0.9794	-0.1970	-11.370	2.552	40.356	5312.	-0.17	50445.	16.69
83	316.850	219.550	0.0	31.2	-3.511	-0.161										
				43.5	1.063	-0.376										
							-0.1155	0.9611	-0.2510	-14.638	-6.851	33.435	5242.	-1.49	42233.	-2.31
84	321.000	214.200	0.0	43.1	-0.528	1.417										
				43.3	0.322	0.615										

	AVG. SPEED (RPM)	AVG. ABS(SPEED ERROR) (PERCENT)	AVERAGE YAW (DEG.)	AVERAGE PITCH (DEG.)	MEAN BALL POSITION (DEG.)
SEPARATOR	5321.63	0.6361			
BALL	43230.98	10.2773	3.025	-10.339	0.0

I T I BALL MOTION DATA REDUCTION

ITI BALL MOTION TEST NO. 1-A-6 5-5-73 APP. -1-

SHAFT RPM	BALL DIA.	TEST BALL NO.	PITCH DIA.	SEPARATOR MEAN RAD	FILM MAGNIFICATION	OBJECT LENGTH
12000.	0.750	3	5.6350	2.8175	12.750	34.276

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	MEASURED COORDINATES RAD	SPIN AXIS DIRECTION X	SPIN AXIS DIRECTION Y	SPIN AXIS DIRECTION Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
1	149.400	73.650	0.0	36.5	0.916	-0.068										
				42.2	2.989	0.164	0.0316	0.9308	-0.3640	-21.360	1.942	33.910	5198.	-1.34	43521.	-37.85
2	153.450	68.350	0.0	42.4	0.044	1.472										
				36.5	-0.050	0.271	0.0316	0.9308	-0.3640	-21.360	1.942	33.910	5326.	1.09	43521.	-37.85
3	157.600	63.150	0.0	43.1	-3.046	0.536										
				36.1	1.297	-0.608	-0.4956	0.8488	0.1840	12.228	-30.279	162.287	5270.	0.02	206078.	194.31
4	161.750	57.850	0.0	42.4	-2.563	-0.270										
				36.3	-0.221	-0.764	-0.4222	0.8921	-0.1608	-10.220	-25.325	18.469	5242.	-0.50	23329.	-66.68
5	165.900	52.500	0.0	42.2	-2.997	-0.152										
				36.3	-0.553	-0.035	-0.7567	0.6507	-0.0641	-5.627	-49.308	122.625	5234.	-0.66	156543.	123.56
6	170.000	47.200	0.0	42.2	-3.925	-0.770										
				35.2	0.779	1.715	-0.0030	0.9904	-0.1382	-7.944	-0.174	50.968	5538.	5.12	62730.	-10.41
7	174.500	41.950	0.0	35.2	-1.100	1.568										
				36.2	1.351	0.294	-0.0236	0.9343	-0.3557	-20.841	-1.447	37.941	4984.	-5.41	49759.	-28.94
8	178.300	36.600	0.0	35.2	-2.565	0.422										
				36.2	0.224	0.751	-0.0094	0.9434	-0.3315	-19.362	-0.570	35.199	5020.	-4.71	43101.	-38.45
9	182.400	30.900	0.0	35.3	-2.797	-0.292										
				36.2	-1.045	0.461	0.0606	0.9215	-0.3836	-22.601	3.764	35.342	5497.	4.34	47386.	-32.33

FRAME NO.	C.R. POSITION (DEG)	I.P. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
10	186.500	26.050	0.0	36.4	-1.077	0.248										
				42.4	7.806	-0.618	-0.0125	0.9398	-0.3414	-19.962	-0.763	32.692	5362.	1.76	41734.	-40.40
11	190.700	20.850	0.0	38.1	-3.576	0.176										
				36.6	-1.442	0.570	-0.9336	0.2335	0.2716	49.314	-75.957	58.733	4827.	-8.39	78749.	12.46
12	194.300	15.500	0.0	38.2	-3.769	-0.372										
				36.3	0.730	-1.019	-0.7418	0.4783	-0.4701	-44.507	-57.186	98.065	5662.	7.46	120696.	72.37
13	198.900	10.350	0.0	43.4	-3.939	-0.042										
				36.5	-0.718	0.064	0.2882	0.9056	-0.3111	-18.956	17.651	30.626	5206.	-1.18	38891.	-44.46
14	203.000	5.000	0.0	43.1	-3.457	-0.657										
				36.5	-1.389	-0.630	0.0355	0.8923	-0.4501	-26.770	2.279	36.454	5362.	1.76	46536.	-33.54
15	207.200	359.800	0.0	42.2	-2.766	0.362										
				34.2	0.111	1.433	0.0245	0.9401	-0.3402	-19.892	1.490	35.804	5319.	0.95	46449.	-33.67
16	211.300	354.650	0.0	32.2	-3.880	-0.073										
				37.2	3.763	0.061	0.1417	0.8868	-0.4399	-26.383	9.080	34.559	5215.	-1.02	43425.	-37.98
17	215.450	349.250	0.0	38.1	3.758	-0.066										
				34.2	-2.532	-0.311	-0.0408	0.9328	-0.3581	-21.001	-2.507	31.860	5390.	2.31	40889.	-41.60
18	219.650	344.100	0.0	35.1	-2.937	-0.647										
				36.2	0.524	0.732	0.0631	0.9271	-0.3695	-21.731	3.895	34.415	5242.	-0.50	43473.	-37.91
19	223.800	338.750	0.0	35.2	-2.896	-0.669										
				36.4	0.386	0.592	-0.0435	0.9607	-0.2742	-15.931	-2.593	39.533	5355.	1.63	51010.	-27.15
20	227.950	333.600	0.0	37.2	-3.149	0.394										
				36.2	-1.702	-0.032	0.2188	0.9021	-0.3718	-22.400	13.635	30.144	5179.	-1.70	38077.	-45.62
21	232.050	328.200	0.0	37.4	-3.631	-0.291										
				36.4	-1.614	-0.382	0.0663	0.9175	-0.3922	-23.144	4.136	69.808	5244.	-0.47	44916.	-35.85
22	240.200	317.700	0.0	36.5	-0.417	0.226										
				34.2	2.740	-0.710	0.2653	0.9102	-0.3180	-19.255	16.251	21.076	5290.	0.41	27195.	-61.16
23	244.300	312.500	0.0	43.1	-3.353	-0.037										
				35.1	2.870	0.038	-0.6941	0.7059	0.1407	11.275	-44.518	166.123	5347.	1.49	206576.	195.02
24	248.600	307.150	0.0	42.3	-4.048	-0.416										
				36.3	-0.390	-0.796	-0.7263	0.6766	-0.1211	-10.146	-47.031	50.145	5198.	-1.35	64357.	-8.09
25	252.650	301.850	0.0	34.1	-1.026	1.253										
				36.3	-0.639	-1.148	-0.3256	0.4289	-0.8426	-63.024	-37.204	29.651	5340.	1.36	37258.	-46.79
26	256.900	296.550	0.0	35.3	0.887	1.660										
				38.1	3.822	-0.655	-0.0557	0.9654	-0.2547	-14.779	-3.301	36.147	5226.	-0.81	46642.	-33.39
27	260.950	291.300	0.0	34.1	-3.692	-0.622										
				35.1	-2.807	-0.105	0.0825	0.9043	-0.4189	-24.854	5.210	33.852	5340.	1.36	42537.	-39.25
28	265.200	286.000	0.0	35.2	-2.798	-0.126										
				36.4	0.733	0.548	0.0147	0.9269	-0.3750	-22.028	0.910	39.273	5326.	1.09	50403.	-28.02
29	269.350	280.800	0.0	36.4	-0.486	0.578										
				36.6	0.717	1.057	0.0938	0.9355	-0.3407	-20.013	5.729	30.774	5152.	-2.22	38669.	-44.78

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO POINT SEP POS (IN.)	MEASURED COORDINATES NO.	TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
30	273.450	275.350	0.0	37.3	-3.864	-0.108										
				37.2	-3.516	-0.937	0.0938	0.9355	-0.3407	-20.013	5.729	30.774	5254.	-0.28	39923.	-42.98
31	277.500	270.150	0.0	38.1	-3.725	-0.603										
				36.5	0.810	0.106	-0.4631	0.8139	-0.3509	-23.320	-29.637	140.283	5319.	0.95	181994.	159.91
32	281.600	265.000	0.0	26.3	0.603	-0.850										
				34.1	-3.785	-1.332	0.1809	0.4875	-0.8542	-60.286	20.364	119.592	5234.	-0.66	152668.	118.03
33	285.700	259.700	0.0	43.3	-3.897	0.669										
				36.5	-1.029	-0.163	0.1701	0.8872	-0.4289	-25.799	10.855	33.483	5290.	0.41	43205.	-38.30
34	289.800	254.500	0.0	42.4	-2.628	-0.394										
				34.2	0.989	1.279	0.0240	0.9377	-0.3467	-20.290	1.468	35.372	5234.	-0.66	45156.	-35.51
35	293.900	249.200	0.0	42.2	-3.063	-0.320										
				35.3	2.731	0.245	0.0436	0.9420	-0.3327	-19.450	2.652	69.297	5284.	0.29	44115.	-37.00
36	302.200	238.650	0.0	34.1	-3.595	0.088										
				38.2	3.857	-0.087	-0.1407	0.8570	-0.4957	-30.048	-9.322	23.607	5368.	1.89	29819.	-57.41
37	306.450	233.400	0.0	36.2	0.068	0.827										
				36.4	0.993	0.396	0.0267	0.9373	-0.3475	-20.341	1.631	38.676	5189.	-1.51	50175.	-28.34
38	310.450	228.150	0.0	36.2	-1.219	0.348										
				36.4	-0.089	0.601	0.0404	0.9490	-0.3128	-18.241	2.441	34.724	5270.	0.02	44094.	-37.03
39	314.600	222.850	0.0	37.2	-3.404	-0.375										
				36.6	-0.278	1.092	0.0793	0.9215	-0.3803	-22.425	4.920	33.991	5262.	-0.13	43624.	-37.70
40	318.700	217.600	0.0	38.1	-3.600	0.075										
				36.5	1.068	-0.110	0.0165	0.9127	-0.4084	-24.108	1.035	70.387	5270.	0.02	44690.	-36.18
41	327.000	207.000	0.0	34.1	3.657	0.148										
				42.2	0.230	2.041	-0.0476	0.8317	0.5532	33.633	-3.274	23.523	5319.	0.95	30517.	-56.42
42	331.100	201.850	0.0	36.3	-0.189	-0.711										
				35.2	3.079	-1.084	-0.6433	0.6199	-0.4494	-35.940	-46.063	21.007	5277.	0.17	26396.	-62.30
43	335.300	196.500	0.0	42.2	-2.910	0.201										
				34.2	-0.135	1.382	0.0023	0.9040	-0.4275	-25.306	0.144	40.239	5254.	-0.28	52202.	-25.45
44	339.350	191.300	0.0	37.4	3.803	-0.822										
				37.3	3.950	0.099	0.0023	0.9040	-0.4275	-25.306	0.144	40.239	5242.	-0.50	50828.	-27.41
45	343.500	185.950	0.0	34.1	-3.370	0.565										
				35.2	-0.764	1.681	0.0250	0.8531	-0.5211	-31.419	1.678	28.789	5254.	-0.28	37348.	-46.66
46	347.550	180.750	0.0	36.2	0.464	0.696										
				36.4	1.322	0.129	-0.0172	0.9566	-0.2909	-16.912	-1.030	37.211	5312.	0.83	46513.	-33.57
47	351.800	175.400	0.0	35.3	-2.691	0.069										
				36.2	-0.815	0.570	0.0773	0.9401	-0.3321	-19.458	4.699	33.744	5189.	-1.51	43776.	-37.48
48	355.800	170.150	0.0	37.2	-3.203	0.193										
				36.4	-0.865	0.371	-0.0096	0.9399	-0.3412	-19.951	-0.584	35.560	5290.	0.41	45883.	-34.47
49	359.900	164.950	0.0	37.3	-3.883	-1.038										
				37.4	-3.704	-0.535	-0.0096	0.9399	-0.3412	-19.951	-0.584	35.560	5170.	-1.87	45395.	-35.17

FRAME NO.	O.R. POSITION (DEG)	I.P. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
50	3.950	159.600	0.0	38.2	-3.742	-0.428										
				36.5	0.435	0.201	-0.7575	0.6012	0.2546	22.949	-51.564	108.115	5390.	2.31	138758.	98.17
51	8.150	154.450	0.0	43.4	-3.890	0.445										
				36.3	0.445	-0.775	-0.6041	0.7496	-0.2706	-19.846	-38.866	147.958	5198.	-1.34	189893.	171.19
52	12.200	149.150	0.0	43.1	-3.309	-0.267										
				36.5	-1.280	-0.487	0.0107	0.9219	-0.3874	-22.791	0.664	36.036	5298.	0.55	46003.	-34.30
53	16.350	143.900	0.0	42.3	-4.011	-0.682										
				36.1	0.619	-0.328	-0.2163	0.8785	-0.4259	-25.861	-13.834	60.903	5106.	-3.08	77748.	11.04
54	20.350	138.500	0.0	32.2	-3.767	-0.387										
				34.2	-1.143	1.094	0.1946	0.7606	-0.6193	-39.153	14.347	74.806	5326.	1.09	96007.	37.11
55	24.500	133.300	0.0	35.2	-2.902	-0.195										
				36.2	-0.813	-0.504	0.4521	0.5691	-0.6868	-50.357	38.466	23.852	5270.	0.02	30288.	-56.74
56	28.650	128.000	0.0	34.1	-3.675	-0.796										
				35.1	-2.757	-0.326	0.0012	0.8598	-0.5105	-30.700	0.082	32.990	5283.	0.26	43030.	-38.55
57	32.700	122.850	0.0	36.2	-0.428	0.697										
				36.4	0.611	0.522	-0.0025	0.9408	-0.3389	-19.813	-0.153	37.338	5250.	-0.36	46673.	-33.34
58	36.900	117.450	0.0	36.2	-1.502	0.073										
				36.6	0.573	1.045	0.0728	0.9391	-0.3358	-19.678	4.430	30.475	5290.	0.41	39323.	-43.84
59	41.000	112.250	0.0	37.4	-3.548	0.147										
				36.4	-1.457	-0.172	0.2112	0.9004	-0.3803	-22.900	13.202	32.194	5161.	-2.04	41541.	-40.67
60	45.000	106.950	0.0	38.2	-3.590	0.243										
				32.2	3.976	0.143	0.0145	0.9920	0.1257	7.223	0.835	123.127	5384.	2.18	159732.	128.12
61	49.150	101.850	0.0	36.5	-0.245	0.218										
				36.3	0.523	-0.857	-0.3637	0.8726	0.3260	20.484	-22.623	140.491	5187.	-1.54	175614.	150.80
62	53.300	96.400	0.0	43.1	-3.223	0.331										
				36.5	-1.110	-0.288	-0.5057	0.8611	-0.0526	-3.492	-30.426	98.783	5254.	-0.28	128152.	83.02
63	57.350	91.200	0.0	42.2	-2.692	-0.645										
				36.3	-0.303	-0.817	-0.6020	0.7775	-0.1820	-13.175	-37.749	177.432	5298.	0.55	226508.	223.48
64	61.500	85.950	0.0	42.2	-3.108	-0.519										
				34.2	-0.710	-1.245	-0.5247	0.7644	-0.3748	-26.120	-34.466	61.520	5270.	0.02	78120.	11.57
65	65.650	80.650	0.0	32.2	-3.932	-1.266										
				35.1	-1.352	1.365	-0.0051	0.9370	-0.3492	-20.440	-0.310	37.870	5290.	0.41	48864.	-30.21
66	69.750	75.450	0.0	34.1	-3.606	-0.186										
				35.1	-2.668	0.190	0.0303	0.9040	-0.4264	-25.249	1.916	35.881	5124.	-2.74	46548.	-33.52
67	73.700	70.150	0.0	35.2	-2.633	0.146										
				36.2	-0.084	0.743	0.0754	0.9205	-0.3835	-22.617	4.686	32.031	5340.	1.36	40249.	-42.52
68	77.950	64.850	0.0	35.3	-2.845	-0.583										
				36.4	-0.182	0.556	-0.1369	0.8700	-0.4736	-28.564	-8.944	53.528	5170.	-1.87	68333.	-2.41
69	82.000	59.500	0.0	37.3	-4.100	-0.084										
				36.4	-1.203	0.106	-0.0997	0.9794	-0.1756	-10.167	-5.811	28.194	5326.	1.09	36185.	-48.32

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO POINT SEP POS (IN.)	MEASURED NO.	COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
70	86.150	54.300	0.0	37.4	-3.645	-1.348										
				42.2	3.084	0.0	-0.9793	0.1059	0.1723	58.436	-83.830	60.060	5262.	-0.13	77083.	10.08
71	90.250	49.050	0.0	38.2	-3.709	-1.282										
				36.3	-0.688	-0.950	-0.8151	0.2547	-0.5203	-63.915	-72.645	82.440	5326.	1.09	105806.	51.11
72	94.400	43.850	0.0	43.4	-4.000	-0.490										
				36.5	-0.872	-0.083	0.1202	0.9459	-0.3012	-17.664	7.239	33.948	5254.	-0.28	44040.	-37.10
73	98.450	38.650	0.0	43.1	-3.483	-1.074										
				42.4	-2.542	-0.144	0.3307	0.8814	-0.3373	-20.939	20.568	29.148	5277.	0.17	36626.	-47.69
74	102.650	33.300	0.0	42.2	-2.905	0.060										
				35.3	2.889	-0.176	0.2816	0.9054	-0.3176	-19.329	17.275	28.498	5198.	-1.34	36575.	-47.77
75	106.700	28.000	0.0	32.2	-3.928	-0.497										
				37.2	3.268	0.323	-0.2616	0.8420	-0.4718	-29.261	-17.260	27.583	5326.	1.09	35400.	-49.44
76	110.850	22.800	0.0	35.2	-0.809	1.640										
				34.2	-2.549	-0.528	0.0396	0.9450	-0.3247	-18.961	2.397	32.954	5270.	0.02	41847.	-40.24
77	115.000	17.500	0.0	35.1	-2.842	-0.945										
				36.2	0.326	0.726	0.0454	0.9079	-0.4168	-24.658	2.865	36.978	5368.	1.89	46709.	-33.29
78	119.250	12.250	0.0	35.2	-2.910	-0.992										
				35.3	-2.689	-0.118	0.0454	0.9079	-0.4168	-24.658	2.865	36.978	5124.	-2.74	47971.	-31.49
79	123.200	6.950	0.0	37.2	-3.296	0.111										
				36.6	0.058	1.102	-0.0757	0.9496	-0.3041	-17.755	-4.560	39.207	5290.	0.41	50590.	-27.75
80	127.300	1.750	0.0	37.4	-3.675	-0.676										
				38.1	-3.452	0.498	-0.0757	0.9496	-0.3041	-17.755	-4.560	39.207	5270.	0.02	49786.	-28.90
81	131.450	356.450	0.0	38.2	-3.751	-0.586										
				42.4	0.679	1.423	-0.1596	0.9696	0.1856	10.836	-9.348	173.428	5298.	0.55	221397.	216.19
82	135.600	351.200	0.0	36.5	-0.669	-0.064										
				36.3	0.386	-0.780	-0.5033	0.8422	0.1932	12.921	-30.863	146.308	5270.	0.02	185787.	165.33
83	139.750	345.900	0.0	43.1	-3.444	-0.435										
				36.5	-1.351	-0.704	0.2652	0.8561	-0.4435	-27.385	17.212	31.511	5326.	1.09	40443.	-42.24
84	143.900	340.700	0.0	42.2	-2.759	0.489										
				35.3	2.998	-0.703	-0.0820	0.8892	-0.4502	-26.854	-5.272	31.358	5242.	-0.51	39610.	-43.43
85	148.050	335.350	0.0	37.2	3.471	-0.261										
				37.3	3.972	-0.636	-0.0820	0.8892	-0.4502	-26.854	-5.272	31.358	5262.	-0.13	40246.	-42.52
86	152.150	330.100	0.0	35.3	0.638	1.683										
				38.1	3.809	-0.360	0.0491	0.9280	-0.3692	-21.694	3.031	33.089	5362.	1.77	42241.	-39.67
87	156.350	324.900	0.0	35.1	-2.852	-0.467										
				36.4	1.557	-0.090	-0.0866	0.9165	-0.3906	-23.083	-5.400	42.117	5215.	-1.02	52923.	-24.42
88	160.500	319.500	0.0	35.2	-2.858	-0.482										
				36.2	-0.546	0.671	0.0928	0.9328	-0.3483	-20.473	5.679	33.860	5348.	1.50	44165.	-36.93
89	164.600	314.400	0.0	37.2	-3.011	0.582										
				36.4	-0.614	0.472	0.1372	0.9157	-0.3778	-22.420	8.519	31.221	5198.	-1.35	40069.	-42.78

FRAME NO.	C.R. POSITION (DEG)	I.P. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
90	168.650	309.100	0.0	37.3	-3.881	-0.504										
				36.6	-0.900	0.880										
							0.0553	0.8913	-0.4501	-26.796	3.550	35.416	5290.	0.41	45699.	-34.74
91	172.750	303.900	0.0	32.2	3.910	0.328										
				36.5	0.678	0.165										
							-0.0183	0.9378	-0.3468	-20.296	-1.121	35.350	5305.	0.69	44652.	-36.23
92	176.550	298.600	0.0	34.1	3.792	-1.024										
				42.2	1.135	1.947										
							0.0429	0.9477	-0.3163	-18.455	2.591	35.085	5226.	-0.81	45271.	-35.35
93	181.000	293.350	0.0	36.5	-1.111	-0.317										
				35.1	2.937	-0.213										
							-0.6704	0.7282	0.1426	11.081	-42.632	165.297	5305.	0.69	208795.	198.19
94	185.200	288.050	0.0	42.3	-4.033	-0.110										
				36.3	-0.418	-0.790										
							-0.5681	0.7300	0.3800	27.502	-37.891	165.368	5290.	0.41	213380.	204.74
95	189.300	282.850	0.0	42.2	-3.131	-0.660										
				37.2	-3.551	-0.857										
							0.0373	0.9887	-0.1451	-8.350	2.163	161.437	5206.	-1.18	205003.	192.77
96	193.400	277.500	0.0	38.1	3.851	-1.034										
				37.4	3.657	1.660										

	AVG. SPEED (RPM)	AVG. ABS(SPEED ERROR) (PERCENT)	AVERAGE YAW (DEG.)	AVERAGE PITCH (DEG.)	MEAN BALL POSITION (DEG.)
SEPARATOR	5268.71	1.2591			
BALL	70021.25	57.9802	-7.514	-17.508	0.0

A P P E N D I X 2

Ball Motion Printout for Tests

IB-1 through IB-4

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I T T BALL MOTION DATA REDUCTION

ITI BALL MOTION TEST NO. 1-B-1 2-23-73

APP -2-

SHAFT RPM	BALL DIA.	TEST BALL NO.	PITCH DIA.	SEPARATOR MEAN RAD	FILM MAGNIFICATION	OBJECT LENGTH
4000.	0.750	3	5.6350	2.8175	12.750	34.276

IHC251I SQRT NEGATIVE ARGUMENT=-0.4660246E 04

TRACEBACK	ROUTINE	CALLED FROM ISN	REG. 14	REG. 15	REG. 0	REG. 1
	SQRT	0008	5205A408	00062E80	00058110	0005A304
	CNVRT		62059088	0005A290	00058110	000562DC
	MAIN		00015354	01055E48	FD000008	0008E7F8

ENTRY POINT= 01055E48

STANDARD FIXUP TAKEN , EXECUTION CONTINUING

IHC208I IBCOM - PROGRAM INTERRUPT (P) - UNDERFLOW OLD PSW IS FF75000092059C1C . REGISTER CONTAINED FB10AA4530000000

TRACEBACK	ROUTINE	CALLED FROM ISN	REG. 14	REG. 15	REG. 0	REG. 1
	CRSPDT	0005	6205A682	00059818	00056468	0005A53C
	RELAV		62059194	0005A4C8	00056468	000562F0
	MAIN		00015354	01055E48	FD000008	0008E7F8

ENTRY POINT= 01055E48

STANDARD FIXUP TAKEN , EXECUTION CONTINUING

IHC208I IBCOM - PROGRAM INTERRUPT (P) - UNDERFLOW OLD PSW IS FF75000DA2059C30 . REGISTER CONTAINED 7A10E56040000000

TRACEBACK	ROUTINE	CALLED FROM ISN	REG. 14	REG. 15	REG. 0	REG. 1
	CRSPDT	0005	6205A682	00059818	00056468	0005A53C
	RELAV		62059194	0005A4C8	00056468	000562F0
	MAIN		00015354	01055E48	FD000008	0008E7F8

ENTRY POINT= 01055E48

STANDARD FIXUP TAKEN , EXECUTION CONTINUING

IHC208I IBCOM - PROGRAM INTERRUPT (P) - UNDERFLOW OLD PSW IS FF75000062059FC4 . REGISTER CONTAINED 606008168304A400

TRACEBACK	ROUTINE	CALLED FROM ISN	REG. 14	REG. 15	REG. 0	REG. 1
	VMAG	0006	4205A6C0	00059F08	00056468	0005A548
	RELAV		62059194	0005A4C8	00056468	000562F0
	MAIN		00015354	01055E48	FD000008	0008E7F8

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ENTRY POINT=  01055E48

STANDARD FIXUP TAKEN , EXECUTION CONTINUING

IHC251I SQRT NEGATIVE ARGUMENT=-0.590295BE 21

TRACEBACK  ROUTINE  CALLED FROM ISN   REG.  14   REG.  15   REG.  0   REG.  1

           SQRT                0008   5205A408   00062E80   00058110   0005A304

             CNVRT                    62059098   0005A290   00058110   000562DC

              MAIN                    00015354   01055E48   FD000008   0008E7F8

ENTRY POINT=  01055E48

STANDARD FIXUP TAKEN , EXECUTION CONTINUING
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FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL SEP POS (IN.)	TO POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
1	242.950	207.200	0.0	34.1	-2.893	0.446										
				36.1	-0.408	-1.130										
							-0.4178	0.8394	0.3476	22.492	-26.458	18.909	1836.	0.44	9514.	-53.07
2	246.600	202.900	0.0	22.1	-3.751	-0.825										
				35.2	-0.728	0.912										
							-0.3808	0.9067	0.1815	11.320	-22.781	63.633	1816.	-0.68	31231.	54.07
3	250.300	198.450	0.0	35.2	-1.131	0.317										
				35.3	1.138	-0.780										
							0.0650	0.9977	-0.0186	-1.068	3.725	31.520	1860.	1.72	16061.	-20.77
4	253.950	194.250	0.0	23.1	-3.164	-0.790										
				35.3	-1.314	0.418										
							0.2500	0.9664	0.0599	3.545	14.506	27.294	1825.	-0.19	13647.	-32.68
5	257.600	189.900	0.0	25.1	-3.764	-0.827										
				35.2	-0.775	-1.091										
							-0.3792	0.4135	0.8278	63.456	-42.518	5.902	1827.	-0.07	2915.	-85.62
6	261.300	185.500	0.0	37.3	3.499	-0.583										
				35.3	-1.182	-0.926										
							-0.0131	0.9976	-0.0678	-3.889	-0.753	124.634	1823.	-0.30	63105.	211.30
7	264.900	181.200	0.0	38.1	-3.789	-0.944										
				35.1	2.001	-0.130										
							0.0288	0.9915	-0.1268	-7.287	1.663	34.612	1838.	0.55	17199.	-15.16
8	268.600	176.850	0.0	36.6	-3.351	-0.616										
				36.1	-0.295	0.963										
							0.1489	0.9864	-0.0700	-4.058	8.582	30.733	1811.	-0.93	15463.	-23.72
9	272.200	172.500	0.0	36.5	-3.034	0.246										
				36.1	-0.843	0.520										
							0.2647	0.9619	-0.0690	-4.101	15.385	27.036	1863.	1.91	13434.	-33.73

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
10	275.950	168.200	0.0	42.2	-3.878	0.323										
				36.1	-1.022	-0.113	0.4719	0.5544	-0.6855	-51.039	40.409	12.059	1797.	-1.69	6106.	-69.88
11	279.500	163.850	0.0	42.2	-4.208	-0.454										
				36.1	-0.851	-0.731	-0.1264	0.9895	-0.0696	-4.024	-7.278	60.476	1816.	-0.68	29681.	46.42
12	283.200	159.400	0.0	34.1	-2.938	0.357										
				35.2	-0.138	1.235	-0.8540	0.4055	-0.3259	-38.796	-64.603	1.023	1825.	-0.19	511.	-97.48
13	286.850	155.050	0.0	22.1	-3.711	-1.037										
				35.3	-0.097	1.416	0.0770	0.9046	-0.4193	-24.869	4.862	52.175	1823.	-0.30	26417.	30.32
14	290.450	150.750	0.0	35.2	-1.260	0.216										
				36.1	0.794	-0.950	-0.0790	0.9956	-0.0506	-2.908	-4.534	26.863	1809.	-1.06	13688.	-22.48
15	294.000	146.450	0.0	23.1	-3.208	-1.014										
				35.2	-1.237	-0.531	0.0838	0.9938	-0.0726	-4.179	4.818	31.972	1863.	1.91	15857.	-21.78
16	297.750	142.150	0.0	37.1	-3.673	0.428										
				35.3	-1.456	-0.523	0.0071	0.9888	-0.1492	-8.579	0.414	33.813	1811.	-0.93	17013.	-16.07
17	301.350	137.800	0.0	37.3	-3.514	-0.876										
				37.4	-3.568	-0.142	0.0071	0.9888	-0.1492	-8.579	0.414	33.813	1837.	0.45	17012.	-16.08
18	305.000	133.500	0.0	36.1	0.115	0.989										
				34.1	2.971	0.451	0.8644	0.5024	-0.0191	-2.175	59.838	24.706	1811.	-0.93	12421.	-38.68
19	308.600	129.150	0.0	36.6	-3.378	-0.876										
				36.1	-0.478	-0.843	0.2347	0.9714	-0.0365	-2.151	13.583	29.400	1825.	-0.18	14700.	-27.48
20	312.250	124.800	0.0	42.4	-3.880	0.486										
				36.5	-3.110	-0.067	0.0160	0.9918	-0.1271	-7.304	0.925	34.388	1802.	-1.42	16982.	-16.23
21	315.900	120.350	0.0	42.2	-3.904	-0.076										
				35.1	-0.431	1.621	0.0166	0.9780	-0.2080	-12.009	0.971	33.398	1786.	-2.31	16804.	-17.10
22	319.450	115.950	0.0	35.2	0.465	1.110										
				37.3	3.698	-0.214	-0.9604	0.0598	0.2720	77.608	-86.440	27.983	1850.	1.18	13992.	-30.98
23	323.150	111.650	0.0	34.1	-2.977	-0.047										
				35.2	-0.316	-1.102	-0.5828	0.7672	-0.2677	-19.233	-37.223	43.572	1795.	-1.83	22344.	10.23
24	326.650	107.350	0.0	35.2	-0.952	0.691										
				35.3	-0.270	1.341	0.0680	0.9959	-0.0601	-3.455	3.906	31.247	1823.	-0.30	15821.	-21.95
25	330.250	103.050	0.0	23.1	-3.234	0.510										
				35.3	-1.015	0.897	-0.0068	0.9710	-0.2390	-13.826	-0.398	33.604	1825.	-0.19	16802.	-17.11
26	333.900	98.700	0.0	36.1	1.161	-0.403										
				42.2	3.825	-1.115	0.0202	0.9899	-0.1402	-8.059	1.169	33.405	1836.	0.44	16808.	-17.09
27	337.550	94.400	0.0	36.1	1.056	0.204										
				35.2	-0.635	-1.345	0.3238	0.9372	0.1296	7.875	19.059	35.525	1800.	-1.55	17762.	-12.38
28	341.150	90.000	0.0	36.1	0.687	0.677										
				34.1	0.299	-1.014	0.2938	0.7554	-0.5857	-37.788	21.255	12.615	1850.	1.18	6308.	-68.88
29	344.850	85.700	0.0	36.4	-2.645	-0.130										
				34.1	0.296	0.725	0.4623	0.8863	-0.0276	-1.782	27.548	23.470	1811.	-0.93	11809.	-41.75

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
30	348.450	81.350	0.0	36.1	-0.592	0.711										
				35.2	1.300	-0.692	0.2202	0.9601	-0.1725	-10.185	12.916	16.767	1811.	-0.93	8436.	-58.38
31	352.050	77.000	0.0	36.5	-3.091	-0.434										
				36.1	-0.961	0.190	0.0126	0.9946	-0.1030	-5.911	0.727	33.732	1825.	-0.18	16866.	-16.80
32	355.700	72.650	0.0	42.2	-3.864	-0.469										
				35.1	-0.571	1.541	0.0126	0.9946	-0.1030	-5.911	0.727	33.732	1823.	-0.31	17080.	-15.74
33	359.300	68.350	0.0	35.1	0.0	36.100										
				-0.7	0.0	-0.995	-0.9996	0.0261	0.0070	15.127	-88.507	168.929	1825.	-0.18	84462.	316.66
34	2.950	64.000	0.0	22.1	-3.851	0.372										
				34.1	-2.950	-0.351	-0.3354	0.8212	-0.4617	-29.343	-22.217	61.287	1616.	-11.59	33582.	65.66
35	5.900	59.650	0.0	35.2	-0.971	0.575										
				35.3	-0.354	1.186	0.0222	0.9989	-0.0401	-2.300	1.275	36.786	1930.	5.57	17110.	-15.59
36	10.050	55.200	0.0	23.1	-3.238	0.142										
				35.3	-1.090	0.782	0.3441	0.9386	-0.0241	-1.468	20.131	26.118	1836.	0.44	13141.	-35.17
37	13.700	50.900	0.0	25.1	-3.790	0.348										
				35.3	-1.410	-0.039	0.0107	0.9857	-0.1679	-9.669	0.623	34.634	1834.	0.33	17648.	-12.94
38	17.300	46.650	0.0	37.1	-3.646	-0.364										
				37.2	-2.768	0.100	0.0633	0.9901	-0.1254	-7.221	3.661	33.566	1862.	1.82	16889.	-16.69
39	21.000	42.400	0.0	38.1	-3.868	0.249										
				36.1	0.624	0.780	0.1527	0.9799	-0.1285	-7.470	8.856	31.603	1816.	-0.68	15511.	-23.48
40	24.700	37.950	0.0	36.6	-3.330	0.426										
				36.1	0.0	0.916	-0.0452	0.9742	-0.2211	-12.787	-2.659	34.256	1806.	-1.20	17681.	-12.78
41	28.200	33.700	0.0	35.2	1.375	-0.565										
				23.1	3.215	-1.346	0.0749	0.9940	-0.0799	-4.597	4.311	33.774	1800.	-1.55	16887.	-16.69
42	31.800	29.300	0.0	42.4	-3.864	-0.282										
				36.5	-3.011	-0.661	0.0471	0.9789	-0.1989	-11.488	2.757	33.743	1795.	-1.83	17304.	-14.64
43	35.300	25.000	0.0	36.1	-0.994	-0.496										
				35.2	0.952	0.801	-0.0137	0.9862	-0.1652	-9.513	-0.795	29.195	1839.	0.55	14507.	-28.44
44	39.000	20.650	0.0	35.2	0.244	1.146										
				35.3	1.246	0.943	-0.0137	0.9862	-0.1652	-9.513	-0.795	29.195	1811.	-0.93	14689.	-27.54
45	42.600	16.300	0.0	22.1	-3.822	0.034										
				35.1	-1.802	-0.245	-0.0919	0.8643	-0.4946	-29.780	-6.069	54.570	1823.	-0.31	27630.	36.30
46	46.200	12.000	0.0	35.3	-0.497	1.225										
				36.6	3.445	0.367	0.0649	0.9969	-0.0441	-2.536	3.724	34.593	1834.	0.33	17627.	-13.04
47	49.800	7.750	0.0	23.1	-3.279	-0.079										
				35.2	-1.307	-0.285	0.0433	0.9805	-0.1915	-11.052	2.526	33.966	1823.	-0.31	17198.	-15.16
48	53.400	3.450	0.0	35.3	-1.481	-0.185										
				36.1	1.157	-0.271	-0.4856	0.8502	0.2035	13.461	-29.735	171.042	1811.	-0.93	86057.	324.53
49	57.000	359.100	0.0	37.1	-0.363	-0.571										
				37.2	-2.857	-0.119	-0.5136	0.8205	-0.2509	-17.006	-32.046	125.480	1823.	-0.31	63534.	213.42

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	MEASURED COORDINATES RAD	SPIN AXIS DIRECTION X	SPIN AXIS DIRECTION Y	SPIN AXIS DIRECTION Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
50	60.600	354.900	0.0	34.1	3.031	-0.637										
				36.1	0.475	0.726										
							-0.4070	0.9113	0.0627	3.934	-24.069	77.488	1800.	-1.55	38744.	91.13
51	64.200	350.400	0.0	36.6	-0.342	0.180										
				36.1	-0.109	0.832										
							0.4066	0.2883	-0.8669	-71.607	54.667	7.505	1797.	-1.69	3800.	-81.25
52	67.750	346.050	0.0	36.5	-2.948	0.903										
				36.1	-0.484	0.563										
							0.1977	0.9719	-0.1276	-7.476	11.495	32.150	1848.	1.08	16785.	-17.20
53	71.400	341.800	0.0	42.2	-3.772	0.847										
				35.2	1.330	0.151										
							-0.7336	0.6750	-0.0782	-6.611	-47.382	42.766	1811.	-0.93	21518.	6.15
54	75.000	337.450	0.0	42.2	-3.828	-0.985										
				36.1	-0.812	1.380										
							0.3043	0.9523	-0.0222	-1.336	17.721	27.650	1795.	-1.83	14180.	-30.05
55	78.500	333.150	0.0	36.1	-0.645	-1.131										
				35.1	-1.486	0.598										
							0.3043	0.9523	-0.0222	-1.336	17.721	27.650	1852.	1.28	13654.	-32.66
56	82.250	328.900	0.0	22.2	4.258	******										
				22.1	-3.869	-0.069										
							0.8626	0.5058	-0.0036	-0.413	59.613	121.317	1809.	-1.06	61819.	204.96
57	85.800	324.500	0.0	24.1	-3.884	-0.822										
				35.2	-1.064	0.405										
							0.2560	0.9615	-0.1001	-5.941	14.809	30.931	1825.	-0.19	15465.	-23.71
58	89.450	320.150	0.0	23.1	-3.295	-0.195										
				35.3	-1.206	0.594										
							0.9490	0.1235	-0.2900	-66.933	82.586	35.446	1797.	-1.69	17947.	-11.46
59	93.000	315.800	0.0	25.1	-3.857	-0.043										
				36.2	-1.054	-1.057										
							0.5568	0.8304	0.0172	1.184	33.843	27.154	1837.	0.45	13663.	-32.60
60	96.650	311.500	0.0	37.1	-3.597	-0.691										
				37.2	-2.766	-0.186										
							0.0666	0.9876	-0.1422	-8.192	3.856	33.527	1848.	1.08	16976.	-16.26
61	100.300	307.250	0.0	38.1	-3.863	-0.080										
				36.1	0.576	0.723										
							-0.2706	0.3673	-0.8899	-67.574	-36.281	6.889	1862.	1.82	3466.	-82.90
62	104.000	303.000	0.0	36.6	-3.247	1.690										
				36.4	-2.530	-0.580										
							-0.3458	0.9369	-0.0513	-3.135	-20.259	86.380	1836.	0.44	43461.	114.40
63	107.650	298.700	0.0	36.5	-2.817	0.879										
				35.1	1.297	1.161										
							0.0525	0.9893	-0.1358	-7.814	3.036	31.629	1860.	1.72	16117.	-20.49
64	111.300	294.500	0.0	42.4	-3.863	-0.505										
				36.1	-0.953	0.028										
							-0.9620	0.2707	0.0351	7.397	-74.286	69.417	1850.	1.18	34708.	71.22
65	115.000	290.200	0.0	42.2	-3.357	-0.926										
				0.0	0.0	0.0										
							-0.9028	0.1829	-0.3892	-64.834	-78.550	108.882	1823.	-0.31	55130.	171.96
66	118.600	285.900	0.0	35.2	0.369	1.082										
				35.3	1.284	0.912										
							-0.8495	0.4895	0.1969	21.914	-60.050	5.010	1885.	3.12	2553.	-87.41
67	122.300	281.750	0.0	22.1	-3.772	0.067										
				35.2	-0.350	0.973										
							0.4504	0.8451	-0.2880	-18.818	28.058	41.306	1836.	0.44	20783.	2.52
68	125.950	277.450	0.0	24.1	-3.850	-0.709										
				35.3	-0.350	1.224										
							0.1195	0.9826	-0.1422	-8.234	6.932	32.744	1872.	2.37	16792.	-17.17
69	129.600	273.300	0.0	23.1	-3.209	-0.033										
				35.2	-1.169	-0.240										
							0.0943	0.9922	-0.0811	-4.675	5.431	31.602	1850.	1.19	15801.	-22.05

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
70	133.300	269.000	0.0	25.1	-3.790	0.133										
				35.3	-1.371	-0.097	0.0044	0.9909	-0.1348	-7.749	0.253	33.779	1846.	0.97	17322.	-14.55
71	136.900	264.800	0.0	37.1	-3.569	-0.472										
				37.2	-2.725	0.037	0.9088	0.1518	-0.3888	-68.673	80.518	13.995	1863.	1.92	6954.	-65.69
72	140.650	260.500	0.0	36.1	0.620	0.782										
				36.3	0.365	1.850	0.3239	0.1935	0.9261	78.200	59.150	5.765	1825.	-0.19	2882.	-85.78
73	144.300	256.150	0.0	36.6	-3.318	0.356										
				36.1	0.057	0.907	0.0622	0.9828	-0.1740	-10.040	3.624	33.957	1858.	1.63	17526.	-13.54
74	147.900	252.000	0.0	36.1	-0.530	0.649										
				35.2	1.455	-0.576	0.8297	0.4312	-0.3545	-39.428	62.539	6.709	1821.	-0.43	3440.	-83.03
75	151.450	247.750	0.0	36.5	-2.932	-0.609										
				35.2	1.496	0.066	-0.5550	0.7428	-0.3745	-26.759	-36.764	11.332	1862.	1.82	5702.	-71.87
76	155.150	243.500	0.0	35.1	-0.565	1.517										
				35.3	1.723	0.114	0.0075	0.9931	-0.1167	-6.702	0.435	38.444	1825.	-0.18	19222.	-5.18
77	158.800	239.150	0.0	35.2	0.387	1.173										
				35.3	1.286	0.976	0.0075	0.9931	-0.1167	-6.702	0.435	38.444	1872.	2.38	19715.	-2.75
78	162.450	235.000	0.0	34.1	-2.894	-0.377										
				22.1	-3.719	0.311	-0.6992	0.6177	-0.3599	-30.228	-48.542	144.888	1800.	-1.55	72444.	257.38
79	166.050	230.600	0.0	24.1	-3.869	-0.485										
				35.2	-0.945	0.624	0.2818	0.9561	-0.0799	-4.779	16.424	29.468	1860.	1.72	15016.	-25.93
80	169.700	226.400	0.0	23.1	-3.222	0.230										
				35.3	-1.051	0.882	0.2471	0.9591	-0.1382	-8.201	14.447	22.210	1836.	0.44	11175.	-44.87
81	173.350	222.100	0.0	35.2	-1.024	-0.796										
				35.3	-1.289	0.121	-0.0341	0.9922	-0.1203	-6.913	-1.969	44.469	1848.	1.08	22516.	11.07
82	177.000	217.850	0.0	37.2	-2.791	0.200										
				36.1	1.104	0.379	0.1972	0.9052	-0.3765	-22.581	12.287	73.718	1811.	-0.93	37091.	82.97
83	180.600	213.500	0.0	22.2	4.325	-0.912										
				34.1	3.068	-0.744	0.9230	0.3695	-0.1070	-16.153	68.182	38.968	1823.	-0.31	19730.	-2.67
84	184.200	209.200	0.0	36.6	-3.283	0.474										
				35.2	0.945	-1.274	-0.0836	0.9896	-0.1173	-6.761	-4.830	33.354	1846.	0.97	17105.	-15.62
85	187.800	205.000	0.0	36.6	-3.120	-1.268										
				36.1	-0.561	0.751	0.1824	0.9806	-0.0720	-4.198	10.537	30.744	1786.	-2.31	15469.	-23.69
86	191.350	200.600	0.0	36.5	-2.996	-0.413										
				36.1	-0.873	0.248	0.2601	0.9653	-0.0234	-1.390	15.079	26.951	1836.	0.44	13560.	-33.11
87	195.000	196.300	0.0	42.2	-3.833	-0.472										
				36.1	-0.942	-0.378	0.0429	0.9812	-0.1883	-10.861	2.502	31.965	1836.	0.44	16083.	-20.66
88	198.650	192.000	0.0	35.2	0.473	1.196										
				35.3	1.352	0.878	0.0429	0.9812	-0.1883	-10.861	2.502	31.965	1846.	0.97	16392.	-19.13
89	202.250	187.800	0.0	22.2	-4.263	-0.269										
				34.1	-2.911	-0.149	-0.8638	0.3698	-0.3420	-42.763	-66.823	39.777	1836.	0.44	20013.	-1.27

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
90	205.900	183.500	0.0	34.1	-3.907	-0.193										
				35.3	-0.240	1.400	0.2268	0.9738	-0.0143	-0.960	13.110	30.127	1823.	-0.31	15254.	-24.75
91	209.500	179.200	0.0	32.4	-4.217	-0.215										
				35.2	-1.210	0.049	0.1174	0.9900	-0.0778	-4.492	6.761	33.290	1846.	0.97	16815.	-17.05
92	213.100	175.000	0.0	25.1	-3.684	0.627										
				35.2	-1.403	0.205	-0.0175	0.9838	-0.1785	-10.286	-1.020	35.065	1839.	0.55	17424.	-14.05
93	216.800	170.650	0.0	37.1	-3.658	-0.030										
				37.2	-2.905	0.358	-0.0175	0.9838	-0.1785	-10.286	-1.020	35.065	1821.	-0.43	17982.	-11.29
94	220.350	166.400	0.0	37.4	-3.460	-0.483										
				36.1	0.717	0.913	0.2671	0.6448	0.7162	48.003	22.505	36.901	1860.	1.73	18903.	-7.24
95	224.000	162.200	0.0	36.1	0.136	1.004										
				32.1	0.396	0.285	-0.1817	0.7620	0.6217	39.213	-13.378	105.695	1823.	-0.31	53516.	164.00
96	227.600	157.900	0.0	36.5	-2.748	0.852										
				36.1	-0.447	0.825	0.3709	0.8841	-0.2841	-17.815	22.740	14.737	1836.	0.44	7415.	-63.42
97	231.250	153.600	0.0	36.5	-3.031	-0.193										
				35.2	1.465	0.112	-0.1657	0.9742	-0.1534	-8.951	-9.655	44.165	1823.	-0.31	22362.	10.31
98	234.850	148.300	0.0	42.2	-3.843	-0.162										
				36.1	-0.958	-0.247	0.0306	0.9841	-0.1750	-10.084	1.782	33.135	1809.	-1.06	16884.	-16.71
99	238.400	145.000	0.0	35.2	0.483	1.215										
				36.1	-0.784	-0.780	0.0825	0.9935	0.0789	4.501	4.749	21.928	1823.	-0.31	13103.	-45.23
100	242.000	140.700	0.0	34.1	-2.945	0.075										
				35.2	-0.272	1.238	-0.8006	0.4852	-0.3516	-35.924	-58.780	0.480	1823.	-0.31	243.	-98.80
101	245.600	136.400	0.0	22.1	-3.558	-1.424										
				35.2	-0.913	0.848	0.3688	0.8944	-0.2529	-15.787	22.411	44.867	1860.	1.72	22862.	12.78
102	249.250	132.200	0.0	35.3	-1.031	1.031										
				36.5	3.065	-0.897	-0.2822	0.9592	-0.0159	-0.948	-16.393	20.629	1814.	-0.80	10250.	-49.43
103	252.900	127.800	0.0	36.1	1.169	-0.330										
				42.4	3.958	0.203										

	AVG. SPEED (RPM)	AVG. ABS(SPEED ERROR) (PERCENT)	AVERAGE YAW (DEG.)	AVERAGE PITCH (DEG.)	MEAN BALL POSITION (DEG.)
SEPARATOR	1828.37	1.0927			
BALL	20271.19	48.6743	0.119	-8.156	0.0

I T I BALL MOTION DATA REDUCTION

APP. -2-

ITI BALL MOTION TEST NO. 1-B-2

SHAFT RPM	BALL DIA.	TEST BALL NO.	PITCH DIA.	SEPARATOR MEAN RAD	FILM MAGNIFICATION	OBJECT LENGTH
4000.	0.750	3	5.6350	2.8175	12.750	34.276

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	MEASURED COORDINATES RAD	SPIN AXIS DIRECTION X	SPIN AXIS DIRECTION Y	SPIN AXIS DIRECTION Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
1	30.650	16.200	0.0	17.1	-4.019	0.297										
				5.3	-0.679	-0.138	0.1043	0.8270	-0.5524	-33.742	7.186	26.915	1763.	-1.12	14166.	-4.43
2	34.000	11.950	0.0	16.1	-3.873	-0.047										
				14.2	-1.298	0.376	0.0596	0.8116	-0.5811	-35.602	4.201	28.623	1775.	-0.47	15165.	2.31
3	37.350	7.750	0.0	15.1	-3.187	-0.544										
				13.2	-1.031	-0.340	0.0796	0.8157	-0.5730	-35.087	5.576	26.777	1828.	2.51	14187.	-4.29
4	40.800	3.650	0.0	14.5	-3.524	-0.381										
				13.1	-1.229	-0.416	0.0986	0.7796	-0.6184	-38.421	7.211	27.254	1766.	-0.95	14158.	-4.48
5	44.200	359.350	0.0	12.2	-1.496	-0.345										
				11.4	0.708	1.207	-0.0284	0.8844	-0.4660	-27.784	-1.841	28.723	1783.	0.02	14636.	-1.26
6	47.700	355.000	0.0	23.1	-4.007	-0.483										
				12.4	-2.724	-0.930	0.0366	0.8199	-0.5714	-34.872	2.555	29.411	1792.	0.51	15278.	3.08
7	51.150	350.750	0.0	24.1	-3.475	0.102										
				3.6	-0.337	0.306	-0.5327	0.2085	-0.8202	-75.734	-68.620	19.504	1890.	6.01	10687.	-27.90
8	54.600	346.900	0.0	3.2	-0.210	-0.614										
				9.1	0.197	1.070	-0.0367	0.9772	-0.2090	-12.070	-2.151	50.314	1693.	-5.04	24694.	66.60
9	58.050	342.200	0.0	10.3	-3.393	-0.305										
				3.1	-0.802	-0.433	0.0736	0.8222	-0.5645	-34.474	5.112	28.692	1769.	-0.78	14714.	-0.73

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
10	61.500	337.850	0.0	9.2	-3.435	0.169										
				8.1	-1.044	0.628	0.0262	0.8101	-0.5857	-35.870	1.853	28.394	1806.	1.31	14655.	-1.13
11	65.000	333.600	0.0	8.5	-3.311	-0.434										
				2.2	-0.455	-1.200	0.1195	0.7963	-0.5930	-36.678	8.533	26.980	1744.	-2.22	13836.	-6.66
12	68.400	329.200	0.0	7.3	-3.289	-0.168										
				6.3	-0.253	1.142	-0.0510	0.8269	-0.5600	-34.106	-3.528	29.060	1818.	1.97	15096.	1.84
13	71.900	325.000	0.0	6.4	-2.782	-0.317										
				5.1	-0.185	-0.926	-0.2498	0.6734	0.6958	45.940	-20.357	20.586	1758.	-1.41	10489.	-29.23
14	75.350	320.600	0.0	7.1	-4.195	-0.567										
				5.4	-1.304	0.301	-0.1814	0.9440	-0.2757	-16.280	-10.880	63.615	1792.	0.51	33047.	122.95
15	78.800	316.350	0.0	16.1	-4.064	-0.923										
				14.1	-1.172	0.366	-0.0602	0.8526	-0.5191	-31.335	-4.036	32.773	1781.	-0.14	16915.	14.12
16	82.250	312.050	0.0	14.5	-3.131	0.274										
				13.4	-1.055	0.464	0.0342	0.8348	-0.5495	-33.355	2.347	27.814	1783.	0.02	14173.	-4.38
17	85.750	307.700	0.0	14.5	-3.679	-1.264										
				12.4	-1.324	0.438	0.0747	0.8323	-0.5493	-33.422	5.130	29.094	1783.	0.02	14825.	0.01
18	89.250	303.350	0.0	23.1	-3.704	0.290										
				11.1	0.502	0.552	0.0189	0.8116	-0.5839	-35.734	1.337	29.105	1755.	-1.59	15022.	1.35
19	92.650	299.000	0.0	12.3	-3.011	-0.826										
				11.1	-0.876	0.449	0.0398	0.8500	-0.5252	-31.712	2.684	28.220	1804.	1.16	14755.	-0.46
20	96.100	294.800	0.0	24.1	-3.785	-0.780										
				3.6	-1.009	0.189	-0.3864	0.7693	-0.5088	-33.480	-26.672	54.293	1664.	-6.66	29151.	96.67
21	99.200	290.450	0.0	10.3	-3.641	0.0										
				3.5	1.435	0.161	-0.0483	0.4533	0.8900	63.011	-6.086	7.303	1878.	5.32	3562.	-75.97
22	103.050	286.100	0.0	10.4	-3.940	-0.494										
				8.2	-1.019	0.351	0.0118	0.7994	-0.6007	-36.926	0.843	48.944	2184.	22.47	21165.	42.79
23	108.100	281.900	0.0	20.1	-4.191	-0.199										
				2.4	-1.238	-0.475	0.0518	0.8648	-0.4994	-30.006	3.431	27.170	1589.	-10.88	14888.	0.44
24	111.000	277.500	0.0	19.1	-4.051	-0.395										
				6.2	-0.891	0.389	-0.8940	0.4378	0.0949	12.230	-63.908	28.367	1477.	-17.17	17457.	17.77
25	113.400	273.400	0.0	10.3	-4.184	-0.380										
				7.2	-3.403	-0.491	-0.3024	0.0117	-0.9531	-89.297	-87.785	39.758	1758.	-1.41	20259.	36.68
26	116.850	269.000	0.0	6.6	-3.445	-0.690										
				17.1	-3.957	0.284	-0.7949	0.5439	-0.2689	-26.306	-55.622	114.587	1792.	0.51	59526.	301.59
27	120.300	264.750	0.0	16.1	-3.894	-0.102										
				14.2	-1.349	0.387	0.0748	0.8319	-0.5498	-33.463	5.141	28.323	1744.	-2.22	14524.	-2.01
28	123.700	260.350	0.0	15.4	-4.131	-0.543										
				13.2	-1.073	-0.301	0.0989	0.8308	-0.5478	-33.398	6.791	28.179	1781.	-0.14	14544.	-1.88
29	127.150	256.050	0.0	14.5	-3.524	-0.464										
				13.1	-1.244	-0.386	0.1137	0.7937	-0.5976	-36.981	8.155	27.706	1832.	2.76	14300.	-3.52

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
30	130.700	251.850	0.0	12.2	-1.529	-0.338										
				11.3	0.464	0.581	0.0938	0.8754	-0.4742	-28.441	6.117	25.089	1755.	-1.59	12949.	-12.64
31	134.100	247.500	0.0	23.1	-3.977	-0.491										
				12.3	-2.698	-0.170	-0.0354	0.7532	-0.6569	-41.093	-2.692	31.073	1818.	1.97	16142.	8.90
32	137.600	243.300	0.0	24.1	-3.530	0.058										
				3.3	-0.398	-0.658	-0.1378	0.8080	-0.5729	-35.338	-9.680	32.476	1744.	-2.22	16654.	12.36
33	141.000	238.900	0.0	1.1	0.287	-1.145										
				3.5	-0.822	0.460	0.0989	0.7550	-0.6482	-40.649	7.463	23.182	1804.	1.17	12122.	-18.22
34	144.450	234.700	0.0	10.3	-3.481	-0.353										
				3.1	-0.879	-0.357	0.0882	0.8460	-0.5259	-31.865	5.954	27.388	1769.	-0.78	14045.	-5.24
35	147.900	230.350	0.0	9.2	-3.483	0.154										
				2.2	0.137	-1.048	0.0836	0.8198	-0.5665	-34.647	5.822	28.301	1795.	0.66	14513.	-2.09
36	151.400	226.050	0.0	8.4	-3.220	0.320										
				2.2	-0.496	-1.108	0.1712	0.7883	-0.5910	-36.857	12.252	25.653	1792.	0.51	13326.	-10.09
37	154.850	221.800	0.0	7.3	-3.318	-0.188										
				6.3	-0.357	1.244	0.1560	0.9604	-0.2310	-13.522	9.228	49.353	1704.	-4.45	24372.	64.43
38	158.300	217.150	0.0	6.6	-3.144	0.035										
				5.1	-0.225	-0.822	-0.5277	0.3752	0.7621	63.788	-54.589	6.992	1850.	3.77	3805.	-74.33
39	161.700	213.200	0.0	6.5	-3.301	-0.114										
				5.1	-0.888	-1.066	0.0764	0.8162	-0.5772	-35.268	1.855	29.643	1811.	1.58	14915.	0.62
40	165.300	208.850	0.0	15.1	-2.870	0.112										
				14.1	-1.244	0.434	0.0321	0.8471	-0.5305	-32.059	2.170	28.046	1740.	-2.40	14569.	-1.71
41	168.650	204.500	0.0	14.5	-3.146	0.295										
				13.3	-1.087	0.579	0.0826	0.8249	-0.5593	-34.139	5.721	27.251	1781.	-0.14	14065.	-5.11
42	172.100	200.200	0.0	14.5	-3.697	-1.278										
				12.3	-0.807	1.066	0.0050	0.8050	-0.5933	-36.392	0.359	30.184	1783.	0.02	15380.	3.76
43	175.600	195.850	0.0	11.5	-0.837	0.657										
				11.1	0.516	0.649	0.0084	0.8523	-0.5230	-31.533	0.562	27.637	1792.	0.51	14357.	-3.14
44	179.050	191.600	0.0	12.3	-3.051	-0.778										
				11.1	-0.940	0.546	0.2347	0.8102	-0.5371	-33.542	16.154	24.461	1778.	-0.30	12790.	-13.71
45	182.450	187.350	0.0	24.1	-3.768	-0.737										
				3.3	-0.786	-0.776	-0.0719	0.8627	-0.5005	-30.120	-4.764	49.282	1792.	0.51	25601.	72.72
46	185.900	183.100	0.0	11.2	-0.700	-0.579										
				11.5	-1.438	0.219	-0.0719	0.8627	-0.5005	-30.120	-4.764	49.282	1795.	0.66	25273.	70.50
47	189.400	178.800	0.0	10.4	-3.938	-0.476										
				8.2	-1.036	0.427	0.0873	0.8292	-0.5521	-33.658	6.008	46.847	1669.	-6.42	22992.	55.12
48	192.800	174.050	0.0	9.2	-3.769	-0.662										
				6.2	0.454	0.543	0.0071	0.7706	-0.6373	-39.592	0.526	28.166	1876.	5.20	15540.	4.84
49	196.200	170.200	0.0	6.2	-0.879	0.454										
				6.1	0.549	0.764	0.0195	0.9031	-0.4291	-25.415	1.236	28.962	1766.	-0.95	15045.	1.50

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	PERCENT ERROR	BALL SPEED (RPM)	PERCENT ERROR
50	199.600	165.900	0.0	18.2	-4.164	-0.275										
				5.1	0.716	-0.803	0.8080	0.5779	0.1146	11.214	54.428	50.104	1818.	1.97	26033.	75.60
51	203.100	161.700	0.0	6.6	-3.450	-0.654										
				4.5	0.630	-0.925	-0.0843	0.2769	-0.9571	-73.862	-17.048	19.213	1781.	-0.14	8916.	-33.10
52	206.550	157.400	0.0	16.1	-3.911	-0.043										
				14.2	-1.720	0.490	0.0428	0.8384	-0.5434	-32.950	2.833	28.752	1795.	0.66	14745.	-0.53
53	210.050	153.100	0.0	15.1	-3.302	-0.503										
				13.2	-1.044	-0.213	0.0654	0.8386	-0.5408	-32.815	4.459	27.548	1778.	-0.30	14404.	-2.92
54	213.450	148.950	0.0	14.5	-3.547	-0.378										
				13.1	-1.245	-0.290	0.1649	0.8369	-0.5115	-31.431	13.106	23.829	1804.	1.17	12460.	-15.94
55	216.900	144.650	0.0	25.1	-4.302	-0.409										
				13.2	-1.510	-0.726	-0.2690	0.8236	-0.4993	-31.224	-18.088	34.690	1744.	-2.22	17790.	20.02
56	220.300	140.250	0.0	23.1	-4.005	-0.381										
				11.5	-0.209	0.744	0.0299	0.8344	-0.5503	-33.408	2.050	29.982	1755.	-1.59	15475.	4.40
57	223.700	135.900	0.0	24.1	-3.505	0.209										
				3.1	1.172	-0.455	0.0052	0.8328	-0.5536	-33.614	0.360	30.168	1860.	4.20	15372.	3.71
58	227.350	131.700	0.0	11.4	-2.284	-0.749										
				1.1	0.290	-1.102	0.0766	0.8409	-0.5358	-32.503	5.205	26.288	1725.	-3.23	13746.	-7.27
59	230.650	127.350	0.0	10.2	-2.440	-0.209										
				1.1	-0.210	-1.074	0.1544	0.8394	-0.5211	-31.829	10.424	26.724	1804.	1.17	13973.	-5.73
60	234.100	123.150	0.0	9.2	-3.463	0.272										
				2.3	-0.170	0.491	-0.2511	0.9008	-0.3543	-21.473	-15.575	42.744	1755.	-1.59	22062.	48.84
61	237.500	118.900	0.0	8.5	-3.304	-0.332										
				2.2	-0.456	-0.105	0.7939	0.4435	-0.4346	-44.421	60.503	22.257	1792.	0.51	11562.	-22.00
62	240.950	114.550	0.0	7.3	-3.296	-0.048										
				6.1	-0.135	0.843	0.2154	0.9550	-0.2040	-12.057	12.710	47.490	1769.	-0.78	24354.	64.30
63	244.400	110.200	0.0	6.6	-3.079	0.165										
				5.1	-0.167	-0.789	-0.5146	0.3881	0.7646	63.089	-52.982	7.046	1795.	0.66	3613.	-75.67
64	247.900	105.900	0.0	6.5	-3.246	0.0										
				14.2	-0.610	0.730	0.0397	0.8318	-0.5537	-33.650	2.734	28.482	1775.	-0.47	15090.	1.80
65	251.250	101.700	0.0	15.2	-3.123	-0.298										
				13.5	-0.487	0.782	0.0441	0.8411	-0.5391	-32.661	3.000	28.495	1783.	0.02	14520.	-2.04
66	254.750	97.350	0.0	14.6	-3.408	-0.094										
				13.3	-1.026	0.647	0.0650	0.8426	-0.5346	-32.394	4.414	27.747	1804.	1.16	14509.	-2.12
67	258.200	93.150	0.0	14.5	-3.679	-1.136										
				12.3	-0.707	1.157	0.0554	0.8273	-0.5591	-34.050	3.828	28.538	1806.	1.31	14729.	-0.63
68	261.700	88.900	0.0	23.1	-3.693	0.497										
				11.5	-0.783	0.706	0.0248	0.8311	-0.5555	-33.757	1.710	28.736	1795.	0.66	15249.	2.88
69	265.200	84.600	0.0	12.3	-3.041	-0.673										
				11.1	-0.878	0.610	0.2163	0.7999	-0.5598	-34.984	15.129	24.876	1766.	-0.95	12923.	-12.82

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
70	268.600	80.300	0.0	24.1	-3.797	-0.616										
				9.3	-0.777	-0.726	-0.1053	0.7656	-0.6346	-39.656	-7.831	30.719	1766.	-0.95	15958.	7.66
71	272.000	76.000	0.0	10.2	-2.770	-0.309										
				3.5	-1.424	0.285	0.4854	0.8598	-0.1584	-10.439	29.449	6.630	1548.	-13.16	3422.	-76.91
72	275.000	71.250	0.0	10.4	-3.940	-0.330										
				8.2	-0.990	0.460	0.0653	0.8303	-0.5535	-33.690	4.494	46.925	2026.	13.62	24377.	64.46
73	278.900	67.450	0.0	9.2	-3.770	-0.516										
				2.3	-0.765	0.337	0.0625	0.8451	-0.5310	-32.144	4.231	27.568	1792.	0.51	14321.	-3.38
74	282.350	63.200	0.0	19.1	-4.028	-0.239										
				6.2	-0.811	0.474	0.0806	0.8499	-0.5208	-31.501	5.415	27.746	1790.	0.36	14603.	-1.48
75	285.750	59.000	0.0	18.2	-4.151	-0.225										
				5.1	0.265	-0.857	0.1277	0.9481	-0.2912	-17.073	7.673	49.739	1766.	-0.95	25839.	74.32
76	289.150	54.700	0.0	6.6	-3.394	-0.555										
				14.2	0.169	0.752	0.1664	0.1003	-0.9809	-84.159	58.902	15.362	1769.	-0.78	7878.	-46.85
77	292.600	50.350	0.0	16.1	-3.840	0.077										
				14.2	-1.227	0.506	0.0523	0.8234	-0.5651	-34.461	3.637	28.932	1792.	0.51	15030.	1.40
78	296.050	46.100	0.0	15.1	-3.166	-0.416										
				13.2	-0.987	-0.209	0.0681	0.8513	-0.5203	-31.431	4.576	27.179	1781.	-0.14	14028.	-5.36
79	299.500	41.800	0.0	14.5	-3.467	-0.276										
				13.1	-1.168	-0.249	0.5303	0.6712	-0.5180	-37.660	38.310	23.007	1781.	-0.14	11874.	-19.89
80	302.950	37.500	0.0	25.1	-4.157	-0.366										
				12.1	-1.465	-0.255	-0.0617	0.8078	-0.5862	-35.967	-4.366	32.802	1818.	1.97	17040.	14.96
81	306.450	33.300	0.0	12.3	-2.628	0.0										
				11.1	-0.115	0.738	0.1954	0.7469	-0.6356	-40.395	14.660	24.227	1752.	-1.77	12668.	-14.53
82	309.800	29.000	0.0	24.1	-3.460	0.310										
				3.3	-0.323	-0.592	-0.0927	0.8414	-0.5325	-32.328	-6.290	31.356	1804.	1.17	16395.	10.61
83	313.250	24.800	0.0	11.4	-3.233	-0.618										
				1.1	0.317	-1.167	0.0913	0.8283	-0.5528	-33.720	6.288	27.290	1769.	-0.78	13995.	-5.58
84	316.700	20.450	0.0	10.3	-3.395	-0.150										
				8.2	-0.275	0.590	0.0844	0.8678	-0.4897	-29.439	5.554	27.057	1772.	-0.63	14527.	-1.99
85	320.000	16.300	0.0	9.3	-3.382	-0.475										
				2.2	0.180	-1.045	0.0833	0.7974	-0.5976	-36.850	5.966	28.811	1792.	0.51	14967.	0.97
86	323.450	12.050	0.0	8.5	-3.277	-0.288										
				2.2	-0.436	-1.095	0.1292	0.7987	-0.5876	-36.342	9.190	25.892	1806.	1.31	13364.	-9.84
87	326.950	7.800	0.0	7.3	-3.232	0.030										
				6.1	0.0	0.771	0.0038	0.8653	-0.5012	-30.079	0.253	29.679	1763.	-1.12	15621.	5.39
88	330.300	3.550	0.0	17.2	-3.685	0.0										
				5.1	-0.116	-0.856	0.1690	0.8072	-0.5656	-35.022	11.825	25.945	1783.	0.02	13220.	-10.81
89	333.800	359.200	0.0	6.5	-3.180	0.100										
				14.2	-0.491	0.686	0.0367	0.8105	-0.5846	-35.804	2.595	28.948	1804.	1.17	15136.	2.11

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
90	337.250	355.000	0.0	15.2	-3.114	-0.233										
				13.5	-0.397	0.705										
							0.0195	0.8341	-0.5513	-33.463	1.340	28.456	1789.	0.35	14977.	1.04
91	340.650	350.900	0.0	14.6	-3.376	0.0										
				13.3	-0.903	0.610										
							-0.0170	0.8497	-0.5270	-31.805	-1.143	76.728	1777.	-0.32	3994.	-73.06
92	14.800	308.100	0.0	14.2	0.389	0.643										
				14.1	1.146	0.365										
							0.0667	0.8814	-0.4677	-27.953	4.326	28.912	1787.	0.20	15420.	4.03
93	18.150	303.950	0.0	16.1	-3.697	0.252										
				13.5	0.506	0.632										
							0.0378	0.8188	-0.5728	-34.974	2.643	29.032	1781.	-0.14	14984.	1.09
94	21.600	299.650	0.0	15.4	-4.017	-0.151										
				14.1	-1.503	0.196										
							0.0536	0.8242	-0.5638	-34.372	3.719	27.643	1792.	0.51	14360.	-3.12
95	25.050	295.400	0.0	14.6	-3.562	-0.637										
				13.1	-0.996	-0.287										
							0.1186	0.7377	-0.6647	-42.019	9.133	24.892	1772.	-0.63	13365.	-9.83
96	28.350	291.250	0.0	12.2	-1.262	-0.186										
				12.4	-1.615	0.334										
							0.1186	0.7377	-0.6647	-42.019	9.133	24.892	1781.	-0.14	12847.	-13.33
97	31.800	286.950	0.0	12.1	-1.602	-0.329										
				11.1	0.178	0.634										
							0.1729	0.5999	-0.7812	-52.478	16.075	18.542	1818.	1.97	9632.	-35.02
98	35.300	282.750	0.0	11.3	-1.700	0.065										
				3.3	-0.149	-0.672										
							-0.0866	0.9035	-0.4198	-24.924	-5.477	44.924	1806.	1.31	23187.	56.43
99	38.800	278.500	0.0	3.6	-1.285	0.113										
				3.2	0.028	-0.530										

	AVG. SPEED (RPM)	AVG. ABS(SPEED ERROR) (PERCENT)	AVERAGE YAW (DEG.)	AVERAGE PITCH (DEG.)	MEAN BALL POSITION (DEG.)
SEPARATOR	1783.14	2.0709			
BALL	14822.56	23.1834	0.603	-29.963	0.0

I T I BALL MOTION DATA REDUCTION

ITI BALL MOTION TEST NO. 1-8-3

SHAFT RPM	BALL DIA.	TEST BALL NO.	PITCH DIA.	SEPARATOR MEAN RAD	FILM MAGNIFICATION	OBJECT LENGTH
12000.	0.750	3	5.6350	2.8175	12.750	34.276

FRAME NO.	C.P. POSITION (DEG)	I.P. POSITION (DEG)	BALL SEP POS (IN.)	TC POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
1	257.400	267.950	0.0	23.1	-3.396	0.482										
				35.1	-0.824	-1.210	-0.0375	0.9935	-0.1076	-6.181	-2.160	82.416	5538.	0.05	52466.	2.13
2	266.100	257.800	0.0	37.3	-3.852	-0.287										
				34.2	1.737	-0.223	0.0241	0.9923	-0.1218	-6.996	1.392	40.621	5524.	-0.21	51592.	0.41
3	270.450	252.700	0.0	36.4	-2.848	0.095										
				22.2	3.763	-0.460	-0.2217	0.9564	-0.1903	-11.253	-13.051	32.949	5592.	1.01	41402.	-19.41
4	274.900	247.600	0.0	24.1	3.894	0.665										
				35.1	1.422	0.627	0.0038	0.9999	-0.0146	-0.837	0.220	39.358	5524.	-0.21	49978.	-2.72
5	279.250	242.500	0.0	35.1	0.757	1.300										
				42.4	-3.710	-0.285	0.0293	0.9893	-0.1428	-8.213	1.695	39.685	5460.	-1.36	50395.	-1.91
6	283.550	237.350	0.0	35.2	1.450	0.822										
				34.2	-1.308	0.840	-0.0037	0.9943	-0.1064	-6.109	-0.212	34.257	5621.	1.54	43272.	-15.77
7	288.000	232.300	0.0	35.1	-1.112	0.864										
				34.2	-1.612	-0.198	0.0201	0.9978	-0.0626	-3.591	1.154	33.682	5460.	-1.36	42771.	-16.74
8	292.300	227.150	0.0	36.4	2.967	0.487										
				35.1	-1.428	-0.046	0.0741	0.9958	-0.0531	-3.049	4.254	46.933	5553.	0.32	59913.	16.62
9	296.650	222.100	0.0	36.5	2.953	-0.587										
				35.2	-1.329	0.774	-0.0676	0.9941	-0.0844	-4.852	-3.890	34.761	5524.	-0.21	44141.	-14.08

FRAME NO.	C.P. POSITION (DEG)	I.P. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	PERCENT ERROR	BALL SPEED (RPM)	PERCENT ERROR
10	301.000	217.000	0.0	35.2	-1.567	-0.280										
				42.2	3.629	-0.648	-0.0371	0.9876	-0.0992	-2.394	-2.128	35.064	5455.	-1.47	45001.	-12.40
11	306.750	211.900	0.0	37.2	-3.274	0.329										
				36.1	0.468	0.553	0.0481	0.9896	-0.1353	-7.786	2.782	38.364	5621.	1.54	48448.	-5.70
12	309.700	206.850	0.0	34.1	2.701	-0.549										
				36.1	0.0	0.675	0.7741	0.6301	-0.0609	-5.523	50.854	7.372	5524.	-0.22	3012.	-94.14
13	314.050	201.750	0.0	24.1	3.966	-0.156										
				36.1	0.424	0.465	0.0626	0.9977	-0.0261	-1.498	3.590	39.295	5466.	-1.26	49375.	-3.89
14	318.400	196.550	0.0	42.4	-3.672	0.554										
				35.2	1.626	-0.548	0.0307	0.9946	-0.0994	-5.709	1.749	38.648	5434.	-0.94	49868.	-2.93
15	322.650	191.500	0.0	42.2	-3.560	-0.174										
				35.1	0.097	1.457	0.0570	0.9901	-0.1290	-7.368	3.295	36.452	5592.	1.01	45804.	-10.84
16	327.100	186.400	0.0	37.2	3.379	0.465										
				35.1	-0.851	1.151	0.0303	0.9948	-0.0969	-5.564	1.744	40.620	5524.	-0.21	51590.	0.40
17	331.450	181.300	0.0	36.4	3.004	-0.131										
				35.2	-0.116	1.558	-0.0069	0.9989	-0.0465	-2.664	-0.395	39.941	5529.	-0.13	50188.	-2.31
18	335.850	176.150	0.0	35.2	-1.091	1.070										
				36.1	0.694	-0.353	-0.2525	0.9676	-0.0059	-0.352	-14.626	12.210	5553.	0.32	15597.	-69.66
19	340.200	171.100	0.0	36.1	0.799	0.060										
				42.4	3.806	0.290	0.0671	0.9583	-0.2778	-16.164	4.007	37.525	5499.	-0.84	47905.	-6.75
20	344.500	166.000	0.0	32.2	4.005	-0.588										
				36.1	0.627	0.432	0.0076	0.9985	-0.0547	-3.135	0.439	38.289	5587.	0.93	48622.	-5.36
21	348.900	160.950	0.0	34.2	1.724	0.111										
				34.1	2.497	-1.104	0.0638	0.9951	-0.0752	-4.320	3.671	40.842	5558.	0.40	51590.	0.42
22	353.300	155.850	0.0	26.1	-0.533	0.512										
				35.1	1.555	-0.043	0.2106	0.9563	-0.2029	-11.982	12.420	51.968	5460.	-1.36	65991.	28.45
23	357.600	150.700	0.0	35.1	1.248	0.146										
				23.1	3.406	-1.232	-0.0293	0.9980	-0.0564	-3.232	-1.682	35.677	5489.	-0.84	45545.	-11.35
24	261.900	145.600	0.0	35.1	0.383	1.407										
				35.2	1.691	0.192	0.0696	0.9856	-0.1541	-8.886	4.040	36.254	5529.	-0.12	45555.	-11.33
25	6.300	140.450	0.0	37.2	3.366	-0.212										
				34.2	-1.518	0.488	-0.2353	0.9662	-0.1056	-6.239	-13.687	31.609	5519.	-0.21	40568.	-21.03
26	10.600	135.400	0.0	35.1	-1.307	0.567										
				35.3	1.112	1.696	0.0235	0.9948	-0.0994	-5.709	1.354	36.235	5495.	-0.74	45770.	-10.91
27	14.950	130.250	0.0	35.1	-1.397	-0.475										
				36.6	3.612	0.533	0.1232	0.9924	-0.0059	-0.341	7.075	44.069	5553.	0.32	56258.	9.51
28	19.300	125.200	0.0	35.2	-1.465	0.400										
				36.5	3.007	0.100	0.1287	0.9886	-0.0778	-4.437	7.415	46.605	5500.	-0.64	58256.	13.40
29	23.700	120.000	0.0	42.2	3.657	0.215										
				35.3	-1.988	0.069	-0.7281	0.6289	-0.2725	-23.430	-49.182	28.648	5519.	-0.31	36767.	-28.43

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP. POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
30	28.000	114.950	0.0	37.3	-3.848	-0.518										
				36.1	0.300	0.583	-0.0269	0.9694	-0.2441	-14.134	-1.534	43.447	5553.	0.32	55465.	7.96
31	32.350	109.900	0.0	35.1	1.583	-0.373										
				22.2	3.751	-0.321	0.2699	0.8666	0.4198	25.846	17.300	136.619	5489.	-0.84	174407.	239.49
32	36.650	104.800	0.0	34.2	0.569	1.445										
				36.3	-1.568	0.584	-0.0324	0.1999	-0.9793	-78.463	-9.211	14.570	5592.	1.01	18308.	-64.36
33	41.100	99.700	0.0	23.1	3.575	0.300										
				35.1	0.636	1.265	0.0116	0.9975	-0.0692	-3.969	0.664	37.751	5455.	-1.47	48450.	-5.69
34	45.350	94.600	0.0	35.1	-0.298	1.352										
				37.2	3.315	-0.917	-0.0273	0.9353	-0.3528	-20.670	-1.669	20.643	5524.	-0.21	26213.	-48.98
35	49.700	89.500	0.0	35.2	0.444	1.445										
				36.1	0.043	0.841	0.0167	0.9959	-0.0888	-5.098	0.963	36.650	5524.	-0.21	46539.	-9.41
36	54.050	84.400	0.0	35.1	-1.444	-0.233										
				35.2	-0.554	1.353	0.0141	0.9980	-0.0615	-3.524	0.812	33.088	5524.	-0.21	42017.	-18.21
37	58.400	79.300	0.0	36.5	2.996	-0.538										
				35.2	-1.327	0.652	0.0948	0.9901	-0.1040	-5.996	5.467	44.392	5587.	0.93	56371.	9.73
38	62.800	74.250	0.0	42.2	3.660	-0.530										
				35.2	-1.525	-0.425	-0.2147	0.9658	-0.1453	-8.553	-12.531	32.599	5558.	0.40	41178.	-19.85
39	67.200	69.150	0.0	37.2	-3.273	-0.054										
				32.2	4.007	0.475	-0.7192	0.6173	-0.3188	-27.318	-49.363	31.063	5484.	-0.94	40081.	-21.98
40	71.450	64.100	0.0	36.4	-2.805	0.512										
				36.1	0.0	0.577	-0.0734	0.9793	-0.1887	-10.908	-4.284	42.861	5592.	1.01	53857.	4.84
41	75.900	59.000	0.0	35.1	1.570	0.398										
				24.1	4.007	0.0	0.2973	0.9545	0.0239	1.437	17.299	53.246	5519.	-0.31	68337.	33.02
42	80.200	53.950	0.0	23.1	3.616	-0.378										
				36.5	-2.848	-0.335	0.5363	0.8415	0.0654	4.441	32.507	25.577	5495.	-0.74	32308.	-37.11
43	84.550	48.800	0.0	35.2	1.613	0.548										
				34.2	-1.098	1.028	0.0323	0.9883	-0.1493	-8.593	1.874	36.251	5553.	0.32	46278.	-9.92
44	88.900	43.750	0.0	35.1	-0.918	1.029										
				37.4	3.990	-0.226	-0.0418	0.9988	-0.0265	-1.518	-2.399	37.836	5558.	0.40	47793.	-6.97
45	93.300	38.650	0.0	22.2	-3.642	0.169										
				35.1	-1.382	0.158	0.0514	0.9944	-0.0924	-5.308	2.961	38.606	5558.	0.40	48766.	-5.08
46	97.700	33.550	0.0	35.2	-1.096	0.963										
				24.1	-3.710	-0.980	-0.3876	0.8598	-0.3325	-21.146	-24.268	107.875	6212.	12.21	152295.	196.45
47	102.100	29.450	0.0	55.2	-1.508	0.0										
				23.1	-3.451	-0.500	0.8908	0.3151	0.3275	46.107	70.522	41.754	5077.	-8.29	48178.	-6.22
48	106.500	23.450	0.0	36.1	0.594	0.445										
				35.2	-1.255	-1.051	0.1948	0.7030	0.6839	44.212	15.488	28.987	5541.	0.09	18356.	-64.27
49	115.250	13.250	0.0	36.6	-3.521	0.0										
				22.2	3.727	0.532	-0.2726	0.9611	0.0437	2.605	-15.835	29.386	5553.	0.32	37514.	-26.98

FRAME NO.	O.P. POSITION (DEG)	I.P. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
50	119.600	3.200	0.0	36.3	-1.659	0.248										
				35.1	1.232	0.933	-0.2977	0.4317	-0.8096	-61.930	-42.649	12.247	5583.	0.85	15719.	-69.40
51	123.950	3.200	0.0	35.1	0.347	1.411										
				36.1	-0.614	-0.312	0.0424	0.9989	0.0178	1.023	2.432	17.380	5466.	-1.26	21838.	-57.49
52	128.300	358.000	0.0	37.2	3.387	-0.195										
				35.1	-0.634	1.254	-0.6477	0.7335	-0.2061	-15.692	-41.442	17.134	5524.	-0.22	21758.	-57.65
53	132.650	352.900	0.0	35.2	1.503	0.176										
				36.1	0.197	-0.820	-0.0052	0.9925	-0.1223	-7.025	-0.301	107.543	5519.	-0.31	138023.	168.67
54	136.950	347.850	0.0	35.3	-0.161	1.915										
				35.1	-1.389	-0.460	0.0269	0.9993	-0.0261	-1.495	1.544	46.083	5519.	-0.31	59143.	15.12
55	141.250	342.800	0.0	36.5	3.070	0.078										
				33.1	-3.446	0.367	-0.0184	0.9895	-0.1434	-8.244	-1.066	38.366	5500.	-0.64	47958.	-6.65
56	145.650	337.600	0.0	42.2	3.710	0.100										
				35.2	-1.419	-0.639	0.9928	0.0943	-0.0734	-37.883	84.575	32.902	5621.	1.54	41550.	-19.10
57	150.100	332.550	0.0	37.2	-3.227	-0.605										
				36.3	0.455	1.636	-0.8711	0.0915	-0.4825	-79.264	-84.004	84.566	5524.	-0.21	107387.	109.03
58	154.450	327.450	0.0	36.4	-3.886	0.0										
				35.1	-0.160	0.594	0.0559	0.9882	-0.1427	-8.217	3.238	38.612	5519.	-0.31	49555.	-3.54
59	158.750	322.400	0.0	36.1	-0.517	0.300										
				35.1	1.433	0.583	0.0540	0.9934	-0.1012	-5.815	3.109	46.855	5466.	-1.26	58876.	14.60
60	163.100	317.200	0.0	23.1	3.588	0.185										
				35.2	1.684	-0.234	0.0169	0.9936	-0.0500	-2.864	0.967	38.709	5647.	2.01	49630.	-3.30
61	167.500	312.250	0.0	36.1	-0.442	-0.602										
				35.2	1.462	0.784	-0.2724	0.8423	-0.4651	-28.909	-17.920	16.288	5431.	-1.88	20574.	-59.95
62	171.800	307.050	0.0	35.1	-1.089	0.987										
				37.4	3.959	0.342	0.0595	0.9970	-0.0500	-2.870	3.418	42.635	5587.	0.93	54141.	5.39
63	176.200	302.000	0.0	36.6	3.552	-0.385										
				35.1	-1.407	-0.060	0.9687	0.1580	0.1913	50.442	80.736	12.195	5495.	-0.74	15404.	-70.02
64	180.550	296.850	0.0	36.1	0.755	-0.394										
				35.3	-0.933	1.658	-0.0924	0.9917	-0.0896	-5.165	-5.322	45.516	5587.	0.93	57798.	12.51
65	184.650	291.800	0.0	36.1	0.726	0.122										
				42.2	3.608	-0.872	0.2207	0.9702	-0.1004	-5.907	12.815	49.291	5524.	-0.21	62592.	21.84
66	189.300	286.700	0.0	32.2	4.026	0.085										
				36.1	0.504	0.517	0.0699	0.9972	-0.0269	-1.546	4.010	40.218	5553.	0.32	51342.	-0.06
67	193.650	281.650	0.0	34.1	2.694	-0.759										
				36.1	0.036	0.641	0.2738	0.9566	-0.0999	-5.959	15.970	61.360	5495.	-0.74	77509.	50.87
68	198.000	276.500	0.0	36.6	-3.552	-0.380										
				34.2	1.089	1.287	0.0758	0.9928	-0.0930	-5.354	4.364	38.128	5621.	1.54	48162.	-6.25
69	202.450	271.450	0.0	36.5	-2.354	0.056										
				35.1	1.079	1.064	0.0669	0.9927	-0.1004	-5.774	3.854	35.928	5489.	-0.84	45865.	-10.72

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
70	206.750	266.350	0.0	42.2	-3.584	0.130										
				35.1	0.198	1.449	0.0769	0.9914	-0.1063	-6.120	4.435	36.157	5553.	0.32	46158.	-10.15
71	211.100	261.300	0.0	37.2	3.398	0.174										
				34.2	-1.535	0.315	-0.0143	0.9963	-0.0848	-4.865	-0.823	38.048	5558.	0.40	48052.	-6.45
72	215.500	256.200	0.0	36.4	3.005	-0.434										
				36.1	0.266	-0.753	-0.0974	0.9941	-0.0475	-2.737	-5.595	33.235	5587.	0.93	42203.	-17.85
73	219.900	251.150	0.0	24.1	-3.845	-0.293										
				35.1	-1.344	-0.531	-0.1332	0.9732	-0.1877	-10.915	-7.791	46.551	5529.	-0.12	58494.	13.86
74	224.300	246.000	0.0	23.1	-3.468	0.110										
				35.2	-1.471	0.294	0.0069	0.9875	-0.1576	-9.065	0.395	37.069	5519.	-0.31	47575.	-7.39
75	228.600	240.950	0.0	35.2	-1.460	-0.683										
				42.2	3.688	0.464	0.1268	0.9917	-0.0192	-1.108	7.288	44.717	5524.	-0.21	56783.	10.53
76	232.950	235.850	0.0	36.1	0.245	0.650										
				34.2	1.776	-0.119	0.2416	0.9669	-0.0814	-4.813	14.030	5.759	5621.	1.54	7274.	-85.84
77	237.400	230.800	0.0	36.4	-2.838	-0.158										
				36.1	-0.179	0.620	0.0757	0.9861	-0.1478	-8.523	4.387	38.995	5495.	-0.74	49257.	-4.12
78	241.750	225.650	0.0	36.1	-0.522	0.305										
				12.3	4.236	-0.454	-0.1238	0.9914	-0.0426	-2.463	-7.116	38.273	5617.	1.47	48859.	-4.89
79	246.150	220.650	0.0	34.2	-0.528	1.493										
				35.2	1.724	0.072	0.0075	0.9955	-0.0947	-5.432	0.432	65.489	5538.	0.05	41691.	-18.85

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
80	254.850	210.500	0.0	35.1	-1.128	0.853										
				36.2	2.580	-0.261	0.1808	0.9757	-0.1240	-7.240	10.496	27.551	5558.	0.40	34801.	-32.26
81	259.250	205.400	0.0	36.6	3.681	-0.134										
				35.2	-0.513	1.417	-0.0844	0.9964	0.0048	0.277	-4.843	36.587	5524.	-0.22	46460.	-9.56
82	263.600	200.300	0.0	35.2	-1.350	0.747										
				12.3	-4.120	-0.369	0.2658	0.9633	-0.0372	-2.214	15.424	35.364	5558.	0.40	44669.	-13.05
83	268.000	195.200	0.0	23.1	-3.292	-1.176										
				36.1	0.768	0.237	-0.2915	0.8961	-0.3347	-20.479	-18.019	8.000	5489.	-0.84	10212.	-80.12
84	272.300	190.100	0.0	37.2	-3.241	0.108										
				36.1	0.464	0.590	0.8380	0.4115	-0.3582	-41.038	63.846	119.691	5460.	-1.36	151988.	195.85
85	276.600	184.950	0.0	22.1	4.237	-0.303										
				34.2	4.646	0.489	0.7153	0.6908	0.1058	8.711	45.958	168.646	5587.	0.93	214150.	316.85
86	281.000	179.900	0.0	36.6	-3.518	-0.672										
				36.1	-0.473	0.390	0.1061	0.9802	-0.0283	-1.653	11.313	35.007	5617.	1.47	44690.	-13.01
87	285.400	174.900	0.0	36.5	-2.901	-0.213										
				35.1	0.963	1.174	0.0473	0.9936	-0.1024	-5.884	2.728	37.416	5529.	-0.13	47016.	-8.48
88	289.800	169.750	0.0	42.2	-3.619	-0.273										
				35.1	0.033	1.454	0.0475	0.9919	-0.1179	-6.777	2.744	38.466	5519.	-0.31	49368.	-3.90
89	294.100	164.700	0.0	34.2	-1.594	0.112										
				35.2	0.881	1.299										

	AVG. SPEED (RPM)	AVG. ABS(SPEED ERROR) (PERCENT)	AVERAGE YAW (DEG.)	AVERAGE PITCH (DEG.)	MEAN BALL POSITION (DEG.)
SEPARATOR	5535.68	0.8990			
BALL	51373.39	32.4792	2.551	-7.275	0.0

I T I BALL MOTION DATA REDUCTION

ITI BALL MOTION TEST NO. 1-8-4 5-23-73

APP. - 2 -

SHAFT RPM	BALL DIA.	TEST BALL NO.	PITCH DIA.	SEPARATOR MEAN RAD	FILM MAGNIFICATION	OBJECT LENGTH
12000.	0.750	3	5.6350	2.8175	12.750	34.276

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
1	108.500	44.800	0.0	36.5	-2.777	-0.237										
				34.2	0.153	1.277										
							0.0903	0.9856	-0.1430	-8.253	5.232	35.906	5466.	-0.63	45117.	5.95
2	112.850	39.600	0.0	42.2	-3.475	-0.122										
				35.1	0.331	1.147										
							0.0605	0.9791	-0.1943	-11.227	3.534	38.368	5524.	0.42	48721.	14.41
3	117.200	34.500	0.0	34.2	-1.407	0.062										
				37.2	3.505	0.0										
							-0.1882	0.9664	-0.1752	-10.279	-11.023	32.027	5484.	-0.30	41325.	-2.95
4	121.450	29.450	0.0	35.1	-1.232	0.236										
				35.2	0.161	1.399										
							0.0985	0.9947	-0.0294	-1.695	5.656	30.842	5548.	0.87	39796.	-6.55
5	125.750	24.450	0.0	24.1	-3.815	-0.328										
				35.1	-1.313	-0.700										
							0.0320	0.9675	-0.2508	-14.533	1.892	39.498	5455.	-0.84	50692.	19.04
6	130.000	19.350	0.0	36.5	3.016	0.189										
				42.4	3.826	-0.355										
							0.8751	0.4834	0.0232	2.750	61.083	35.399	5509.	0.16	22416.	-47.36
7	138.700	9.100	0.0	36.3	0.316	1.457										
				34.2	1.711	-0.424										
							-0.9209	0.3746	-0.1083	-16.131	-67.866	11.935	5548.	0.87	15400.	-63.84
8	143.000	4.100	0.0	36.6	-3.450	0.616										
				36.1	-0.223	0.314										
							0.1706	0.9653	-0.1575	-11.565	10.019	39.868	5460.	-0.73	50626.	18.89
9	147.300	358.950	0.0	34.2	0.587	1.152										
				35.1	1.480	0.315										
							-0.0019	0.9796	-0.2010	-11.594	-0.113	31.483	5519.	0.33	40406.	-5.11

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
10	151.600	3[illegible]3.900	0.0	34.2	-0.388	1.213										
				35.2	1.774	-0.466										
							0.0038	0.9863	-0.1650	-9.497	0.218	32.228	6173.	12.23	37186.	-12.68
11	156.950	3[illegible]8.850	0.0	35.1	-0.169	1.142										
				35.2	1.506	0.541										
							0.0354	0.9865	-0.1600	-9.215	2.054	34.355	4671.	-15.08	49374.	15.95
12	160.200	343.750	0.0	35.1	-0.969	0.680										
				37.4	4.030	0.259										
							-0.0464	0.9849	-0.1671	-9.629	-2.699	34.550	5524.	0.42	43873.	3.03
13	164.550	338.650	0.0	35.2	-0.393	1.289										
				36.4	2.986	0.209										
							-0.0138	0.9937	-0.1110	-6.371	-0.793	36.562	5548.	0.87	47177.	10.79
14	168.850	333.650	0.0	35.2	-1.265	0.692										
				35.3	-0.910	1.540										
							-0.0241	0.9971	-0.0716	-4.109	-1.387	42.080	5432.	-1.25	53153.	24.82
15	173.150	328.450	0.0	23.1	-3.430	-0.981										
				36.1	0.780	-0.056										
							-0.3399	0.8725	-0.3511	-21.919	-21.287	7.297	5519.	0.33	9365.	-78.01
16	177.450	323.400	0.0	37.2	-3.216	0.255										
				36.1	0.524	0.304										
							0.3030	0.9116	0.2778	16.949	18.386	124.352	5507.	0.11	79163.	85.90
17	186.100	313.200	0.0	36.3	-1.195	0.928										
				34.2	1.133	0.956										
							-0.4338	0.2124	-0.8756	-76.366	-63.916	10.118	5432.	-1.25	12781.	-69.99
18	190.400	308.000	0.0	36.5	-2.779	0.021										
				36.1	-0.560	-0.187										
							0.0472	0.9783	-0.2020	-11.665	2.762	37.014	5583.	1.50	47505.	11.56
19	194.750	303.000	0.0	35.1	0.418	1.159										
				42.2	-3.557	0.202										
							0.0468	0.9878	-0.1485	-8.547	2.714	39.297	5489.	-0.20	50166.	17.81
20	199.050	297.900	0.0	34.2	-1.395	0.177										
				35.2	1.236	0.942										
							-0.0200	0.9881	-0.1524	-8.765	-1.161	34.532	5524.	0.42	43850.	2.97
21	203.400	292.800	0.0	35.1	-1.227	0.364										
				36.1	0.326	-0.952										
							-0.1093	0.9930	-0.0455	-2.622	-6.282	19.812	5519.	0.33	25428.	-40.29
22	207.700	287.750	0.0	24.1	-3.844	-0.054										
				35.1	-1.333	-0.564										
							0.0662	0.9815	-0.1795	-10.365	3.857	38.119	5519.	0.33	48923.	14.89
23	212.000	282.700	0.0	35.2	-1.440	0.303										
				36.1	0.852	-0.294										
							0.7816	0.5848	0.2169	20.352	53.156	25.888	5553.	0.96	16524.	-61.20
24	220.700	272.600	0.0	37.2	-3.252	-0.561										
				36.1	0.317	0.381										
							0.0044	0.9762	-0.2166	-12.512	0.257	41.210	5460.	-0.73	52331.	22.89
25	225.000	267.450	0.0	36.1	-0.096	0.416										
				22.2	3.691	-0.815										
							-0.0895	0.9896	-0.1128	-6.504	-5.169	33.527	5514.	0.24	43494.	2.14
26	229.250	262.450	0.0	35.1	1.562	0.231										
				24.1	3.985	0.224										
							0.0579	0.9851	-0.1621	-9.347	3.366	36.759	5466.	-0.63	46190.	8.47
27	233.600	257.250	0.0	42.4	-3.609	-0.074										
				34.2	-0.142	1.347										
							0.0595	0.9823	-0.1775	-10.243	3.468	39.333	5613.	2.04	50752.	19.18
28	237.950	252.300	0.0	34.2	-1.045	0.833										
				35.1	0.025	1.260										
							0.0549	0.9836	-0.1718	-9.909	3.193	34.687	5460.	-0.73	44047.	3.44
29	242.250	247.150	0.0	35.1	-0.816	0.892										
				37.3	4.010	0.578										
							0.1073	0.9937	-0.0339	-1.953	6.162	40.134	5553.	0.96	51234.	20.32

FRAME NO.	O.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
30	246.600	242.100	0.0	22.2	-3.512	0.040										
				35.2	-0.164	1.412	0.4413	0.0490	-0.8960	-86.868	83.659	12.851	5553.	0.96	16405.	-61.48
31	250.950	237.050	0.0	35.2	-1.120	0.934										
				36.1	-0.788	-0.455	-0.0577	0.9983	-0.0093	-0.536	-3.309	51.396	5484.	-0.30	66317.	55.73
32	255.200	232.000	0.0	23.1	-3.462	-0.471										
				36.1	0.816	-0.041	-0.2050	0.9305	-0.3035	-18.067	-12.424	54.066	5489.	-0.20	69020.	62.08
33	259.500	226.900	0.0	36.1	0.559	0.308										
				32.2	3.957	-0.607	-0.6472	0.2861	-0.7066	-67.957	-66.150	55.288	5489.	-0.20	35290.	-17.13
34	268.100	216.700	0.0	36.3	-1.064	1.127										
				22.2	3.746	0.216	-0.8034	0.4659	-0.3708	-38.519	-59.891	29.921	5553.	0.96	38196.	-10.30
35	272.450	211.650	0.0	36.5	-2.801	0.376										
				35.1	1.287	0.631	-0.0060	0.9823	-0.1875	-10.805	-0.348	39.471	5426.	-1.36	50389.	18.33
36	276.700	206.500	0.0	35.1	0.527	1.147										
				36.1	-0.586	-0.573	0.1059	0.9734	0.2030	11.781	6.211	14.849	5489.	-0.20	18955.	-55.49
37	281.000	201.400	0.0	32.2	-3.896	-0.250										
				34.2	-1.392	0.376	0.1655	0.9689	-0.1841	-10.757	9.696	34.535	5524.	0.42	43855.	2.99
38	285.350	196.300	0.0	35.1	-1.195	0.489										
				35.2	0.417	1.343	0.0648	0.9976	-0.0250	-1.433	3.715	33.583	5489.	-0.20	42871.	0.68
39	289.650	191.200	0.0	24.1	-3.828	0.259										
				35.1	-1.383	-0.415	0.0725	0.9784	-0.1935	-11.187	4.241	38.040	5426.	-1.36	48562.	14.04
40	293.900	186.050	0.0	35.2	-1.414	0.416										
				36.5	3.044	-0.306	-0.0234	0.9879	-0.1533	-8.819	-1.354	71.734	5501.	0.02	46156.	8.39
41	302.450	175.950	0.0	36.1	0.323	0.376										
				37.2	-3.334	-0.343	0.0278	0.9833	-0.1798	-10.362	1.619	77.666	5475.	-0.47	49443.	16.11
42	311.050	165.700	0.0	35.1	1.531	0.071										
				34.2	0.853	1.148	0.0992	0.9843	-0.1462	-8.451	5.754	30.531	5489.	-0.20	38975.	-8.47
43	315.350	160.600	0.0	42.4	-3.625	0.0										
				34.2	-0.145	1.309	0.0499	0.9801	-0.1919	-11.079	2.915	36.856	5553.	0.96	47050.	10.49
44	319.700	155.550	0.0	35.1	0.016	1.208										
				42.2	-3.498	-0.593	0.0430	0.9817	-0.1858	-10.716	2.507	38.031	5455.	-0.84	48809.	14.62
45	323.950	150.450	0.0	36.1	-0.038	-1.006										
				35.1	-0.840	0.832	-0.0742	0.9972	-0.0061	-0.352	-4.257	23.497	5489.	-0.20	29996.	-29.56
46	328.250	145.350	0.0	22.2	-3.572	0.098										
				35.2	-0.143	1.400	0.0699	0.9719	-0.2248	-13.026	4.114	35.951	5455.	-0.84	46140.	8.35
47	332.500	140.250	0.0	35.2	-1.090	0.909										
				35.3	-0.654	1.639	-0.0559	0.9928	-0.1063	-6.109	-3.218	44.435	5553.	0.96	56727.	33.21
48	336.850	135.200	0.0	42.4	3.813	0.179										
				36.1	0.779	-0.143	0.0186	0.9929	-0.1175	-6.749	1.074	37.527	5449.	-0.94	48684.	14.33
49	341.050	130.150	0.0	36.1	0.584	0.241										
				32.2	3.989	-0.745	-0.8702	0.1511	-0.4690	-72.137	-80.147	40.569	5524.	0.43	25758.	-39.51

FRAME NO.	T.R. POSITION (DEG)	I.R. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
50	349.750	119.950	0.0	36.3	-1.047	1.114										
				36.1	-0.379	0.264										
							-0.5386	0.4523	0.7108	57.533	-49.980	6.836	5455.	-0.84	8774.	-79.40
51	354.000	114.850	0.0	12.3	4.264	-0.089										
				35.1	1.310	0.579										
							0.1291	0.9916	-0.0123	-0.711	7.417	40.779	5524.	0.42	51783.	21.60
52	358.350	109.750	0.0	35.1	0.557	1.074										
				42.4	-3.528	-1.192										
							0.1244	0.9895	-0.0733	-4.236	7.163	36.799	5419.	-1.47	47482.	11.50
53	2.550	104.650	0.0	32.2	-3.865	-0.310										
				34.2	-1.395	0.331										
							0.2356	0.9511	-0.1999	-11.869	13.914	33.132	5524.	0.42	42072.	-1.20
54	6.900	99.550	0.0	35.1	-1.183	0.410										
				35.2	0.415	1.243										
							0.0415	0.9956	-0.0839	-4.815	2.384	37.242	5519.	0.33	47797.	12.24
55	11.200	94.500	0.0	24.1	-3.869	0.194										
				35.1	-1.404	-0.530										
							0.0518	0.9786	-0.1991	-11.500	3.032	38.536	5460.	-0.73	48935.	14.92
56	15.500	89.350	0.0	35.2	-1.440	0.332										
				36.5	3.008	-0.335										
							-0.1325	0.9753	-0.1767	-10.271	-7.735	32.198	5613.	2.04	41545.	-2.44
57	19.850	84.400	0.0	36.1	0.633	0.042										
				42.2	3.669	-0.338										
							0.9814	0.0147	0.1913	85.612	89.143	3.426	5362.	-2.52	4373.	-89.73
58	24.050	79.200	0.0	37.3	-3.900	-0.154										
				36.1	0.336	0.304										
							0.3336	0.9399	-0.0727	-4.421	19.544	33.585	5484.	-0.30	43336.	1.77
59	28.300	74.150	0.0	36.4	-2.837	0.105										
				34.1	2.751	-0.522										
							-0.0425	0.9970	0.0652	3.741	-2.443	44.554	5489.	-0.20	56878.	33.57
60	32.600	69.050	0.0	36.3	-1.402	0.508										
				34.2	0.829	1.078										
							-0.2181	0.1783	-0.9595	-79.474	-50.732	10.640	5519.	0.33	13655.	-67.93
61	36.900	64.000	0.0	42.4	-3.653	-0.086										
				34.2	-0.164	1.256										
							0.1052	0.9851	-0.1363	-7.881	6.094	35.479	5489.	-0.20	45292.	6.36
62	41.200	58.900	0.0	42.2	-3.462	-0.693										
				35.1	0.015	1.148										
							0.0367	0.9795	-0.1980	-11.426	2.148	40.346	5548.	0.87	52059.	22.25
63	45.500	53.900	0.0	34.2	-1.516	-0.240										
				36.1	0.0	-1.045										
							-0.0571	0.9927	-0.1060	-6.093	-3.291	49.061	5558.	1.04	61972.	45.53
64	49.900	48.800	0.0	22.2	-3.553	-0.055										
				35.1	-1.344	-0.071										
							0.0712	0.9702	-0.2315	-13.422	4.197	37.182	5489.	-0.20	47466.	11.47
65	54.200	43.700	0.0	35.2	-1.115	0.782										
				35.3	-0.690	1.577										
							0.0165	0.9982	-0.0570	-3.268	0.946	40.226	5489.	-0.20	51352.	20.59
66	58.500	38.600	0.0	23.1	-3.417	-0.622										
				35.2	-1.536	-0.238										
							0.6266	0.7517	-0.2056	-15.298	39.813	64.724	5501.	0.02	41645.	-2.20
67	67.050	28.500	0.0	36.1	0.034	0.348										
				36.3	-0.100	1.459										
							-0.2000	0.5597	0.8042	55.166	-19.666	2.747	5455.	-0.84	3526.	-91.72
68	71.300	23.400	0.0	36.6	-3.536	0.0										
				35.1	1.595	-0.340										
							0.2456	0.9608	-0.1286	-7.626	14.339	34.252	5460.	-0.73	43495.	2.14
69	75.600	18.250	0.0	36.5	-2.800	0.258										
				35.1	1.304	0.584										
							-0.0112	0.9810	-0.1939	-11.183	-0.654	40.239	5583.	1.80	51643.	21.28

FRAME NO.	O.R. POSITION (DEG)	I.P. POSITION (DEG)	BALL TO SEP POS (IN.)	POINT NO.	MEASURED COORDINATES TANG	RAD	SPIN AXIS DIRECTION X	Y	Z	SPIN AXIS PITCH (DEG)	SPIN AXIS YAW (DEG)	BALL ROTATION (DEG)	SEPARATOR SPEED (RPM)	SEPARATOR PERCENT ERROR	BALL SPEED (RPM)	BALL PERCENT ERROR
70	79.350	13.250	0.0	36.1	-0.545	-0.622										
				34.2	-0.708	1.093	-0.0240	0.9997	0.0043	0.249	-1.377	24.617	5426.	-1.36	31426.	-26.20
71	84.200	8.100	0.0	32.2	-3.385	-0.368										
				34.2	-1.387	0.315	0.1732	0.9691	-0.1755	-10.266	10.132	34.681	5519.	0.33	44511.	4.53
72	89.500	3.050	0.0	35.1	-1.179	0.403										
				36.2	2.634	-0.158	0.3980	0.9154	-0.0599	-3.745	23.499	18.566	5489.	-0.20	23701.	-44.34
73	92.800	357.950	0.0	24.1	-3.809	0.241										
				35.2	-0.681	1.119	0.0827	0.9752	-0.2054	-11.894	4.850	38.331	5524.	0.42	48673.	14.30
74	97.150	352.850	0.0	35.2	-1.384	0.361										
				36.5	3.028	-0.341	-0.0088	0.9915	-0.1298	-7.460	-0.510	35.881	5460.	-0.73	45563.	7.00
75	101.450	347.700	0.0	35.3	-1.915	0.141										
				36.1	0.669	0.054	0.9509	0.2785	0.1351	25.877	73.678	16.176	5514.	0.24	20985.	-50.72
76	105.700	342.700	0.0	37.3	-3.903	-0.074										
				36.1	0.356	0.328	0.3719	0.9272	-0.0440	-2.717	21.855	33.366	5489.	-0.20	42594.	0.03
77	110.000	337.600	0.0	36.4	-2.809	0.170										
				34.1	2.761	-0.527	-0.0345	0.9963	0.0785	4.503	-1.986	43.432	5484.	-0.30	56041.	31.60
78	114.250	332.550	0.0	36.3	-1.388	0.614										
				34.2	0.893	1.102	-0.2203	0.1729	-0.9600	-79.788	-51.874	10.867	5524.	0.43	13800.	-67.59
79	118.600	327.450	0.0	42.4	-3.655	0.059										
				34.2	-0.099	1.296	-0.4706	0.8757	0.1084	7.057	-28.255	142.615	5519.	0.33	183034.	329.82
80	122.900	322.400	0.0	42.2	-3.482	-0.561										
				85.1	0.101	1.214	11.6875	-0.0000	*******	0.000	********	-0.000	0.	0.0	*******	0.0
80	122.900	322.400	0.0	42.2	-3.482	-0.561										
				85.1	0.101	1.214										

	AVG. SPEED (RPM)	AVG. ABS(SPEED ERROR) (PERCENT)	AVERAGE YAW (DEG.)	AVERAGE PITCH (DEG.)	MEAN BALL POSITION (DEG.)
SEPARATOR	5500.48	0.9695			
BALL	42583.39	29.0956	0.322	-9.323	0.0

A P P E N D I X 3

Ball Map Printout for Test

Balls No. 2 and 3

++WRITE POINT,W5358ALL2

* DATA SET W5358ALL2 AT LEVEL 001 AS OF 03/20/73

BALL MAP - BALL #2

(X) 1	(Y) 2	(Z)	TARGET POINT NO	
0.33263	-0.18520	0.03690	1.1	00001
0.29729	-0.26010	0.03910	1.2	00002
0.22105	-0.20250	0.12210	1.3	00003
0.25749	-0.26460	-0.06490	2.1	00004
0.23480	-0.26526	-0.12300	2.2	00005
0.18270	-0.32713	-0.01530	2.3	00006
0.15350	-0.33318	-0.07780	2.4	00007
0.05110	-0.34399	-0.14030	3.1	00008
0.00660	-0.34095	-0.15600	3.2	00009
-0.16850	-0.27370	-0.18590	3.3	00010
-0.21490	-0.23915	-0.19300	3.4	00011
-0.07100	-0.36775	-0.07030	3.5	00012
-0.19400	-0.30206	-0.10840	3.6	00013
0.17660	-0.26774	-0.19430	4.1	00014
0.16900	-0.21710	-0.25482	4.2	00015
0.13410	-0.28415	-0.20470	4.3	00016
0.06710	-0.29787	-0.21770	4.4	00017
0.05920	-0.32960	-0.29029	4.5	00018
-0.07760	-0.23850	-0.27873	5.1	00019
-0.11200	-0.25190	-0.25422	5.2	00020
-0.04600	-0.28100	-0.24402	5.3	00021
-0.01980	-0.30491	-0.21740	5.4	00022
0.30599	-0.18630	-0.09910	6.1	00023
0.35523	-0.07240	-0.09590	6.2	00024
0.29446	-0.19320	-0.12880	6.3	00025
0.33035	-0.07780	-0.15950	6.4	00026
0.25787	-0.20150	-0.18310	6.5	00027
0.30322	-0.08620	-0.20310	6.6	00028
0.08290	-0.36572	0.00220	7.1	00029
0.06040	-0.36969	0.01750	7.2	00030
0.07700	-0.36312	0.05330	7.3	00031
-0.29773	-0.21020	-0.08830	8.1	00032
-0.33413	-0.10240	-0.13600	8.2	00033
.335235	-0.15190	-.0719	8.3	00034
-0.33346	-0.15330	0.07700	8.4	00035
-0.37372	-0.03010	0.00710	8.5	00036
-0.32246	-0.19120	-0.00930	8.6	00037
0.00200	-0.17400	-0.33218	9.1	00038
-0.10620	-0.15790	-0.32313	9.2	00039
-0.10450	-0.08910	-0.34895	9.3	00040
0.09730	-0.15820	-0.32578	10.1	00041
0.19710	-0.07020	-0.31120	10.2	00042
0.12630	-0.07850	-0.34425	10.3	00043
0.06400	-0.11060	-0.35256	10.4	00044
0.17170	-0.01950	-0.33281	10.5	00045
0.28705	0.02090	-0.24040	11.1	00046
				00047

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0.30870	0.10830	-0.18330	11.2	00048
0.27550	0.08330	-0.24030	11.3	00049
0.23900	0.05630	-0.29157	11.4	00050
0.19254	0.14890	-0.23390	11.5	00051
0.36001	0.04080	-0.09670	12.1	00052
0.34227	-0.00590	0.09670	12.2	00053
0.32223	0.09150	-0.09030	12.3	00054
0.26974	0.03610	-0.05110	12.4	00055
0.17700	0.07350	-0.34125	13.1	00056
0.14120	0.14000	-0.31794	13.2	00057
0.07910	0.06250	-0.35716	13.3	00058
-0.01660	0.11720	-0.35583	13.4	00059
0.09850	0.14840	-0.33282	13.5	00060
0.03110	0.16310	-0.33624	13.6	00061
0.22290	0.21318	-0.21330	14.1	00062
0.27243	0.22320	-0.12880	14.2	00063
0.17300	0.26768	-0.19760	14.3	00064
0.21420	0.28044	-0.12670	14.4	00065
0.11900	0.30717	-0.17920	14.5	00066
0.14090	0.32032	-0.11010	14.6	00067
-0.09610	0.10030	-0.35093	15.1	00068
-0.12200	0.05020	-0.35103	15.2	00069
-0.15460	-0.00120	-0.34165	15.3	00070
0.01660	-0.03550	-0.37295	15.4	00071
-0.22300	-0.04690	-0.29782	16.1	00072
-0.29720	-0.05730	-0.22139	16.2	00073
-0.18770	-0.12910	-0.29787	16.3	00074
-0.22070	-0.14450	-0.26653	16.4	00075
-0.25820	-0.16300	-0.21769	16.5	00076
-0.21630	0.05500	-0.30135	17.1	00077
-0.21200	0.13680	-0.27743	17.2	00078
-0.29400	0.05200	-0.22690	17.3	00079
0.02780	0.31225	-0.20590	18.1	00080
-0.03930	0.27307	-0.25400	18.2	00081
-0.12770	0.21780	-0.27727	18.3	00082
0.02050	0.26252	-0.26700	18.4	00083
-0.04500	0.21710	-0.30244	18.5	00084
-0.18790	0.22621	-0.23270	19.1	00085
-0.13250	0.30294	-0.17690	19.2	00086
-0.20680	0.27413	-0.15070	19.3	00087
-0.25650	0.24112	-0.12920	19.4	00088
-0.21180	0.30266	-0.06450	19.5	00089
-0.00950	0.34694	-0.14200	20.1	00090
0.07070	0.35430	-0.10050	20.2	00091
0.01800	0.36812	-0.06920	20.3	00092
-0.33967	0.07110	-0.14210	21.1	00093
-0.31498	0.16020	-0.12550	21.2	00094
-0.36144	0.09270	-0.03730	21.3	00095
-0.33567	0.16560	-0.02290	21.4	00096
-0.23870	-0.28916	0.00600	22.1	00097
-0.21200	-0.30029	0.07420	22.2	00098
0.32092	0.18100	-0.06980	23.1	00099
0.36610	0.01460	0.07990	24.1	00100

0.38724	-0.11330	-0.01250	24.2	00101
0.13910	0.32873	-0.26250	25.1	00102
-0.13670	0.34910	0.00930	26.1	00103
-0.21530	0.29964	0.06700	26.2	00104
-0.24700	0.26640	0.09300	26.3	00105
-0.34692	0.13030	0.05740	27.1	00106
-0.31664	0.19000	0.06530	27.2	00107
0.08400	0.36209	-0.02620	28.1	00108
0.17860	0.32928	-0.03100	28.2	00109
0.23930	0.28647	-0.03600	28.3	00110
0.17940	0.32379	0.06000	28.4	00111
0.31822	0.19840	0.00030	29.1	00112
0.35560	0.11330	0.03660	29.2	00113
0.31463	0.18630	0.08320	29.3	00114
0.13490	-0.32325	0.04410	30.1	00115
0.14460	-0.32250	0.12610	30.2	00116
0.21400	-0.29260	0.09600	30.3	00117
0.27620	-0.27023	0.12820	30.4	00118
-0.12570	0.32852	0.13000	31.1	00119
-0.14440	0.27983	0.20500	31.2	00120
-0.04900	0.26178	0.26400	32.1	00121
0.07200	0.30443	0.20680	32.2	00122
0.24980	0.15591	0.23220	33.1	00123
0.13700	0.23068	0.26200	33.2	00124
0.25240	0.24868	0.12280	33.3	00125
0.15600	0.30104	0.16020	33.4	00126
-0.18650	0.03200	0.32376	34.1	00127
-0.13530	0.13600	0.28980	34.2	00128
-0.29320	0.12930	0.19478	34.3	00129
-0.33122	-0.08430	0.15430	35.1	00130
-0.21740	-0.17600	0.24977	35.2	00131
-0.13480	-0.25161	0.24320	35.3	00132
-0.26280	-0.12000	0.23908	35.4	00133
-0.06820	-0.32701	0.17040	36.1	00134
0.02360	-0.22133	0.30180	36.2	00135
-0.01130	-0.24491	0.14670	36.3	00136
0.07500	-0.23103	0.28570	36.4	00137
0.04630	-0.35388	0.11510	36.5	00138
0.12420	-0.23693	0.26280	36.6	00139
-0.03200	-0.27946	0.24800	36.7	00140
0.10520	-0.30959	0.18360	36.8	00141
-0.04900	-0.05850	0.36715	37.1	00142
-0.12660	0.01070	0.35282	37.2	00143
-0.13270	-0.06500	0.34835	37.3	00144
-0.22630	-0.05550	0.29363	37.4	00145
0.05900	0.23940	0.28254	38.1	00146
-0.00720	0.20720	0.31248	38.2	00147
-0.02700	0.12880	0.35115	38.3	00148
-0.09780	0.12430	0.34001	38.4	00149
0.09470	0.18120	0.31436	38.5	00150
0.01430	0.36794	0.07100	39.1	00151
0.08300	0.34698	0.11550	39.2	00152
-0.01030	0.35926	0.10700	39.3	00153

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  -0.03200   0.26555   0.07730      39.4                              00154
   0.04000   0.11880   0.35343      40.1                              00155
   0.10700   0.12580   0.33668      40.2                              00156
   0.11210   0.02690   0.35684      40.3                              00157
   0.17450  -0.07200   0.32402      40.4                              00158
   0.08900  -0.10540   0.34870      40.5                              00159
   0.34396   0.04290   0.13550      41.1                              00160
   0.34315  -0.08940   0.12200      41.2                              00161
   0.30793   0.11480   0.18080      41.3                              00162
   0.30235   0.05530   0.21200      41.4                              00163
   0.31490  -0.04270   0.19910      41.5                              00164
   0.27197  -0.07180   0.24800      41.6                              00165
   0.22480   0.00200   0.30014      41.7                              00166
   0.18920   0.08870   0.31139      41.8                              00167
   0.26320   0.07820   0.25541      41.9                              00168
   0.23620   0.05650   0.28573      41.1                              00169
  -0.19150  -0.29413   0.14550      42.1                              00170
  -0.23930  -0.26333   0.11840      42.2                              00171
  -0.18290  -0.27009   0.18500      42.3                              00172
  -0.24980  -0.23695   0.14860      42.4                              00173
   0.20347  -0.18410   0.25560      43.1                              00174
   0.27466  -0.11430   0.22830      43.2                              00175
   0.21557  -0.20480   0.22850      43.3                              00176
   0.30110  -0.13780   0.17600      43.4                              00177
   0.23030  -0.22890   0.18760      43.5                            1 00178
***** ABOVE ACTION SATISFACTORILY COMPLETED *****
```

++WRITE POINT,W535BALL3

* DATA SET W535BALL3 AT LEVEL 002 AS OF 06/11/73

X 1	Y 2	Z	TARGET POINT NO.
-0.36604	-0.07900	0.02000	1.1
-0.34355	-0.14900	-0.02000	1.2
-0.35328	-0.05500	-0.07500	1.3
-0.31104	-0.19400	0.07900	2.1
-0.33295	-0.15400	0.04500	2.2
-0.31548	-0.12700	0.15900	2.3
-0.34666	-0.08500	0.11500	2.4
-0.36364	-0.01200	0.06200	3.1
-0.36576	-0.08000	0.02100	3.2
-0.36828	0.03000	-0.06400	3.3
-0.35870	0.07000	-0.08400	3.4
-0.36535	0.07900	0.02000	3.5
-0.36269	0.08400	-0.04500	3.6
-0.34476	-0.08300	-0.12200	4.1
-0.31896	-0.11100	-0.16300	4.3
-0.29940	-0.12200	-0.19000	4.4
-0.28655	-0.20400	-0.13000	4.5
-0.28986	-0.23400	-0.04300	5.1
-0.27752	-0.24700	0.05100	5.2
-0.23600	-0.28728	-0.04900	5.3
-0.19200	-0.31789	-0.05200	5.4
-0.21300	-0.30012	0.07200	6.1
-0.27139	-0.21700	0.14100	6.2

BALL MAP - BALL #3

00001
00002
00003
00004
00005
00006
00007
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00009
00010
00011
00012
00013
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00021
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00023
00024

-0.13600	-0.31021	0.09803	6.3	00025
-0.24129	-0.22600	0.17700	6.4	00026
-0.15400	-0.31624	0.13000	6.5	00027
-0.10500	-0.29593	0.20500	6.6	00028
-0.27023	-0.15600	0.20800	7.1	00029
-0.25437	-0.12800	0.24400	7.2	00030
-0.26746	-0.08700	0.24800	7.3	00031
-0.32347	-0.05000	0.18300	8.1	00032
-0.34768	-0.01200	0.14000	8.2	00033
-0.32532	-0.01400	0.18600	8.3	00034
-0.29161	0.01900	0.23500	8.4	00035
-0.31377	0.05500	0.18800	8.5	00036
-0.34449	0.07700	0.12100	9.1	00037
-0.31425	0.16200	0.12500	9.2	00038
-0.33068	0.16600	0.06100	9.3	00039
-0.33955	0.15900	0.00700	10.1	00040
-0.34282	0.12600	-0.08500	10.2	00041
-0.31936	0.13900	-0.05400	10.3	00042
-0.27166	0.23000	-0.11900	10.4	00043
-0.28519	0.21300	-0.11900	10.5	00044
-0.33795	0.08900	-0.13600	11.1	00045
-0.34064	0.01600	-0.15600	11.2	00046
-0.32157	0.06400	-0.18200	11.3	00047
-0.29417	0.11700	-0.20100	11.4	00048
-0.30163	0.04100	-0.21900	11.5	00049
-0.29477	-0.03600	-0.22900	12.1	00050
-0.27236	-0.09900	-0.23800	12.2	00051
-0.23300	-0.07000	-0.26824	12.3	00052
-0.23600	-0.09500	-0.27551	12.4	00053
-0.26054	-0.16800	-0.21100	13.1	00054
-0.24231	-0.22800	-0.17300	13.2	00055
-0.21000	-0.18100	-0.25252	13.3	00056
-0.20100	-0.21400	-0.23330	13.4	00057
-0.19300	-0.24173	-0.21200	13.5	00058
-0.19000	-0.27500	-0.17000	14.1	00059
-0.18500	-0.30636	-0.11200	14.2	00060
-0.14600	-0.29105	-0.18600	14.3	00061
-0.14100	-0.32498	-0.12300	14.4	00062
-0.09900	-0.31373	-0.18000	14.5	00063
-0.09700	-0.33733	-0.13200	14.6	00064
-0.13500	-0.34551	-0.05500	15.1	00065
-0.14300	-0.34666	0.00200	15.2	00066
-0.14600	-0.34100	0.05500	15.3	00067
-0.04400	-0.37202	0.01700	15.4	00068
-0.08600	-0.34366	0.12300	16.1	00069
-0.12300	-0.30211	0.18500	16.2	00070
-0.00900	-0.33464	0.16900	16.3	00071
-0.03100	-0.31378	0.20300	16.4	00072
-0.05300	-0.29140	0.23000	16.5	00073
-0.11100	-0.25941	0.24700	17.1	00074
-0.19000	-0.18700	0.26373	17.2	00075
-0.10900	-0.19200	0.30312	17.3	00076
-0.15800	-0.14300	0.30856	18.1	00077

-0.20400	-0.05600	0.30963	18.2	00078
-0.23300	0.01800	0.29328	18.3	00079
-0.17200	-0.04900	0.34747	18.4	00080
-0.17100	0.00600	0.33369	18.5	00081
-0.24400	0.07700	0.25400	19.1	00082
-0.28400	0.13800	0.19900	19.2	00083
-0.24400	0.12900	0.25232	19.3	00084
-0.20900	0.17800	0.28383	19.4	00085
-0.21900	0.18300	0.24326	19.5	00086
-0.29031	0.19500	0.15500	20.1	00087
-0.28026	0.23300	0.09400	20.2	00088
-0.24300	0.26010	0.11800	20.3	00089
-0.21100	0.30374	0.06200	21.1	00090
-0.23000	0.29456	-0.03100	21.2	00091
-0.13500	0.34839	0.03200	21.3	00092
-0.15400	0.33713	-0.05700	21.4	00093
-0.18600	0.26587	-0.18800	22.1	00094
-0.16900	0.20000	-0.26945	22.2	00095
-0.10400	-0.10200	-0.24555	23.1	00096
-0.21900	0.09600	-0.28887	24.1	00097
-0.03200	-0.25600	-0.27215	25.1	00098
-0.01300	-0.34614	-0.14300	26.1	00099
0.09000	-0.34785	-0.11500	26.2	00100
0.13900	-0.33619	-0.09100	26.3	00101
0.04300	-0.37188	0.02200	27.1	00102
0.07600	-0.36535	0.03700	27.2	00103
0.11400	-0.32377	0.15100	27.3	00104
0.04400	-0.30194	0.21800	28.1	00105
0.00400	-0.25900	0.27116	28.2	00106
-0.04500	-0.20000	0.31401	28.3	00107
0.09900	-0.20200	0.30003	28.4	00108
-0.05900	0.16600	0.33104	29.1	00109
-0.14600	0.23700	0.25128	29.2	00110
-0.02600	0.22800	0.29659	29.3	00111
-0.01900	-0.05500	0.37046	30.1	00112
0.04600	0.01600	0.37182	30.3	00113
0.08800	0.06800	0.35913	30.4	00114
-0.07100	0.34374	0.13200	31.1	00115
0.04100	0.34745	0.13500	31.2	00116
-0.11000	0.34623	-0.09300	32.1	00117
0.04700	0.35997	-0.09400	32.2	00118
-0.05900	0.20700	-0.30707	34.1	00119
0.06600	0.21100	-0.30290	34.2	00120
0.02200	0.14000	-0.34719	35.1	00121
0.05500	0.0	-0.37094	35.2	00122
0.09600	-0.06500	-0.35663	35.3	00123
0.17600	0.13000	-0.30455	36.1	00124
0.23400	-0.06900	-0.28479	36.2	00125
0.24096	0.15800	0.24000	36.3	00126
0.30067	-0.05600	-0.21700	36.4	00127
0.29123	0.18000	-0.15300	36.5	00128
0.35055	-0.02900	-0.13000	36.6	00129
0.09100	-0.26616	-0.24800	37.1	00130

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   0.14300  -0.18900  -0.28758      37.2                                  00131
   0.15700  -0.24930  -0.23200      37.3                                  00132
   0.20600  -0.23347  -0.20900      37.4                                  00133
   0.27649  -0.21500  -0.13400      38.1                                  00134
   0.32035  -0.18200  -0.06700      38.2                                  00135
   0.28326  -0.23700   0.02800      38.3                                  00136
   0.33173  -0.15600   0.07900      38.4                                  00137
   0.19900  -0.21200   0.23681      39.1                                  00138
   0.26864  -0.18700   0.18300      39.3                                  00139
   0.13000  -0.04100   0.34935      40.1                                  00140
   0.10500   0.00600   0.35995      40.2                                  00141
   0.18400   0.04300   0.32391      40.3                                  00142
   0.17100   0.12400   0.30985      40.4                                  00143
   0.23000   0.12800   0.26710      40.5                                  00144
   0.16600   0.32824   0.07300      42.1                                  00145
   0.17700   0.31479  -0.10100      42.2                                  00146
   0.24500   0.26754   0.09500      42.3                                  00147
   0.28573   0.23400  -0.06500      42.4                                  00148
   0.33339   0.16300   0.05400      43.1                                  00149
   0.32877   0.12400   0.13100      43.3                                  00150
   0.36156   0.01000   0.09900      43.4                                  00151
   0.31661   0.09700   0.17600      43.5                                  00152
   0.27080   0.02700   0.25800      43.6                                  00153
   0.05300   0.27714   0.24700      44.1                                  00154
   0.12500   0.24400   0.25586      44.2                                  00155
   0.18500   0.20400   0.25453      44.3                                1 00156
***** ABOVE ACTION SATISFACTORILY COMPLETED *****
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