U.S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 77-103-474

OCCIDENTAL CHEMICAL COMPANY
LATHROP, CALIFORNIA

MARCH 1978

I. TOXICITY DETERMINATION

Based on a series of medical evaluations conducted at Occidental Chemical Company in July 1977 the following conclusions are reported:

A) Employees in the Ag-Chem area at the time of the study were judged to be exposed to toxic concentrations of dibromo chloropropane (DPCP).

B) Workers who had an occupational history that included exposure to DBCP were more likely to have abnormalities of sperm counts than controls.

C) Testicular biopsies done in ten individuals as well as cumulative DBCP exposure history indicate a dose-response type situation. Those workers who were exposed the longest were more likely to have reduced or zero sperm counts.

These conclusions as well as other results contained in the report are a result of numerous medical and biological tests. Data obtained from DOW and Shell Companies served to substantiate results at Oxy-Chem and were instrumental in indentifying DBCP as the causative agent.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this determination report are currently available upon request from NIOSH, Division of Technical Services; Information and Dissemination Section; 4676 Columbia Parkway; Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS); Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

a) Occidental Chemical Company

b) Authorized representative of employees

c) U.S. Department of Labor, Region IX

d) NIOSH Region IX

For the purpose of informing the approximately 200-300 employees, the employer shall promptly post for a period of 30 calendar days the determination report in a prominent place(s) near where exposed employees work.

III. INTRODUCTION

In late June and early July 1977 the Oil, Chemical, and Atomic Workers Union (OCAW), Local 1-5 asked seven male employees of the Occidental Chemical Company's Agricultural Chemical Division (ACD) to volunteer for sperm analysis. The reason for such an unprecedented action was the persistence of an unfounded suspicion that the men in this area of the plant were infertile. The results of these sperm counts were sent to Dr. Donald Whorton, University of California, who had functioned as a consultant to the Union in the past (the laboratory would only release the results to a physician). By the middle of July, Dr. Whorton had received seven sperm count reports, all of which were abnormal. Dr. Whorton informed the Secretary-Treasurer of the OCAW local of the abnormal results and requested an opportunity to meet with the men. On July 19 Dr. Whorton participated in a joint meeting with the management of Occidental Chemical and the Union. At that meeting Dr. Whorton stated that he wished to talk with the men and to re-test them. This was agreed upon. Later in the afternoon Dr. Whorton met with six of the seven men, five of whom were requested to submit to re-testing. The sixth man was omitted because of a prior vasectomy. Arrangements were made for the men to be re-examined on July 22, 1977 in Berkeley, California. Each man was requested to refrain from further ejaculations until after the examination. Dr. Whorton had a later meeting with both the Union and the management on the evening of the 19th to reconfirm the procedures.

On July 22 the five men came to Dr. Whorton's office in Berkeley, California for the re-examination. Each had been given a medical history questionnaire to complete prior to the examination. On arrival at the office each was given a specimen container and each provided a semen specimen. The specimens were immediately taken to the laboratory at Alta Bates Hospital for analysis. Also while at the hospital blood samples were taken for complete blood count with differential, SMA 12, T3 resin uptake, T4, serum testosterone, follicle stimulating hormone (FSH), and luteinizing hormone (LH). A urine specimen for routine urinalysis was also obtained. The men returned to Dr. Whorton's office and each reviewed his medical questionnaire with Dr. Whorton. Dr. Whorton also asked a series of specific questions relating to the genitourinary system. He then performed a complete physical on each individual. Late in the afternoon of the 22nd Dr. Whorton received the results of the semen analyses from the laboratory. Again, all results were decidedly abnormal; most men were azoospermic, the remainder severely oligospermic. Each man was informed of the results of his sperm count.

Dr. Whorton then informed the Union and the Company of the results. On July 23, 1977 he met again with the Union and Company representatives to determine other individuals to be tested. A list of all current ACD workers, mechanics assigned to the ACD area, clerical personnel assigned to the ACD, and the laboratory personnel who work with various ACD products was assembled. In addition, several former ACD employees who still worked for Occidental were included. In total, 36 individuals in addition to the original five were examined during the next two weeks. Each received a similar medical examination and underwent similar laboratory testing as the original five. The only exceptions were the vasectomized males who, of course, were not requested to give a sperm sample. The females were not tested for serum testosterone.

Of the 41 workers examined three were women, eleven were men with previous vasectomies, and twenty-seven were men who were able to provide a semen specimen.

None of the three women experienced abnormal menstrual cycles and all had previously borne children. None of the men had loss of libido, difficulty with erection or ejaculation, loss or altered distribution of facial or body hair, evidence of testicular atrophy or epididymal abnormalities, evidence of gynecomastia, or abnormalities of the prostrate. Three had varicoceles, but all three had previously fathered children. Seven of the 36 had never fathered children. Some of the production workers complained of experiencing occasional symptoms such as mild headaches, nausea, light headedness, and weakness when formulating some organophosphorous pesticides. Symptoms due to irritation of the upper respiratory tract were also mentioned by some as being associated with their work in the manufacture of certain thiocarbamate compounds.

No other important information was brought to light by the history of the physical examination of any of the workers. Laboratory studies revealed no hepatic, renal, hematopoietic, or thyroid abnormalities, other than a few which were consistent with previous medical problems.

Of major note, however, was the relationship between duration of exposure to dibromochloropropane (DBCP) and sperm counts and levels of LH and FSH. Early in the investigation it became apparent that men who had worked in the ACD for three or more years were likely to have decidedly depressed sperm count. Equally apparent was the suggestion that men who had been employed in the ACD for only a very few months appeared to have relatively normal sperm counts. In order to examine the relationship between exposure duration and sperm counts, three women, eleven men with vasectomies, two former employees of ACD, and three men with sperm counts greater than ten million but less than 40 million were excluded from the original group of 41. Remaining were eleven men with indisputably depressed sperm counts (one million or less) and 11 men with sperm counts many consider to be within the normal range. (greater than 40 million/ml). These two groups were then compared by age, time worked in ACD, and serum LH, FSH, and testosterone levels. Table 1 shows this comparison. Here it can be seen clearly that the mean is significantly higher in Group A (severely affected), a finding consistent with the presence of oligospermia in these individuals. The FSH levels in Group B (the normal sperm group) are in a range comparable with those in a larger unexposed population from other studies.

Group A also had a higher mean LH level. It is possible that this also represents a response to testicular damage, although serum testosterone levels are similar in the two groups, thus the stimulus for the increase in LH is not known.

The two women workers not currently using oral contraceptives have normal FSH and LH results.

A most striking aspect of the data was the between group relationship of exposure time and response. In group B, mean exposure time was only a few months while mean exposure time in group A was 3 years. Although the paucity of intermediate data points is regrettable, it is worthy to note that the three men with sperm counts greater than 10 million but less than 40 million had exposure times approximating one year.

IV. HEALTH HAZARD EVALUATION

In late July of 1977 both the Union and the Company requested NIOSH to perform a Health Hazard Evaluation on the remaining workers in the plant. NIOSH contracted with Dr. Whorton for this study. Dr. Whorton sub-contracted with Dr. Thomas H. Milby of Environmental Health Associates, Berkeley, and Dr. Ronald Krauss of Alta Bates Hospital. Berkeley, for assistance in this study.

A. Rationale

After analysis of the results of the first forty-one examinations, the need to address four major questions in the subsequent Health Hazard Evaluation became apparent:

1) Did the infertility problem extend beyond the ACD to involve other male employees;
2) What was the extent of the infertility problem in former male employees of the ACD;
3) Is there a hormonal assay available that is equally effective as a sperm count for identifying affected individuals; and
4) Although DBCP was considered to be the most likely causal agent, could one or more other chemical agents also be involved.

In order to answer these questions a rationale for the approach to the medical evaluations of the remaining employees was formulated. Two major decisions were involved. First, to which employees should the examination be offered. Some consideration was given to examining only a sample of the Occidental Chemical Company plant population, and a diagram (Figure 1) was prepared to aid in the sample selection process. However, this notion was abandoned in favor of offering the examination to the entire employee population. This approach was chosen because it was felt that any employee who wished to be examined should be given the opportunity.

The second decision addressed the content of the Health Hazard Evaluation Medical Examination. Careful assessment of the data from the first forty-one examinations made it clear that there would be little gained by exhaustive medical workup on each of the subsequent participants. Accordingly, an abbreviated medical history form and physical examination strategy were devised. The questionnaire focused on the reproductive system, especially reproductive history. Medical evaluation was largely confined to the genitourinary system and laboratory work was limited to sperm counts and evaluation of certain hormonal levels that appeared to hold promise as indicators of effect.

B. Methods

A NIOSH trailer was brought to the plant site and all examinations were conducted therein. The employees were informed by both the Union and the Management about the study and were urged to participate. The transmittal of information was accomplished by both the Union shop stewards and the Plant Foreman. Patients were scheduled for the examination and collection of sperm and blood samples by the company nurse. She distributed specimen containers along with semen collection instruction sheets written by the authors. All sperm specimens were obtained at home immediately prior to coming to work. Employees were requested to utilize masturbation for collection, however coitus interruptus was also acceptable. The blood for determination of the endocrine levels was obtained in the early morning hours prior to 9:00 a.m. All specimens were sent to the clinical and endocrine laboratories at Alta Bates Hospital, Berkeley, California, within two hours of collection. Sperm counts were done daily. The serum for determination of endocrine levels was promptly prepared by the laboratory and frozen for later batch running. Employees of certain work areas (Best products, ACD, field applicators, and distributors) also had blood drawn for SMA 12 analysis at the request and expense of the company.

All patients were seen either by Dr. Donald Whorton or Dr. Tom Wilcox (the participating NIOSH physician). Both physicians completed the history form for each individual by recording the patient's verbal response to oral questions. Physical examinations were also done according to a standardized format.

A major, never well-resolved problem was estimation of individual exposure to DBCP. For data analysis purposes exposure was coded two ways, both qualitative. The first of these qualitative exposure estimates was based upon simply whether the participant had ever worked in the ACD. A somewhat more refined, though yet qualitative estimate of exposure was devised later in the study when it was realized that exposure to the chemical DBCP could have occurred in the past in several areas in the plant in addition to the ACD, notably the pellet plant where DBCP was formulated for a brief period with fertilizers. Applicators, set-up men, and demonstrators constituted another group not originally classified as exposed.

Late in the study, a semi-quantitative estimate of exposure was devised. Each employee was questioned about his exposure to DBCP. Time in ACD was considered de facto exposure. The total time of exposure was estimated by months worked in ACD, pellet plant, application, etc. This information was then coded and reduced. The data were grouped according to the time of exposure in groups large enough to be statistically useful. In some individuals in whom the fact of exposure was known, no reasonable quantification could be determined. These employees were placed into a group of unquantifiable exposure.

The various biostatistical strategies applied to the analysis of data gathered from medical histories, physical examinations, laboratory testing, and job classification included simple descriptive presentation of distributions of results by age and exposure categories, calculation of Pearson correlation coefficients, one-way analysis of variance, stepwise multiple regression, and discriminant function analysis.

Production records of formulated products by the ACD from 1968 to July 1977 were combined with the composition information for each product (in terms of technical materials by weight) to determine monthly amounts of technical materials processed by the ACD.

Finally, in an effort to reach employees who chose not to participate in the study, a questionnaire was prepared and distributed by a foreman. The unsigned questionnaires were then returned to a collection box in sealed envelopes.

V. Results

1. The Study Population

The entire population at risk was 310 individuals. Two-hundred sixty-one were hourly plant employees; fifteen individuals were employed as applicators, set-up men, or tractor drivers, and the remainder were salaried employees. One-hundred ninety-six male workers were examined, including the 38 who were originally examined prior to HHE-supported investigation. Five women workers were examined; three prior to the HHE and two included in the HHE-supported evaluation. In addition, two neighboring dairy farmers were examined at their request. Thus a total of 203 individuals were examined and evaluated. This report will focus on the 196 male workers, since no effects of exposure were found in the five women employees. One-hundred twelve workers were not seen; however, 62 of them were reached by questionnaire. The nonparticipants will be discussed later in this report.

Table 2 provides the number and percentage of hourly employees by work area who participated in the examination, the number who responded to the questionnaire, plus the number and percentage of nonparticipants who neither appeared for examination nor completed the questionnaire. Table 3 shows the number of nonvasectomized and vasectomized men by exposure group.

2. The Work Areas

The various work areas within the plant were the warehouse, the ammonia plant, the fertilizer plant, the

Agricultural Chemical Division plant, Best products, pellet plant, and the phosphate plant. Another large group of employees was comprised of maintenance men who generally tended to work all over the plant. The remaining workers were classified as clerical.

The warehouse was a general operation that usually did not involve handling of products from the ACD plant. The ammonia, fertilizer, pellet, and phosphate plants were related in that they made ammonia-phosphate-type fertilizers. The ACD plant produced agricultural chemicals for use by commercial farms. The Best products produced insecticides and chemicals for household or consumer use. The maintenance employees, sub-divided into many smaller crafts or trades, were employed throughout the plant, frequently rotating in and out of particular areas. Some maintenance employees were assigned to specific areas. This was true in the ACD plant. Other maintenance workers were assigned to specific repair shops and only infrequently visited the plant area. The clerical workers included in the study were those primarily from the ACD plant or adjacent areas.

The applicators were employees who worked for Occidental Chemical Company but were responsible for demonstration, set-up operations, or actual application of chemicals for farmers.

Table 4 is the distribution of the participants by work area and age group.

3. Production Records

Tables 5 A through F summarize the amount of technical material used per quarter from 1969 to 1977 for selected chemicals. DBCP, epichlorohydrin, ethylene dibromide, and carbaryl were included because of the possibility that exposure may be associated with adverse reproductive effects. Toxaphene and methyl parathion were added as examples of commonly used chemicals. Other heavily used chemicals included Diazinon, Dinoseb, Endosulfan, Malathion, Maneb. Parathion, and Zineb. Other chemicals were not consistently used during the time period or were used infrequently.

The Table 5A shows that 1, 2-dibromo-3-chloropropane was extensively used throughout the entire period. Information from both individual workers and company officials indicated that in the early 1960's DBCP was used in the pellet plant for impregnation into pellet fertilizers. This process operated for two or three years and has not been utilized since. No production data were available on the amount of DBCP used prior to mid-1968.

4. Estimation of Exposure

Initially, the assumption was made that anyone who worked in the ACD plant was exposed to DBCP. Based on this assumption, there were 135 ACD or former ACD workers and 61 individuals who never worked in the ACD plant. However, further refinement of this exposure index was necessary since DBCP had been used in the pellet plant and was also used by the applicators. By this refinement, 154 individuals were exposed to DBCP; 42 were not. For individuals who were currently working in ACD, exposure duration could be calculated. However, for most individuals--for example mechanics --who were periodically in and out of ACD, this exposure tabulation was more difficult. Because of the paucity of reliable records prior to 1976, the investigators were forced to rely upon individual memories to estimate length of exposure. The exposures were added in a cumulative manner in order to provide a sum by months or years. Finally, there were some exposed workers for whom no measure of time could be determined and they were thus placed in the category of unquantifiable exposure.

Personal communications from Dr. Stephen Rappaport and Dr. Robert Spear, industrial hygiene consultants from University of California, Berkeley have shown that in April and July of 1977 eight-hour time-weighted exposure to DBCP in the ACD plant was less than 0.4 ppm.

5. Sperm Counts

As discussed earlier in this report, it appears that the best indicator of response to DBCP exposure in our population is the sperm count. Accordingly, a number of statistical manipulations, both descriptive and analytical, were carried out on our sperm count data. Of special interest, of course, are the relationships, if any, between sperm counts, exposure, age, work area, and hormone levels.

a. Sperm Count vs. Exposure

The original study, discussed earlier in this report found a clear relationship between exposure time and sperm count, at least in two exposure groups (less than 3 months and more than 3 years). In these data, a wide gap containing only three data points existed between the two groups. Table 6 is an attempt to show the relationship between azoospermia and oligospermia (less than 40 million), and normospermia (40 million or greater) by exposure duration utilizing additional data obtained in the HHE. In this comparison, vasectomized men are excluded. A clear increase in the prevalence of oligospermia with increasing exposure is evident from this table. This association is especially striking after 43 months of exposure. Other ways of looking at sperm count and exposure are seen in Tables 7 , 8 , and 9 and Figures 2, 3, and 4.

Figures 2 and 3 show cumulative distribution of sperm count by exposure. Figure 2 is cumulative distribution of sperm counts for two groups: once employed in ACD and never employed in ACD. The median sperm count for once in ACD was 45×10^6/ml, while the median sperm count for never in ACD was 73.3×10^6/ml. Figure 3 is cumulative percentage distribution for sperm count for two groups; exposed to DBCP or never exposed to DBCP. The median sperm count for those with history of exposure to DBCP was 45.6×10^6/ml while for the non-exposed group the median sperm count was 78.7×10^6/ml. The exposure category in Figure 3 is considered by us to be more accurate than that in Figure 2 since the category "never been employed in ACD" includes some individuals exposed to DBCP elsewhere. The reason for use of the median sperm count in Figures 2 and 3 is that the median is a better statistical tool in this situation because of the extremes in the data. These extremes are best shown in Tables 8 and 9. In Table 9 for example, in the age group of 30-39, the mean sperm count is 57.6×10^6/ml, the standard deviation is 59.2×10^6/ml, the minimum sperm count is 0, and the maximum is 232×10^6/ml. An even more extreme example is seen in the 40-49 age group: a minimum of zero and a maximum of 358×10^6/ml, a mean of 90.1×10^6/ml, and a standard deviation of 126.2×10^6/ml. This problem is also seen in Table 8.

Table 7 is the cross-tabulation by grouping of sperm counts by 10 million in the exposed and nonexposed groups. This data is represented in Figure 4, a bar graph. There is a marked difference in distribution as the exposed group has a marked predominance of sperm count below 40 million, while the nonexposed group the predominance is above 40 million.

Although analysis of sperm count by place of work provided little useful information, worthy of note is the fact that 9 of 14 applicators had sperm counts less than 40 million.

b. <u>Sperm Count by Age</u>

Because of the possibility that age and sperm count are associated, we examined age vs. sperm count in both exposed and nonexposed employees. Table 10 is a comparison of sperm count by age. The sperm counts are divided into groups of ten million. All above 120 million are grouped together. The zero sperm counts were also grouped together in a single category. The reason for selecting these group-intervals will be discussed later in this report. Figure 5 is a scattergram which demonstrates that there is no significant relationship between sperm count and age. Figures 6 and 7 are scattergrams for the 35 nonexposed and 107 exposed employees by sperm count and age. Again, there appears to be no significant association between sperm count and age.

6. Serum Hormone Levels

The initial study of 38 male ACD employees suggested that serum levels of FSH, LH, and/or testosterone might hold promise as valid indicators of DBCP induced sperm count depression. Because of the nontrivial problems involved with collection of semen and interpretation of sperm counts, and also because of surprisingly large and probably increasing prevalence of men with vasectomies, the value of a reliable serum indicator of testicular function would be considerable. Accordingly, we spent a good deal of effort in examining the relationship between levels of these three hormones and age, exposure, and sperm count.

Serum hormone assays for FSH, LH, and testosterone were done on all medically examined participants. The results were categorized into four groups, vasectomized and nonvasectomized by nonexposed and exposed status. The data were analyzed for age relationship. In the nonvasectomized exposed group, nine individuals who had not provided sperm samples were included. In the case of two individuals with sperm counts, the results of the hormone assays were excluded for technical reasons.

a. FSH Values

Tables 11 and 12 show the mean, standard error, and range of FSH levels by 10-year age groups in 35 men never exposed to DBCP and 114 men exposed at one time or another to DBCP. Figures 8 and 9 are scattergrams of the same data. There is a significant increase in FSH with age in both groups.

Tables 13 and 14 show the mean, standard error, and range of LH levels by 10-year age group in 35 men never exposed to DBCP and 114 men exposed to DBCP. Figures 10 and 11 are scattergrams of the same data. There is significant increase in LH with age in the exposed group but not in the unexposed group.

Tables 15 and 16 show the mean, standard error, and testosterone levels by 10-year age group in 35 men never exposed to DBCP and 114 men exposed to DBCP. Figures 12 and 13 are scattergrams of the same data. There is a significant decrease in testosterone with age in the exposed group, but not in the unexposed group.

Comparison of sperm counts and FSH assays were done for both the exposed and nonexposed groups. Table 17 shows the mean FSH value by grouped sperm count values for the nonexposed workers. Table 18 is a different grouping of the data in Table 17. Group 1 includes from zero to 29 million sperm per ml. Mean FSH values in Group 1 are much higher than the means of the other three groups. Table 19 is a comparison of group sperm count and FSH values for exposed workers. Table 20 is a condensation of Table 19 in that Group 6 now encompasses sperm counts from 50-99 million, and Group 7, 100 million and above. The most striking observation is the difference in Group 0 from all other groups.

b. LH Values

LH values and group sperm count data were compared for both the nonexposed and exposed populations. Table 21 shows the mean LH values by sperm count group among nonexposed individuals. Table 22 is a condensation of Table 21 similar to that described above for the FSH values. There are no apparent differences in LH among these groups. Table 23 shows the mean LH values by sperm count group for the exposed individuals. Table 24 is a condensation of Table 23. There is a very striking difference between Group 0 (azoospermic) and the other groups.

c. Testosterone

Serum testosterone values were compared to grouped sperm counts for both the nonexposed and exposed populations. Table 25 is a comparison of the mean testosterone levels by grouped sperm counts for the nonexposed population. Table 26 is a condensation of Table 25. There appear to be no important differences among any of the groups. Table 27 is the mean testosterone level by sperm group for the exposed population. Table 28 is a condensation of Table 27. Again, there appear to be no important differences among the groups.

d. Comment on Statistical Interrelationships Between Observed Sperm Counts and Hormone Levels

One of the variables of principal interest in this investigation was sperm count. It is illuminating to examine how sperm count is related to the many physiological measures for which data were collected. The mode of statistical analysis known as multiple regression provides a means of examining and understanding the complex dependency of a response, or dependent variable (i.e. sperm count) on a set of stimulous variables (i.e. endocrine levels and SMA 12 measures). Specifically, it is important to know if sperm count can be predicted on the basis of knowledge of a set of one or more physiological measures.

Thirty-five men who had provided both semen and blood samples had never been exposed to DBCP. There were 116 non-vasectomized men who had been exposed to DBCP but this group was reduced to 90 for this analysis because of missing data or unquantifiable levels of exposure to DBCP. Number of months exposed to DBCP was ascertained by the examining physicians and this variable was included in the analysis of this group.

Stepwise multiple regressions were performed separately for both exposed and nonexposed groups. The endocrine variables LH, testosterone, and FSH were considered together with age as independent variables for the unexposed group, and the effects of these variables on sperm count were examined.

None of the variables were found to be individually significantly related to sperm count at p = .05. Not surprisingly, the summary table of the stepwise regression demonstrates that no linear combination of these variables was found to be significantly related to sperm count at p = .01.

The matrix of correlation coefficients for the exposed group is provided in Table 29. Some unusually large observed associations are noteworthy; sperm count is inversely related to exposure, LH and FSH at p = .01. Exposure is the likely causal factor in the observed associations between sperm and LH and FSH since it is also highly correlated with these variables at p = .01. LH and FSH are themselves highly correlated and account for the largest observed association, r = .63376. Table 30 is the same correlation for the nonexposed.

Indeed, the summary table of the stepwise regression of all of the independent variables on sperm count indicates that exposure is the overwhelmingly best predictor of sperm count. The variables LH and FSH contribute very little to the prediction of sperm count once exposure is included in the regression equation. The exposure variable itself accounts for 14.7 percent of the total variation. Including all the variables in the regression equation accounts for 27.2 percent of the total variation. The overall F statistics at each step of the regression are significant at p = .01.

The advantages of using blood samples as opposed to semen samples for screening exposed populations for affected individuals are well recognized. Various discriminant analyses were performed to evaluate the predictive values of the various hormone tests. Tables 31-35 provide the ultimate classifications of the sample arising from the application of the derived discriminant functions to the sample data. Oligospermia was defined differently in each of these tables. Classification by individual discriminant functions was best when oligospermia was defined as less than 20×10^6 sperm/ml. (This result is perhaps attributable to the relative contribution of azoospermics being greater when oligospermia is thusly defined).

Tables 36-39 show the results of the predictive values of LH and FSH individually. FSH is the single most sensitive predictor for having the fewest false positives, but use of either FSH or LH results in a large percent of false negatives. Approximately one-half of the true positives are identified by either FSH or LH, but use of LH results in a large number of false positives.

In summary, the FSH either alone or with LH could be used as a screening tool for populations in which sperm samples are unobtainable. However, according to the data of this study, a large percentage of false negatives would occur using either of these indicators. Use of FSH is preferable on the basis of indications that fewer false positives will occur.

7. SMA 12 Results

Complete Serum Multiphasic Analysis (SMA)-12 data was collected on 64 men, 18 of whom were vasectomized. Semen samples were obtained and sperm counts were done on the remaining 46 men. A stepwise multiple regression was performed to ascertain if a linear combination of SMA 12 values and age could be useful in predicting an individual's sperm count.

Prior to the actual regression calculations a matrix consisting of pairwise Pearson correlation coefficients is calculated for all the regression variables and this matrix is given in Table 40. All pairwise correlations presented in this table are based on 46 men. One may observe that although many of the SMA 12 variables are inter-correlated, only calcium is significantly related to sperm count and this association is significant only at p=.05 and not at p=.01. The largest observed correlation exists between calcium and albumin, r=.65712. Cholesterol is highly related to glucose, total protein and LDH, r=.64719, r=.57802 and r=.55185 respectively. Age is not significantly related to any of the variables at p=.01 for this data.

Table 41 provides a summary of the stepwise regression for assessing the dependency of sperm count on the SMA 12 variables and age. One can see from this table that only calcium contributes significantly (at p = .05) to the prediction of sperm count in the presence of all variables. The percent of the total variation in sperm counts explained by calcium alone is 9.375%. Including the seven most important variables in the regression equation raises this percent of variation explained to 31.391%. (see R square column of Table 41). However, although the overall regression remains statistically significant the inclusion of additional variables into the regression equation after calcium does not contribute significantly in reducing the unexplained variation.

Table 42 is a summary of the SMA 12 means by area of work.

8. Questionnaire to Nonparticipants

An assessment of nonparticipants was done by questionnaires. Each worker who had not appeared for a medical examination received a multiple-choice questionnaire and an envelope to ensure anonymity. Sixty-two of the original 112 nonparticipants responded to the questionnaire. Table 43 shows the distribution of the reasons for nonparticipation for those reporting. Table 44 shows the amount of work experience in ACD. It is interesting to note that the majority of the employees were either not interested, had vasectomies, or had sterile wives. Only a small minority did not want to give a semen specimen. Only one individual cited religious reasons for nonparticipation. The majority either had not worked in ACD or had worked there for less than one year. Table 2 shows the total production workers, the number of participants, the number of respondents to the questionnaire, and the number who did not respond to the questionnaire by area of the plant. Eighty percent of all production workers were either examined or responded to the questionnaire. Response by the acid plant workers was very poor; however, the response was much better in the other sections of the plant. During the medical examination, each worker was questioned about current birth control measures. Table 45 shows the results of the responses. The largest two groups either used no birth control measures or the husband had previously had a vasectomy. Thirteen percent of the respondents reported that oral contraceptives were used by their spouse.

VI. Summary and Discussion

The extent of the infertility problem at the Occidental Chemical Company's Lathrop plant can be summarized as follows: 13.1 percent of the exposed, nonvasectomized group were azoospermic, 16.8 percent were definitely oligospermic, and 15.8 percent were mildly oligospermic (20-39 million sperm per ml of seminal fluid). Of the 142 men examined who provided semen specimens, 75.4 percent were eventually classified as exposed. One can assume from the responses of the nonparticipating group that the majority of the exposed individuals were seen.

During the investigation, individuals from areas other than ACD were found to have been exposed at one time or another to DBCP. In the early 1960's the company impregnated fertilizer pellets with DBCP. Some of the individuals who worked in this area were found to be severely affected. Also, a high percentage of the applicators, demonstrators, or set-up men were found to be affected.

The likelihood of a causal relationship between DBCP exposure and the observed infertility is great, especially if one considers the other studies reported from Dow and Shell. Examination of Occidental Chemical Company's production records alone would not have allowed the authors to conclude that DBCP was the sole etiological agent.

FSH, LH, and testosterone assays were done in an attempt to find a hormonal indicator that would predict alterations in sperm count, thus obviating the need to obtain a semen specimen in a population of employees exposed to a chemical suspected of possessing infertility-inducing properties. Our observations suggest that either FSH or LH (but not testosterone) could be useful in this role if a study population, like ours, contains a high percentage of azoospermics. The predictive value of both FSH and LH decrease to vanishing if one removes the azoospermics from the study population, as we did by statistical manipulation. In short, in a population of men severely damaged to the point of widespread azoospermia, FSH or LH serum values would likely predict the existence of a problem which would then require the collection of sperm samples for clarification. (Attention is called to Tables 31-39 which indicate a high false negative rate where either hormone assay is used as a case finding). In a population of oligospermic men, neither hormone assay could be counted upon to detect a problem. Thus the sperm count remains the single best indicator of DBCP induced infertility.

In the initial study of the 41 ACD employees prior to the initiation of the HHE, there was 100 percent cooperation among the workers. In the later study the nonparticipation rate among workers was considerable, despite the full cooperation and assurance of both the Union and the Company. A number of those who only responded to the questionnaire but were not interested in participating inthis type of a study gave the reason that either they had vasectomies, their wives were sterile or beyond the child-bearing age, or were not interested for unstated reasons. Only a few individuals stated that they did not wish to give a sperm sample; however, the authors feel that the nature of the examination was inhibiting to many potential participants.

The data we have been able to collect do not provide a clear answer to the question of reversibility of DBCP induced infertility, nor to the issue of carcinogenicity; long-term follow-up will be required to answer both questions. There are also no data about mutagenicity of human germ cells and potential fetal mutogenic effects. The data do indicate that DBCP is a selective germ cell or spermatogonia toxin.

VII. RECOMMENDATIONS

A) If DBCP is produced or formulated in the future, all effort must be made to keep the environmental concentration below the currently proposed OSHA Standard for DBCP of 1 part per billion (PPb).

B) In an effort to determine the reversibility of injury, repeat semen analysis should be performed at least at yearly intervals for the first five years following the identification of the problem.

C) Workers with significant DBCP exposure should be followed and records be kept on these individuals for at least 30 years. This measure would likely discover any long term effects caused by DBCP exposure.

D) Company and Workers cooperation and participation in the NIOSH DBCP Registry is encouraged.

E) The employer follow the recommendation for medical surveillance of workers outlined in the OSHA proposed standard for DBCP.

VIII. AUTHORSHIP AND ACKNOWLEDGEMENTS

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The following Tables were prepared from data collected during the months of July and August 1977, at Oxy-Chem, Lathrop, California. These data were collected and analyzed as a part of Health Hazard Evaluation 77-103.

Table I

Mean Age, Years of Exposure, Sperm Counts, and Serum FSH, LH and Testosterone Levels in 22 Nonvasectomized DBCP Formulators

Group	N	Age - Yrs		Exposure Yrs		Sperm Count x 10^6/ml		FSH mIu/ml		LH mIu/ml		Testosterone ng/dl	
		Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
A	11	32.7	1.6^{++}	8.0	1.2^{+}	0.2	0.1^{*+}	11.3	1.8^{+}	28.4	3.3^{++}	459	35
B	11	26.7	1.2^{++}	0.08	0.02^{+}	93	18^{+}	2.6	0.4^{+}	14.0	2.8^{++}	463	31

*Nine workers with 0 sperm/ml; two with 1 x 10^6/ml.

+Difference between groups A and B significant at $p < 0.001$.

++Difference between groups A and B significant at $p < 0.01$.

SEM = Standard error of mean.

TABLE 2

NUMBER AND PERCENT OF OCCIDENTAL CHEMICAL COMPANY HOURLY EMPLOYEES BY WORK AREA WHO PARTICIPATED IN MEDICAL OR QUESTIONNAIRE PHASE OF THE STUDY

WORK	TOTAL EMPLOYEES	# EXAM	% EXAM	# RESPONSES TO QUEST.	#NO EXAM OR RESPONSE	% NO EXAM OR RESPONSE
Ag Chem	24	24	100	N.A.	0	0
Best	12	11	91	1	0	0
Maint.	135	82	61	25	28	21
Ammonia Plant	28	14	50	11	3	11
Warehouse	28	7	25	13	8	29
Fertilizer Plant	14	5	35	9	0	0
Acid Plant	20	4	20	3	13	65
TOTAL	261	147	56	162	52	20

TABLE 3

NUMBER EXPOSED TO DBCP BY EXPOSURE GROUP AND VASECTOMY STATUS

Number	Vasectomy Status	Exposure Group
35	Nonvasectomized	Not exposed
107	Nonvasectomized	Exposed
9	Nonvasectomized (no sample)	Exposed
7	Vasectomized	Not exposed
38	Vasectomized	Exposed

TABLE 4

Work Area by 10 Year Age Group, Number
And
Percent of Total Workforce

WORK AREA	AGE GROUP 20-29	30-39	40-49	50-59	60-69	ROW TOTAL
Warehouse	8 (57.1)	3 (21.4)	1 (7.1)	2 (14.3)	0 (0)	14 (7.1)
Ammonia Plant	6 (37.5)	7 (43.8)	1 (6.3)	2 (12.5)	0 (0)	16 (8.1)
Fertilizer Plant	2 (40.0)	2 (40.0)	0 (0)	0 (0)	1 (20.0)	5 (2.5)
AG Chem Plant	17 (44.7)	14 (36.8)	5 (13.2)	2 (5.3)	0 (0)	38 (19.3)
Best Products	1 (7.7)	8 (53.8)	4 (30.8)	1 (7.7)	0 (0)	13 (6.6)
Applicators	1 (6.7)	8 (53.3)	4 (26.7)	2 (13.3)	0 (0)	15 (7.6)
Pellet Plant	3 (30.0)	1 (10.0)	6 (60.0)	0 (0)	0 (0)	10 (5.1)
Clerical	3 (33.3)	3 (33.3)	2 (22.2)	1 (11.1)	0 (0)	9 (4.6)
All Over Plant	16 (22.2)	32 (44.4)	15 (20.8)	7 (9.7)	2 (2.8)	72 (36.5)
Phosphoric Acid Plant	2 (40.0)	1 (20.0)	1 (20.0)	1 (20.0)	0 (0)	5 (2.5)
COLUMN TOTAL	59 (29.9)	78 (39.6)	39 (19.8)	18 (9.1)	3 (1.5)	197 (100.0)

Numbers in parentheses are percent of row or column

TOTAL PLANT POPULATION	310
NUMBER SEEN	197
NUMBER NOT SEEN	112
REACHED BY QUESTIONNAIRE	62

Table 5A

Pounds of DBCP Formulated
By The
Agricultural Chemical Division
By
Quarter From 1968 To 1977

Year, Cmpd, ID#	Jan-Mar	Apr-June	July-Sept	Oct-Dec
1968	-	-	59499.	327520.
1969	503450.	727554.	136916.	162815.
1970	488076.	441971.	212798.	335275.
1971	418602.	355978.	138865.	315800.
1972	429755.	241890.	406146.	428480.
1973	395910.	464980.	193211.	832214.
1974	622673.	678446.	422868.	1159824.
1975	852882.	602052.	553775.	503530.
1976	620786.	445723.	961584.	266734.
1977	728790.	362341.	255401.	-

Table 5B

Pounds of Ethylene Dibromide Formulated
By The
Agricultural Chemical Division
By
Quarter From 1968 To 1977

Year, Cmpd, ID#	Jan-Mar	Apr-June	July-Sept	Oct-Dec
1968	-	-	0	0
1969	80620.	36785.	0	3610.
1970	45087.	44401.	0	0
1971	0	47542.	0	0
1972	0	0	0	0
1973	39708.	0	0	12033.
1974	414889.	0	37543.	0
1975	0	0	0	41166.
1976	37543.	54869.	0	39708.
1977	80860.	0	0	-

Table 5C

Pounds of Epichlorohydrin Formulated
By The
Agricultural Chemical Division
By
Quarter From 1968 To 1977

Year, Cmpd, ID#	Jan-Mar	Apr-June	July-Sept	Oct-Dec
1968	-	-	1098.	3846.
1969	5915.	10196.	3532.	1856.
1970	5986.	6032.	3620.	3873.
1971	4900.	5562.	2558.	3670.
1972	549.	1561.	463.	83.
1973	4635.	5676.	2444.	9666.
1974	7311.	8764.	4850.	12334.
1975	6413.	2314.	5894.	5069.
1976	4540.	4463.	11468.	3261.
1977	8450.	4435.	3132.	-

Table 5D

Pounds Of Carbaryl Formulated
By The
Agricultural Chemical Division
By
Quarter From 1968 To 1977

Year, Cmpd, ID#	Jan-Mar	Apr-June	July-Sept	Oct-Dec
1968	-	-	10665.	3541.
1969	2482.	19556.	176768.	2775.
1970	6428.	19240.	66948.	1087.
1971	1345.	17433.	33320.	0
1972	790.	76037.	47545	106.
1973	0	2663.	9490.	0
1974	0	240.	187.	8239.
1975	4161.	2660.	5938.	436.
1976	545.	1691.	2832.	197.
1977	860.	0	158.	-

Table 5E

Pounds of Methyl Parathion Formulated
By The
Agricultural Chemical Division
By
Quarter From 1968 To 1977

Year, Cmpd, ID#	Jan-Mar	Apr-June	July-Sept	Oct-Dec
#148				
1968	-	-	24287.	503.
1969	100.	38228.	11850.	15.
1970	5006.	38441.	13167.	2372.
1971	5918.	6173.	17118.	7329.
1972	27701.	33477.	27213.	15087.
1973	36483.	39690.	39747.	18692.
1974	12111.	24408.	16089.	21764.
1975	20803.	17248.	20160.	11650.
1976	17712.	57424.	38408.	23630.
1977	22565.	22120.	13482.	-

Table 5F

Pounds of Toxaphene Formulated
By The
Agricultural Chemical Division
By
Quarter From 1968 To 1977

Year, Cmpd, ID#	Jan-Mar	Apr-June	July-Sept	Oct-Dec
#211				
1968	-	-	41902.	5123.
1969	6993.	192018.	167107.	817.
1970	224.	96174.	113767.	1360.
1971	428.	157144.	174365.	0
1972	8696.	190845.	42669.	522.
1973	0	21976.	53997.	3199.
1974	17427.	42130.	43933.	0
1975	240.	16709.	85457.	453.
1976	0	47474.	88421.	694.
1977	0	34135.	33092.	-

TABLE 6

RELATIONSHIP OF OLIGOSPERMIA AND NORMOSPERMIA WITH EXPOSURE IN MONTHS TO DBCP IN 126 NONVASECTOMIZED MEN

EXPOSURE TO DBCP

Sperm Count	None	1-6 Months	6-24 Months	24-42 Months	43 Months	Total
$<40 \times 10^6$/ml	4 (9.1)	11 (25)	7 (15.5)	8 (18.2)	14 (31.8)	44 (34.5)
$>40 \times 10^6$/ml	31 (37.8)	37 (45.1)	7 (8.5)	4 (4.9)	3 (3.7)	82 (65.1)
TOTAL #	35	48	14	12	17	126
%	27.8	38.1	11.1	9.5	13.5	100%

Percentage in parentheses

Table 7

SPERM COUNTS OF 142 EMPLOYEES OF OCCIDENTAL
CHEMICAL COMPANY BY CATEGORY OF EXPOSURE TO DBCP

xposure Category	SPERM 0	1-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-110	110-119	120+	ROW TOTAL
	SPERM COUNT IN MILLIONS														
ever Exposed	1 (2.9)	0 (0)	0 (0)	2 (5.7)	1 (2.9)	5 (14.3)	2 (5.7)	3 (8.6)	4 (11.4)	0 (0)	2 (5.7)	3 (8.6)	2 (5.7)	10 (28.6)	35 (24.6)
nce or Currently Exposed	14 (13.1)	9 (8.4)	9 (8.4)	11 (10.3)	6 (5.6)	8 (7.5)	8 (7.5)	7 (6.5)	6 (5.6)	2 (1.9)	8 (7.5)	2 (1.9)	2 (1.9)	15 (14.0)	107 (75.4)
COLUMN TOTAL	15 (10.6)	9 (6.3)	9 (6.3)	13 (9.2)	7 (4.9)	13 (9.2)	10 (7.0)	10 (7.0)	10 (7.0)	2 (1.4)	10 (7.0)	5 (3.5)	4 (2.8)	25 (17.6)	142 (100.0)

(parentheses show percentages)

Table 8

Mean, Standard Error & Range
Of
Sperm Counts* by 10 Year Age Groups
In
35 Employees Never Exposed to DBCP

AGE GROUP	COUNT	MEAN	STANDARD ERROR	MINIMUM	MAXIMUM
20-29	16	89.7	12.0	30.0	184.0
30-39	8	137.1	38.4	42.0	372.0
40-49	9	99.0	27.3	25.0	281.0
50-59	2	147.5	147.5	0	295.0
TOTAL	35	106.2		0	372.0

* in millions per milliliter

Table 9

Mean, Standard Error & Range
Of
Sperm Counts* by 10 Year Age Groups
In
107 Employees With History of Exposure To DBCP

AGE GROUP	COUNT	MEAN	STANDARD ERROR	MINIMUM	MAXIMUM
20 -29	34	65.4	10.3	1.0	244.0
30 -39	46	57.6	59.2	0	232.0
40 -49	18	90.1	126.2	0	358.0
50 -59	9	51.2	16.0	0	153.0
TOTAL	107	63.8		0	358.0

* Sperm Counts in millions per milliliter

Table 10

SPERM COUNTS OF 142 EMPLOYEES OF OCCIDENTAL CHEMICAL COMPANY BY 10 YEAR AGE GROUP

.GE ;ROUP	0	1-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-110	110-119	120+	ROW TOTAL
20-29	0 (0)	4 (8.0)	4 (8.0)	4 (8.0)	1 (2.0)	9 (18.0)	5 (10.0)	3 (6.0)	2 (4.0)	1 (2.0)	4 (8.0)	3 (6.0)	0 (0)	10 (20.0)	50 (35.2)
30 - 39	9 (16.7)	3 (5.6)	3 (5.6)	3 (5.6)	6 (11.1)	3 (5.6)	] (3.7)	4 (7.4)	4 (7.4)	1 (1.9)	5 (9.3)	1 (1.9)	3 (5.6)	7 (13.0)	54 (38.0)
40-49	4 (14.8)	1 (3.7)	2 (7.4)	4 (14.8)	0 (0)	0 (0)	2 (7.4)	2 (7.4)	4 (14.8)	0 (0)	0 (0)	1 (3.7)	1 (3.7)	6 (22.2)	27 (19.0)
50-	2 (18.2)	1 (9.1)	0 (0)	2 (18.2)	0 (0)	1 (9.1)	1 (9.1)	1 (9.1)	0 (0)	0 (0)	1 (9.1)	0 (0)	0 (0)	2 (18.2)	11 (7.7)
TOTAL	15 (10.6)	9 (6.3)	9 (6.3)	13 (9.2)	7 (4.9)	13 (9.2)	10 (7.0)	10 (7.0)	10 (7.0)	2 (1.4)	10 (7.0)	5 (3.5)	4 (2.8)	25 (17.6)	142 (100.0

(parentheses show percentages)

Table 11

Mean, Standard Error & Range
Of
FSH Levels* by 10 Year Age Groups
In
35 Employees Never Exposed to DBCP
(Nonvasectomized Males)

AGE GROUP	WORKERS	MEAN	STANDARD ERROR	MINIMUM	MAXIMUM
20-29	16	2.9	.2	1.6	4.4
30-39	8	3.5	.5	1.8	6.9
40-49	9	3.7	.2	2.7	4.8
50-59	2	6.7	4.0	2.7	10.8
TOTAL	35	3.4		1.6	10.8

* in mIu/ml

Table 12

Mean, Standard Error & Range
Of
FSH Levels* by 10 Year Age Groups
In
114 Nonvasectomized Male Employees
With
History of Exposure to DECP

AGE GROUP	WORKERS	MEAN	STANDARD ERROR	MINIMUM	MAXIMUM
20-29	36	3.5	.2	1.3	8.5
30-39	48	5.5	.6	1.1	24.3
40-49	19	7.7	1.4	2.0	28.1
50-59	11	5.1	1.2	2.4	15.9
TOTAL	114	5.2		1.1	28.1

* in mIu/ml

Table 13

Mean, Standard Error & Range
Of
LH Values* by 10 Year Age Groups
In
35 Employees Never Exposed to DBCP
(Nonvasectimized Males)

AGE GROUP	WORKERS	MEAN	STANDARD ERROR	MINIMUM	MAXIMUM
20 -29	16	13.2	1.5	4.6	21.8
30 -39	8	14.5	3.2	3.5	29.2
40 -49	9	14.1	2.5	5.5	28.0
50 -59	2	18.4	7.7	10.7	26.1
TOTAL	35	14.0		3.5	29.2

* in mIu/ml

Table 14

Mean, Standard Error & Range
Of
LH* Levels by 10 Year Age Groups
In
114 Nonvasectomized Male Employees
With
History of Exposure to DECP

AGE GROUP	WORKERS	MEAN	STANDARD ERROR	MINIMUM	MAXIMUM
20-29	36	14.4	1.3	1.5	37.8
30-39	48	14.5	1.2	1.0	37.4
40-49	19	18.8	3.3	6.0	56.0
50-59	11	20.2	3.9	3.1	53.2
TOTAL	114	15.7		1.0	56.0

* in mIu/ml

Table 15

Mean, Standard Error & Range
Of
Testosterone Levels* by 10 Year Age Groups
In
35 Employees Never Exposed to DBCP
(Nonvasectomized Males)

AGE GROUP	WORKERS	MEAN	STANDARD ERROR	MINIMUM	MAXIMUM
20 - 29	16	605.3	30.5	443.0	906.0
30 - 39	8	574.0	29.0	409.0	661.0
40 - 49	9	545.1	46.4	383.0	760.0
50 - 59	2	531.0	186.0	345.0	717.0
TOTAL	35	578.4		345.0	906.0

* in ng/dl

Table 16

Mean, Standard Error & Range
Of
Testosterone* Levels by 10 Year Age Groups
In
114 Nonvasectomized Male Employees
With
History of Exposure to DECP

AGE GROUP	WORKERS	MEAN	STANDARD ERROR	MINIMUM	MAXIMUM
20 -29	36	576.1	32.4	125.0	998.0
30 -39	48	524.4	21.7	275.0	821.0
40 -49	19	447.5	37.5	219.0	775.0
50 -59	11	492.2	42.0	353.0	770.0
TOTAL	114	524.8		125.0	998.0

* in ng/dl

TABLE 17

ANALYSIS OF VARIANCE FOR FSH BY SPERM COUNT GROUPS FOR 35 NONEXPOSED EMPLOYEES

VARIABLE FSH
BY SPERM

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	10	68.3360	6.8336	6.247	.000
WITHIN GROUPS	24	26.2537	1.0939		
TOTAL	34	94.5897			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN
GRP 0	1	10.8000					
GRP 3	2	4.5000	.1414	.1000	4.4000	4.6000	3.2294 TO 5.7706
GRP 4	1	3.1000					
GRP 5	5	2.7200	1.0010	.4477	1.6000	3.7000	1.4771 TO 3.9629
GRP 6	2	4.2000	.8485	.6000	3.6000	4.8000	-3.4237 TO 11.8237
GRP 7	3	4.4333	2.1455	1.2387	3.0000	6.9000	-.8965 TO 9.7632
GRP 8	4	2.9500	.8851	.4425	2.0000	3.8000	1.5417 TO 4.3583
GRP 10	2	2.5500	.6364	.4500	2.1000	3.0000	-3.1678 TO 8.2678
GRP 11	3	3.6000	.9165	.5292	2.6000	4.4000	1.3232 TO 5.8768
GRP 12	2	2.7000	.4243	.3000	2.4000	3.0000	-1.1119 TO 6.5119
GRP 13	10	3.0600	.9240	.2922	1.8000	4.8000	2.3990 TO 3.7210
TOTAL	35	3.4829			1.6000	10.8000	
UNGROUPED DATA			1.6679	.2819			2.9099 TO 4.0558
FIXED EFFECTS MODEL			1.0459	.1768			3.1180 TO 3.8477
RANDOM EFFECTS MODEL			3.0834	.9297			1.4114 TO 5.5543

TESTS FOR HOMOGENEITY OF VARIANCES

CCCHRANS C = MAX. VARIANCE/SUM(VARIANCES) = .4893, P = .037 (APPROX.)
BARTLETT-BOX F = .887, P = .528
MAXIMUM VARIANCE / MINIMUM VARIANCE = 230.167

Group 0 = Azoospermia

Group 3 = 30-39 x 10^6/ml

. . .

Group 12 = 110-119 x 10^6/ml

Group 13 = $>$ 119 x 10^6/ml

TABLE 18

ANALYSIS OF VARIANCE FOR FSH BY SPERM COUNT GROUPS FOR 35 NONEXPOSED EMPLOYEES

VARIABLE FSH
BY SPERM

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	3	34.0683	11.3561	5.817	.003
WITHIN GROUPS	31	60.5214	1.9523		
TOTAL	34	94.5897			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN
GRP 1	3	6.6000	3.6387	2.1008	4.4000	10.8000	-2.4391 TO 15.6391
GRP 2	6	2.7833	.9087	.3710	1.6000	3.7000	1.8298 TO 3.7369
GRP 3	11	3.5091	1.3889	.4188	2.0000	6.9000	2.5760 TO 4.4421
GRP 4	15	3.1200	.8711	.2249	1.8000	4.8000	2.6376 TO 3.6024
TOTAL	35	3.4829			1.6000	10.8000	
UNGROUPED DATA			1.6679	.2819			2.9099 TO 4.0558
FIXED EFFECTS MODEL			1.3972	.2362			3.0012 TO 3.9645
RANDOM EFFECTS MODEL			6.6242	3.3121			-7.0576 TO 14.0233

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX. VARIANCE/SUM(VARIANCES) = .7903, P = .000 (APPROX.)
BARTLETT-BOX F = 4.288, P = .005
MAXIMUM VARIANCE / MINIMUM VARIANCE = 17.447

Group 1 = 0-29 x 10^6/ml

Group 2 = 30-39 x 10^6/ml

Group 3 = 50-99 x 10^6/ml

Group 4 = $>$ 99 x 10^6/ml

TABLE 19

ANALYSIS OF VARIANCE FOR FSH BY SPERM COUNT GROUPS OF 105 EXPOSED EMPLOYEES

VARIABLE FSH
BY SPERM

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	13	1253.5356	96.4258	10.641	0
WITHIN GROUPS	91	824.6428	9.0620		
TOTAL	104	2078.1785			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN		
GRP 0	14	13.9429	6.6898	1.7879	4.8000	28.1000	10.0803	TO	17.8054
GRP 1	8	4.4CC0	2.7867	.9852	2.2000	9.8000	2.0703	TO	6.7297
GRP 2	9	5.5778	2.2038	.7346	2.8000	9.1000	3.8838	TO	7.2718
GRP 3	10	4.C4C0	2.0716	.6551	1.6000	8.5000	2.5581	TO	5.5219
GRP 4	6	4.4167	.9368	.3825	2.9000	5.1000	3.4335	TO	5.3998
GRP 5	8	4.7750	2.3487	.8304	1.7000	8.5000	2.8114	TO	6.7386
GRP 6	8	4.C5C0	1.1940	.4222	2.0000	6.3000	3.0518	TO	5.0482
GRP 7	7	3.2CC0	2.262C	.8550	1.1000	7.9000	1.1080	TO	5.2920
GRP 8	6	4.C333	.6772	.2765	3.1000	5.0000	3.3226	TO	4.7441
GRP 9	2	2.35C0	.6364	.4500	1.9000	2.8000	-3.3678	TO	8.0678
GRP 10	8	3.35C0	.7838	.2771	2.3000	4.8000	2.6948	TO	4.0052
GRP 11	2	3.15CC	1.4849	1.0500	2.1000	4.2000	-10.1915	TO	16.4915
GRP 12	2	4.65C0	1.3435	.95C0	3.7000	5.6000	-7.4209	TO	16.7209
GRP 13	15	3.1667	1.C796	.2788	1.5000	5.0000	2.5888	TO	3.7845
TOTAL	105	5.3295							
UNGROUPED DATA			4.4702	.4362	1.1000	28.1000	4.4644	TO	6.1946
FIXED EFFECTS MODEL			3.0103	.2938			4.7460	TO	5.9131
RANDOM EFFECTS MODEL			2.8873	.7717			3.6625	TO	6.9966

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX. VARIANCE/SUM(VARIANCES) = .5508, P = 0 (APPROX.)
BARTLETT-BOX F = 6.776, P = .CC0
MAXIMUM VARIANCE / MINIMUM VARIANCE = 110.502

Group 0 = Azoospermia

Group 1 = 1-9 x 10^6/ml

...

Group 12 = 110-119 x 10^6/ml

Group 13 = $>$ 119 x 10^6/ml

TABLE 20

ANALYSIS OF VARIANCE FOR FSH BY SPERM COUNT GROUPS FOR 105 EXPOSED EMPLOYEES

VARIABLE FSH
BY SPERM

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	7	1242.2261	177.4609	20.592	0
WITHIN GROUPS	97	835.9524	8.6181		
TOTAL	104	2078.1785			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN
GRP 0	14	13.9429	6.6898	1.7879	4.8000	28.1000	10.0803 TO 17.8054
GRP 1	8	4.4000	2.7867	.9852	2.2000	9.8000	2.0703 TO 6.7297
GRP 2	9	5.5778	2.2038	.7346	2.8000	9.1000	3.8838 TO 7.2718
GRP 3	10	4.0400	2.0716	.6551	1.6000	8.5000	2.5581 TO 5.5219
GRP 4	6	4.4167	.9368	.3825	2.9000	5.1000	3.4335 TO 5.3998
GRP 5	8	4.7750	2.3487	.8304	1.7000	8.5000	2.8114 TO 6.7386
GRP 6	31	3.5645	1.3556	.2435	1.1000	7.9000	3.0673 TO 4.0618
GRP 7	19	3.3368	1.1591	.2659	1.5000	5.6000	2.7782 TO 3.8955
TOTAL	105	5.3295			1.1000	28.1000	
UNGROUPED DATA			4.4702	.4362			4.4644 TO 6.1946
FIXED EFFECTS MODEL			2.9357	.2865			4.7609 TO 5.8981
RANDOM EFFECTS MODEL			6.0407	2.1357			.2794 TO 10.3796

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX. VARIANCE/SUM(VARIANCES) = .6282, P = .000 (APPROX.)
BARTLETT-BOX F = 11.761, P = .000
MAXIMUM VARIANCE / MINIMUM VARIANCE = 50.991

Group 0 = Azoospermia

Group 1 = 1-9 x 10^6/ml

...

Group 6 = 50-99 x 10^6/ml

Group 7 = > 99 x 10^6/ml

TABLE 21

ANALYSIS OF VARIANCE FOR LH BY SPERM COUNT GROUPS FOR 35 NONEXPOSED EMPLOYEES

VARIABLE LH
BY SPERM

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	10	373.2608	37.3261	.634	.771
WITHIN GROUPS	24	1413.1747	58.8823		
TOTAL	34	1786.4354			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN
GRP 0	1	26.1000					
GRP 3	2	10.7500	2.4749	1.7500	9.0000	12.5000	-11.4858 TO 32.9858
GRP 4	1	21.1000					
GRP 5	5	11.6200	4.8808	2.1828	5.0000	16.4000	5.5598 TO 17.6802
GRP 6	2	13.6500	11.5258	8.1500	5.5000	21.8000	-89.9055 TO 117.2055
GRP 7	3	10.8000	3.6373	2.1000	7.5000	14.7000	1.7643 TO 19.8357
GRP 8	4	17.0000	8.9818	4.4909	8.4000	28.0000	2.7081 TO 31.2919
GRP 10	2	11.0000	10.6066	7.5000	3.5000	18.5000	-84.2965 TO 106.2965
GRP 11	3	13.7667	6.9574	4.0399	5.7000	18.2000	-3.6160 TO 31.1493
GRP 12	2	10.5500	8.2731	5.8500	4.7000	16.4000	-63.7813 TO 84.8813
GRP 13	10	15.3500	8.3770	2.6490	4.6000	29.2000	9.3575 TO 21.3425
TOTAL	35	14.0686			3.5000	29.2000	
UNGROUPED DATA			7.2486	1.2252			11.5786 TO 16.5586
FIXED EFFECTS MODEL			7.6735	1.2971			11.3916 TO 16.7456
RANDOM EFFECTS MODEL			9.2085	2.7765			7.8822 TO 20.2549

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX. VARIANCE/SUM(VARIANCES) = .2386, P = .904 (APPROX.)
BARTLETT-BOX F = .530, P = .834
MAXIMUM VARIANCE / MINIMUM VARIANCE = 21.689

Group 0 = Azoospermia

Group 3 = 20-29 x 10^6/ml

. . .

Group 12 = 110-119 x 10^6/ml

Group 13 = $>$ 119 x 10^6/ml

TABLE 22

ANALYSIS OF VARIANCE FOR LH WITH SPERM COUNT GROUPS

FOR 35 NON-EXPOSED EMPLOYEES

VARIABLE LH
BY SPERM

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	3	18.1303	6.0434	.106	.956
WITHIN GROUPS	31	1768.3051	57.0421		
TOTAL	34	1786.4354			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN
GRP 1	3	15.8667	9.0335	5.2155	9.0000	26.1000	-6.5739 TO 38.3073
GRP 2	6	13.2000	5.8340	2.3817	5.0000	21.1000	7.0776 TO 19.3224
GRP 3	11	13.6091	7.7273	2.3299	3.5000	28.0000	8.4178 TO 18.8003
GRP 4	15	14.3933	7.7359	1.9974	4.6000	29.2000	10.1094 TO 18.6773
TOTAL	35	14.0686			3.5000	29.2000	
UNGROUPED DATA			7.2486	1.2252			11.5786 TO 16.5586
FIXED EFFECTS MODEL			7.5526	1.2766			11.4649 TO 16.6723
RANDOM EFFECTS MODEL			25.7135	12.8567			-26.8467 TO 54.9839

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX. VARIANCE/SUM(VARIANCES) = .3470, P = .537 (APPROX.)
BARTLETT-BOX F = .224, P = .880
MAXIMUM VARIANCE / MINIMUM VARIANCE = 2.398

GROUP 1 = 0-29 x 10^6/ml

GROUP 2 = 30-49 x 10^6/ml

GROUP 3 = 50-99 x 10^6/ml

GROUP 4 = 99 x 10^6/ml

TABLE 23

ANALYSIS OF VARIANCE FOR LH WITH SPERM COUNT GROUPS

FOR 105 EXPOSED EMPLOYEES

VARIABLE LH
BY SPERM

ANALYSIS OF VARIANCE

SCURCE	D.F.	SUM CF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GRCUPS	13	3680.1250	283.0865	3.213	.001
WITHIN GRCUPS	91	8016.9242	88.0981		
TOTAL	104	11697.0491			

GRCUP	CCUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN		
GRP 0	14	29.9643	15.1109	4.0386	12.C000	56.0000	21.2395	TO	38.6891
GRP 1	8	17.1375	10.0739	3.5616	6.2000	33.0000	8.7156	TO	25.5594
GRP 2	9	17.4556	8.5C55	2.8352	10.1000	37.8000	10.9177	TO	23.9934
GRP 3	10	13.2800	6.0157	1.9023	1.5000	20.3000	8.9766	TO	17.5834
GRP 4	6	12.7333	2.3972	.9787	10.0000	16.7000	10.2176	TO	15.2490
GRP 5	8	16.9875	11.0206	3.8964	2.7000	31.0000	7.7741	TO	26.2009
GRP 6	8	11.9625	8.6627	3.0627	2.9000	29.7000	4.7203	TO	19.2047
GRP 7	7	11.8571	4.7634	1.8004	6.4000	18.0000	7.4518	TO	16.2625
GRP 8	6	13.8667	6.6722	2.7239	6.0000	23.2000	6.8647	TO	20.8686
GRP 9	2	11.9CCO	11.1723	7.9000	4.0000	19.8000	-88.4790	TO	112.2790
GRP 1C	8	16.5375	11.1182	3.9309	4.8000	37.4000	7.2425	TO	25.8325
GRP 11	2	10.CCCO	.9899	.7000	9.3000	10.7000	1.1057	TO	18.8943
GRP 12	2	8.95CO	3.0406	2.1500	6.8000	11.1000	-18.3683	TO	36.2683
GRP 13	15	11.6CCO	6.9201	1.7868	5.0000	28.2000	7.7678	TO	15.4322
TCTAL	105	16.C829			1.5000	56.0000			
UNGRCUPED CATA			10.6C53	1.0350			14.0305	TO	18.1352
FIXED EFFECTS MCDEL			9.3861	.9160			14.2634	TO	17.9023
RANDCM EFFECTS MCDEL			5.4137	1.4469			12.9571	TO	19.2086

TESTS FCR HCMCGENEITY CF VARIANCES

CCCHRANS C = MAX. VARIANCE/SUM(VARIANCES) = .2251, P = .016 (APPROX.)
BARTLETT-BCX F = 2.299, P = .CC5
MAXIMUM VARIANCE / MINIMUM VARIANCE = 232.999

GROUP 0 = AZOOSPERMIA

GROUP 1 = 1-9 x 10^6/ml

GROUP 12 = 110-119 x 10^6/ml

GROUP 13 = $>$119 x 10^6/ml

TABLE 24

ANALYSIS OF VARIANCE FOR LH WITH SPERM COUNT GROUPS FOR 105 EXPOSED EMPLOYEES

VARIABLE LH
BY SPERM

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	7	3547.2286	506.7469	6.031	.000
WITHIN GROUPS	97	8149.8205	84.0188		
TOTAL	104	11697.0491			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN
GRP 0	14	29.9643	15.1109	4.0386	12.0000	56.0000	21.2395 TO 38.6891
GRP 1	8	17.1375	10.0739	3.5616	6.2000	33.0000	8.7156 TO 25.5594
GRP 2	9	17.4556	8.5055	2.8352	10.1000	37.8000	10.9177 TO 23.9934
GRP 3	10	13.2800	6.0157	1.9023	1.5000	20.3000	8.9766 TO 17.5834
GRP 4	6	12.7333	2.3972	.9787	10.0000	16.7000	10.2176 TO 15.2490
GRP 5	8	16.9875	11.0206	3.8964	2.7000	31.0000	7.7741 TO 26.2009
GRP 6	31	13.4839	8.1480	1.4634	2.9000	37.4000	10.4952 TO 16.4726
GRP 7	19	11.1526	6.2183	1.4266	5.0000	28.2000	8.1555 TO 14.1497
TOTAL	105	16.0829			1.5000	56.0000	
UNGROUPED DATA			10.6053	1.0350			14.0305 TO 18.1352
FIXED EFFECTS MODEL			9.1662	.8945			14.3075 TO 17.8582
RANDOM EFFECTS MODEL			16.0294	5.6673			2.6820 TO 29.4838

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX. VARIANCE/SUM(VARIANCES) = .3405, P = .002 (APPROX.)
BARTLETT-BOX F = 3.623, P = .001
MAXIMUM VARIANCE / MINIMUM VARIANCE = 39.734

GROUP 0 = AZOOSPERMIA

GROUP 1 = 1- 9 x 10^6/ml

GROUP 12 = 110-119 x 10^6/ml

GROUP 13 = >119 x 10^6/ml

TABLE 25

ANALYSIS OF VARIANCE FOR TESTOSTERONE WITH SPERM COUNT GROUPS FOR 105 EXPOSED EMPLOYEES

VARIABLE TEST
BY SPERM

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	7	233905.9947	33415.1421	1.120	.357
WITHIN GROUPS	97	2892717.5672	29821.8306		
TOTAL	104	3126623.5619			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN
GRP 0	14	472.3571	125.6850	33.5907	264.0000	775.0000	399.7888 TO 544.9255
GRP 1	8	597.2500	159.6252	56.4360	353.0000	801.0000	463.8003 TO 730.6997
GRP 2	9	618.8889	201.4215	67.1405	386.0000	857.0000	464.0628 TO 773.7150
GRP 3	10	551.5000	206.6157	65.3376	219.0000	821.0000	403.6961 TO 699.3039
GRP 4	6	600.1667	103.9469	42.4362	476.0000	750.0000	491.0827 TO 709.2506
GRP 5	8	513.2500	99.5888	35.2100	380.0000	707.0000	429.9919 TO 596.5081
GRP 6	31	509.9032	200.0172	35.9242	125.0000	998.0000	436.5363 TO 583.2701
GRP 7	19	488.6316	162.7142	37.3292	277.0000	806.0000	410.2058 TO 567.0573
TOTAL	105	526.4190			125.0000	998.0000	
		UNGROUPED DATA	173.3888	16.9210			492.8640 TO 559.9741
		FIXED EFFECTS MODEL	172.6900	16.8528			492.9709 TO 559.8672
		RANDOM EFFECTS MODEL	490.9371	173.5725			115.9863 TO 936.8518

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX. VARIANCE/SUM(VARIANCES) = .2016, P = .469 (APPROX.)
BARTLETT-BOX F = 1.342, P = .227
MAXIMUM VARIANCE / MINIMUM VARIANCE = 4.304

GROUP 0 = AZOOSPERMIA

GROUP 1 = $1\text{-}9 \times 10^6$/ml

GROUP 6 = $50\text{-}99 \times 10^6$/ml

GROUP 7 = $>99 \times 10^6$/ml

TABLE 26

ANALYSIS OF VARIANCE FOR TESTOSTERONE WITH
SPERM COUNT GROUPS FOR 35 NON-EXPOSED EMPLOYEES

VARIABLE TEST
BY SPERM

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	10	149278.5881	14927.8588	.961	.500
WITHIN GROUPS	24	372641.9833	15526.7493		
TOTAL	34	521920.5714			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN
GRP 0	1	717.0000					
GRP 3	2	502.0000	63.6396	45.0000	457.0000	547.0000	-69.7790 TO 1073.7790
GRP 4	1	906.0000					
GRP 5	5	551.2000	36.7927	16.4542	501.0000	599.0000	505.5166 TO 596.8834
GRP 6	2	607.5000	317.4909	224.5000	383.0000	832.0000	-2245.0419 TO 3460.0419
GRP 7	3	579.6667	101.9035	58.8340	462.0000	639.0000	326.5214 TO 832.8119
GRP 8	4	564.2500	126.0010	63.0005	446.0000	694.0000	363.7572 TO 764.7428
GRP 10	2	584.5000	21.9203	15.5000	569.0000	600.0000	387.5539 TO 781.4461
GRP 11	3	576.3333	42.8525	24.7409	537.0000	622.0000	469.8808 TO 682.7859
GRP 12	2	535.0000	178.1909	126.0000	409.0000	661.0000	-1065.9812 TO 2135.9812
GRP 13	10	568.3000	132.5284	41.9092	345.0000	760.0000	473.4949 TO 663.1051
TOTAL	35	578.4286			345.0000	906.0000	
UNGROUPED DATA			123.8976	20.9425			535.8683 TO 620.9889
FIXED EFFECTS MODEL			124.6064	21.0623			534.9581 TO 621.8991
RANDOM EFFECTS MODEL			337.6247	101.7977			351.6093 TO 805.2479

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX. VARIANCE/SUM(VARIANCES) = .5475, P = .014 (APPROX.)
BARTLETT-BOX F = 1.705, P = .097
MAXIMUM VARIANCE / MINIMUM VARIANCE = 209.783

GROUP 0 = AZOOSPERMIA

GROUP 3 = 20- 29 x 10^6/ML

GROUP 12 = 110-119 x 10^6/ML

GROUP 13 = >119 x 10^6/ML

TABLE 27

ANALYSIS OF VARIANCE FOR TESTOSTERONE WITH SPERM COUNT GROUPS FOR 35 NON-EXPOSED EMPLOYEES

VARIABLE TEST
BY SPERM

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	3	8722.8381	2907.6127	.176	.912
WITHIN GROUPS	31	513197.7333	16554.7656		
TOTAL	34	521920.5714			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN
GRP 1	3	573.6667	132.0353	76.2306	457.0000	717.0000	245.6691 TO 901.6643
GRP 2	6	610.3333	148.5378	60.6403	501.0000	906.0000	454.4549 TO 766.2118
GRP 3	11	580.0000	131.2341	39.5686	383.0000	832.0000	491.8357 TO 668.1643
GRP 4	15	565.4667	118.2581	30.5341	345.0000	760.0000	499.9775 TO 630.9558
TOTAL	35	578.4286			345.0000	906.0000	
	UNGROUPED DATA		123.8976	20.9425			535.8683 TO 620.9889
	FIXED EFFECTS MODEL		128.6653	21.7484			534.0724 TO 622.7847
	RANDOM EFFECTS MODEL		1056.2524	528.1262			-1102.2802 TO 2259.1373

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX. VARIANCE/SUM(VARIANCES) = .3121, P = .789 (APPROX.)
BARTLETT-BOX F = .130, P = .943
MAXIMUM VARIANCE / MINIMUM VARIANCE = 1.578

GROUP 1 = 0-29 x 10^6/ml

GROUP 2 = 30-49 x 10^6/ml

Group 3 = 50-99 x 10^6/ml

Group 4 = >99 x 10^6/ml

TABLE 28

ANALYSIS OF VARIANCE FOR TESTOSTERONE WITH SPERM COUNT GROUPS

FOR 105 EXPOSED EMPLOYEES

VARIABLE TEST
BY SPERM

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	13	329053.8468	25311.8344	.823	.634
WITHIN GROUPS	91	2797569.7151	30742.5243		
TOTAL	104	3126623.5619			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN		
GRP 0	14	472.3571	125.6850	33.5907	264.0000	775.0000	399.7888	TO	544.9255
GRP 1	8	597.2500	159.6252	56.4360	353.0000	801.0000	463.8003	TO	730.6997
GRP 2	9	618.8889	201.4215	67.1405	386.0000	857.0000	464.0628	TO	773.7150
GRP 3	10	551.5000	206.6157	65.3376	219.0000	821.0000	403.6961	TO	699.3039
GRP 4	6	600.1667	103.9469	42.4362	476.0000	750.0000	491.0827	TO	709.2506
GRP 5	8	513.2500	99.5888	35.2100	380.0000	707.0000	429.9919	TO	596.5081
GRP 6	8	546.1250	303.6396	107.3528	125.0000	998.0000	292.2765	TO	799.9735
GRP 7	7	438.2857	105.6830	39.9444	275.0000	602.0000	340.5457	TO	536.0257
GRP 8	6	515.0000	157.3150	64.2236	298.0000	670.0000	349.9106	TO	680.0894
GRP 9	2	479.5000	92.6310	65.5000	414.0000	545.0000	-352.7561	TO	1311.7561
GRP 10	8	540.1250	206.9447	73.1660	312.0000	924.0000	367.1153	TO	713.1347
GRP 11	2	612.0000	67.8823	48.0000	564.0000	660.0000	2.1024	TO	1221.8976
GRP 12	2	523.0000	48.0833	34.0000	489.0000	557.0000	90.9892	TO	955.0108
GRP 13	15	467.6000	175.2976	45.2617	277.0000	806.0000	370.5234	TO	564.6766
TOTAL	105	526.4190			125.0000	998.0000			
		UNGROUPED DATA	173.3888	16.9210			492.8640	TO	559.9741
		FIXED EFFECTS MODEL	175.3355	17.1110			492.4302	TO	560.4079
		RANDOM EFFECTS MODEL	58.3112	15.5843			492.7512	TO	560.0869

TESTS FOR HOMOGENEITY OF VARIANCES

COCHRANS C = MAX. VARIANCE/SUM(VARIANCES) = .2544, P = .004 (APPROX.)
BARTLETT-BOX F = 1.446, P = .132
MAXIMUM VARIANCE / MINIMUM VARIANCE = 39.878

GROUP 0 - AZOOSPERMIA

GROUP 1 - 1-9 x 10^6/ml

GROUP 12 - 110-119 x 10^6/ml

GROUP 13 - >119 x 10^6/ml

TABLE 29

CORRELATION COEFFICIENTS FOR AGE, SPERM COUNT, KNOWN EXPOSURE, FSH, LH AND TESTOSTERONE IN 90 EXPOSED INDIVIDUALS

Sperm Count	.09	---	---	---	---
LH	.18	-.36*	---	---	---
Testosterone	-.20	-.22	-.04	---	---
FSH	.18	-.35*	.63*	-.02	---
Exposure	.23	-.38*	.52*	-.02	.60*
	Age	Sperm Count	LH	Testosterone	FSH

*Significant at 0.01

TABLE 30

CORRELATION COEFFICIENTS FOR AGE, SPERM COUNT, FSH, LH AND TESTOSTERONE FOR 35 NONEXPOSED INDIVIDUALS

	Age	Sperm Count	LH	Testosterone
Sperm Count	.17	---	---	---
LH	.10	.16	---	---
Testosterone	-.23	-.16	.51*	---
FSH	.40*	-.33**	.25	.10

*Significant correlation at 0.01

**Significant at 0.05

TABLE 31

PREDICTION RESULTS OF SPERM COUNTS BY DISCRIMINANT ANALYSIS OF FSH, LH AND TESTOSTERONE LEVELS FOR 140 MEN

		Predicted Group Membership	
Group	N	Group 1	Group 2
1	32	17 (53.1)	15 (46.9)
2	108	6 (5.6)	102 (94.4)

Group 1: Sperm counts 0 -19 x 10^6/ml

Group 2: Sperm counts $>$19 x 10^6/ml

Percentage in parentheses

TABLE 32

PREDICTION RESULTS OF SPERM COUNTS BY DISCRIMINANT ANALYSIS OF FSH, LH AND TESTOSTERONE LEVELS FOR 140 MEN

Group	N	Predicted Group Membership	
		Group 1	Group 2
1	17	8 (47.1)	9 (52.9)
2	108	27 (25.0)	81 (75.0)
3	15	14 (93.3)	1 (6.7)

Group 1: Sperm counts 1 -19 x 10^6/ml

Group 2: Sperm counts $>$19 x 10^6/ml

Group 3: Azoospermia

Percentage in parentheses

TABLE 33

PREDICTION RESULTS OF SPERM COUNTS BY DISCRIMINANT ANALYSIS OF FSH, LH AND TESTOSTERONE LEVELS FOR 140 MEN

Group	N	Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
1	64	31 (48.4)	33 (51.6)
2	76	11 (14.5)	65 (85.5)

Group 1: Sperm count 0 -49 x 10^6/ml

Group 2: Sperm count >49 x 10^6/ml

Percentage in parentheses

TABLE 34

PREDICTION RESULTS OF SPERM COUNTS BY DISCRIMINANT ANALYSIS OF FSH, LH AND TESTOSTERONE LEVELS FOR 140 MEN

Group	N	Predicted Group Membership: Group 1	Predicted Group Membership: Group 2
1	49	25 (51.0)	24 (49.0)
2	76	20 (26.3)	56 (73.7)
3	15	15 (100)	0

Group 1: Sperm counts 1 -49 x 10^6/ml

Group 2: Sperm count $> 49 \times 10^6$/ml

Group 3: Azoospermia

Percentages are in parentheses

TABLE 35

PREDICTION RESULTS OF SPERM COUNTS BY DISCRIMINANT ANALYSIS OF FSH, LH AND TESTOSTERONE LEVELS FOR 140 MEN

		Predicted Group Membership	
Group	N	Group 1	Group 2
1	34	19 (55.9)	15 (44.1)
2	77	23 (29.9)	54 (70.1)
3	29	(72.4)	(27.6)

Group 1: Sperm counts 20 –49 x 10^6/ml

Group 2: Sperm counts $>$49 x 10^6/ml

Group 3: Sperm counts 0 –19 x 10^6/ml

Percentages are in parentheses

Table 36

PREDICTION RESULTS FOR SPERM COUNTS BY DISCRIMINANT ANALYSIS OF FSH FOR 140 MEN

Group	N	Predicted Group Membership: Group 1	Group 2
1	32	16 (50.0)	16 (50.0)
2	108	3 (2.8)	105 (97.2)

Group 1: Sperm counts 0-19 x 10^6/ml

Group 2: Sperm counts $>$19 x 10^6/ml

Percentages in Parentheses

Table 37

Prediction Results for Sperm Counts by Discriminant Analysis of LH for 140 Men

		Predicted Group Membership	
Group	N	Group 1	Group 2
1	32	17 (53.1)	15 (46.9)
2	108	20 (18.5)	88 (81.5)

Group 1: Sperm counts 0-19 x 10^6/ml

Group 2: Sperm counts $>$19 x 10^6/ml

Percentages in parentheses

TABLE 38

PREDICTION RESULTS FOR SPERM COUNTS BY DISCRIMINANT ANALYSIS OF FSH FOR 140 MEN

		Predicted Group Membership	
Group	N	Group 1	Group 2
1	64	23 (35.9)	41 (64.1)
2	76	3 (3.9)	73 (96.1)

Group 1: Sperm counts 0-49 x 10^6/ml

Group 2: Sperm counts $>$49 x 10^6/ml

Percentages in Parentheses

TABLE 39

PREDICTION RESULTS FOR SPERM COUNTS BY DISCRIMINANT ANALYSIS OF LH FOR 140 MEN

		Predicted Group Membership	
Group	N	Group 1	Group 2
1	64	26 (40.6)	38 (59.4)
2	76	20 (26.3)	56 (73.7)

Group 1: Sperm counts 0-49 x 10^6/ml

Group 2: Sperm counts $>$49 x 10^6/ml

Percentages in Parentheses

TABLE 40

CORRELATION COEFFICIENTS OF SMA-12 DATA
FROM 46 SELECTED OCCID. CHEM. CO. EMPLOYEES - 1977

VARIABLE	MEAN	STANDARD DEV	CASES
AGE	34.8696	10.0716	46
SPERM	50.2567	61.3000	45
TP	7.3999	.3783	46
ALBU	4.5978	.2216	46
CALC	9.5370	.3714	46
INPHOS	2.3457	.3954	46
CHOL	196.5217	65.2951	46
GLU	97.5652	39.9142	46
URIC	6.1843	1.2644	46
CREAT	1.0217	.1381	46
BILI	.7761	.4083	46
ALPHOS	77.1304	19.8266	46
LDH	193.3478	40.0273	46
SGOT	29.0435	15.8029	46

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	AGE	SPERM	TP	ALBU	CALC	INPHOS	CHOL	GLU	URIC	CREAT	BILI	ALPHOS	LDH
SPERM	-.23025												
TP	.25737	.05960											
ALBU	-.14703	.10024	.23857										
CALC	-.23898	.30518	.34480	.65712									
INPHOS	-.07296	-.03580	.18424	-.00139	.07754								
CHOL	.28203	.06053	.57802	.03126	.07332	.18689							
GLU	.29313	-.05079	.41237	-.20286	-.11387	.28490	.64719						
URIC	.08269	.02127	.26089	.00305	.11811	-.01592	-.02300	-.16130					
CREAT	-.13251	.23244	-.07656	.21942	.16596	-.22208	-.13457	-.31794	.42445				
BILI	-.13013	-.06943	-.10070	-.01778	.06750	-.06191	-.30539	-.26420	.28163	.29708			
ALPHOS	.02343	.07615	.33428	-.13043	-.01727	.01623	.35623	.32489	.20743	-.12361	-.22623		
LDH	.25121	-.23993	.45421	-.16652	-.14543	.16832	.55185	.43733	.14518	-.15898	-.23332	.41375	
SGOT	-.08040	-.05294	.19144	-.13768	-.02943	.11811	-.06646	-.03735	.43879	.00465	.01635	.39149	.22271

TABLE 41

SUMMARY OF SMA-12 MULTIPLE REGRESSION ANALYSIS

ON 46 SELECTED OCCID. CHEMICAL CO. EMPLOYEES - 1977

DEPENDENT VARIABLE.. SPERM

S U M M A R Y T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	CALC		4.44906	.041	.30618	.09375	.09375	.30618	4.44806	.041
2	LDH		2.31901	.135	.37569	.14115	.04740	-.23993	3.45120	.041
3	CHOL		1.96179	.16[illegible]	.42469	.18036	.03922	.06093	3.00742	.041
4	AGE		2.17772	.148	.47189	.22268	.04232	-.23625	2.86478	.035
5	CREAT		1.55236	.220	.50243	.25244	.02976	.23244	2.61395	.038
6	ALBU		1.82143	.185	.53538	.28663	.03419	.10024	2.54476	.036
7	BILI		1.47124	.233	.56028	.31391	.02728	-.06043	2.41845	.033
8	ALPHOS		.46330	.500	.56801	.32264	.00872	.07615	2.14340	.057
9	TP		.18437	.670	.57113	.32619	.00355	.05960	1.83259	.088
10	URIC		.12417	.727	.57327	.32864	.00245	.02127	1.66435	.130
11	GLU		.16590	.686	.57619	.33200	.00336	-.05679	1.49101	.182
12	SGOT		.03095	.861	.57675	.33264	.00065	-.05294	1.32920	.251

TABLE 42

MEAN SMA 12 MEASURES DATA BY AREA OF PLANT WORKED AMONG 64 DBCP EXPOSED MALE EMPLOYEES

Area	Variable												
	Age	TP	ALBU	CALC	INPHOS	CHOL	GLU	URIC	CREAT	BILI	ALPHOS	LDH	SGOT
Ag. Chem. N = 38	32.82	7.18	4.62	9.60	2.92	183.64	92.51	5.92	1.00	.82	78.64	178.85	26.97
BEST N = 12	36.89	7.32	4.59	9.51	2.78	198.32	87.89	6.10	1.09	.71	79.67	202.78	27.67
Applicator N = 14	42.50	7.61	4.50	9.36	2.88	239.70	120.30	6.51	.96	.64	88.00	233.50	31.10

TABLE 43

REASON FOR NONPARTICIPATION IN MEDICAL EXAMINATION ASPECT OF STUDY BY 63 WORKERS, BUT WHO ANSWERED QUESTIONNAIRE

Reason		Number
Sterile (Employee) [vasectomized]		20
Sterile (Wife)		6
Did not wish to give specimen		3
"Not interested"		23
Religious		1
Other		10
	TOTAL	63

TABLE 44

WORK EXPERIENCE IN THE AG CHEM PLANT OF 63 NONPARTICIPANTS IN THE MEDICAL EXAMINATION, BUT WHO ANSWERED QUESTIONNAIRE

Work Experience in Ag Chem		Number
None		37
1 year or less		19
More than 1 year		5
Not stated		2
	TOTAL	63

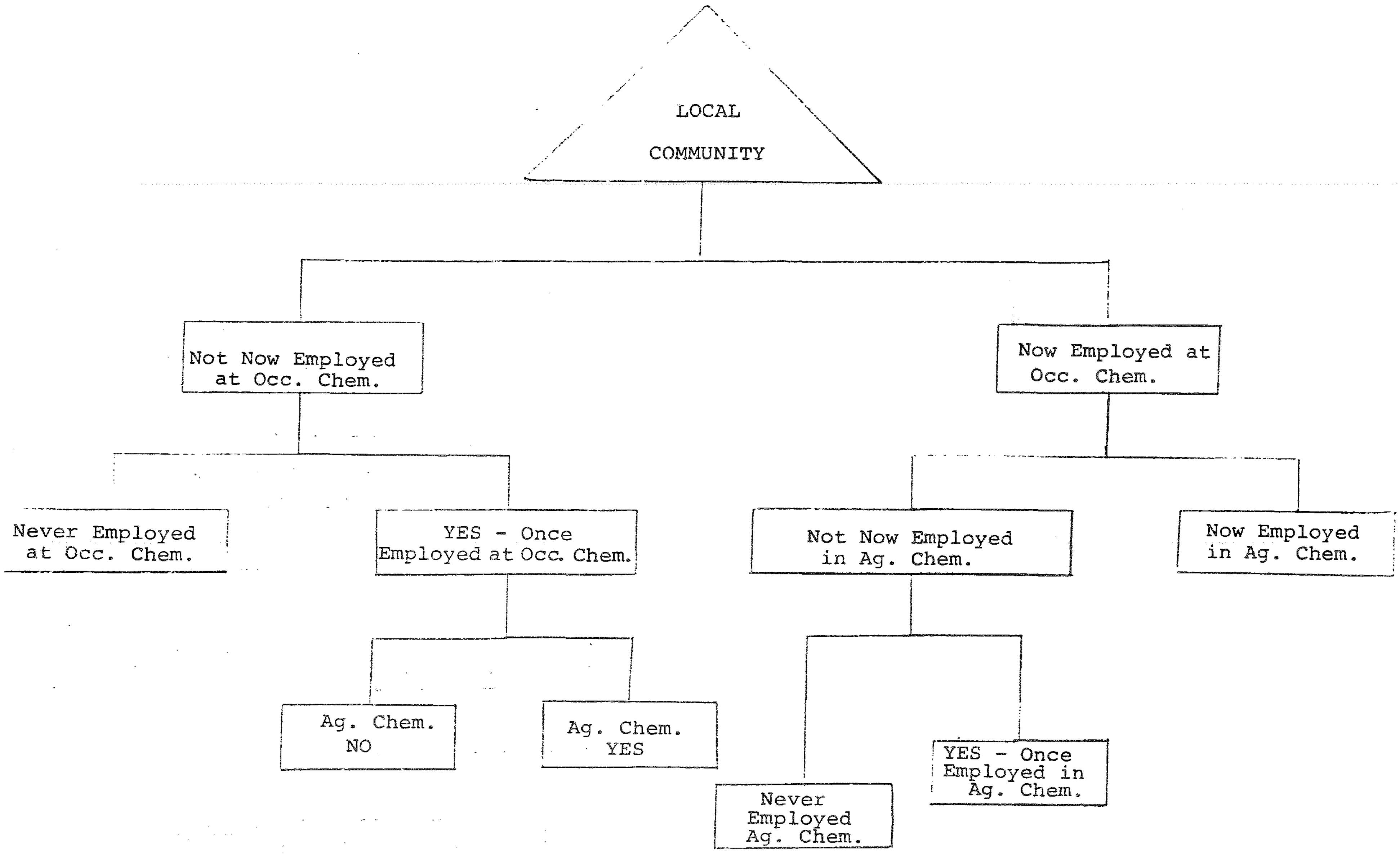
TABLE 45

PERCENTAGE USE OF VARIOUS BIRTH CONTROL METHODS

Type of Method	% Used
None	26.9
Vasectomy	22.8
Wife Sterile (surgical or menopause)	19.3
Pill	13.2
Condom/Diaphragm	3.6
IUD	2.5
Wife Pregnant	2.0
Other	9.6

Figure 1

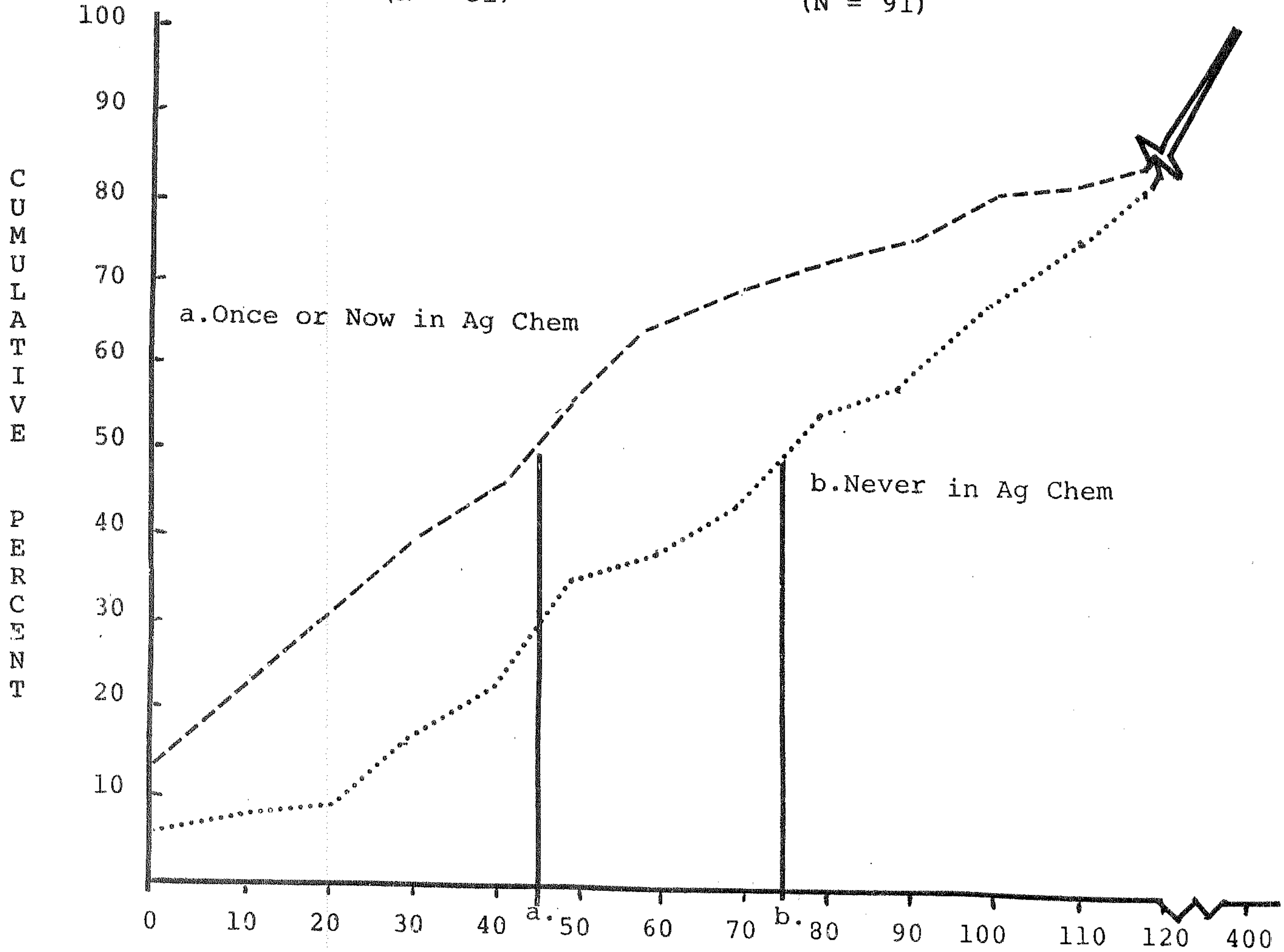
SAMPLING STRATEGY
OCCIDENTAL CHEMICAL COMPANY



Note: To be considered "Employed," 3+ months required.

Figure 2

Cumulative Percentage Distributions for
Sperm Count for Two Groups:
a. Once in Ag Chem (N = 51) b. Never in Ag Chem (N = 91)



Sperm Count in Millions:

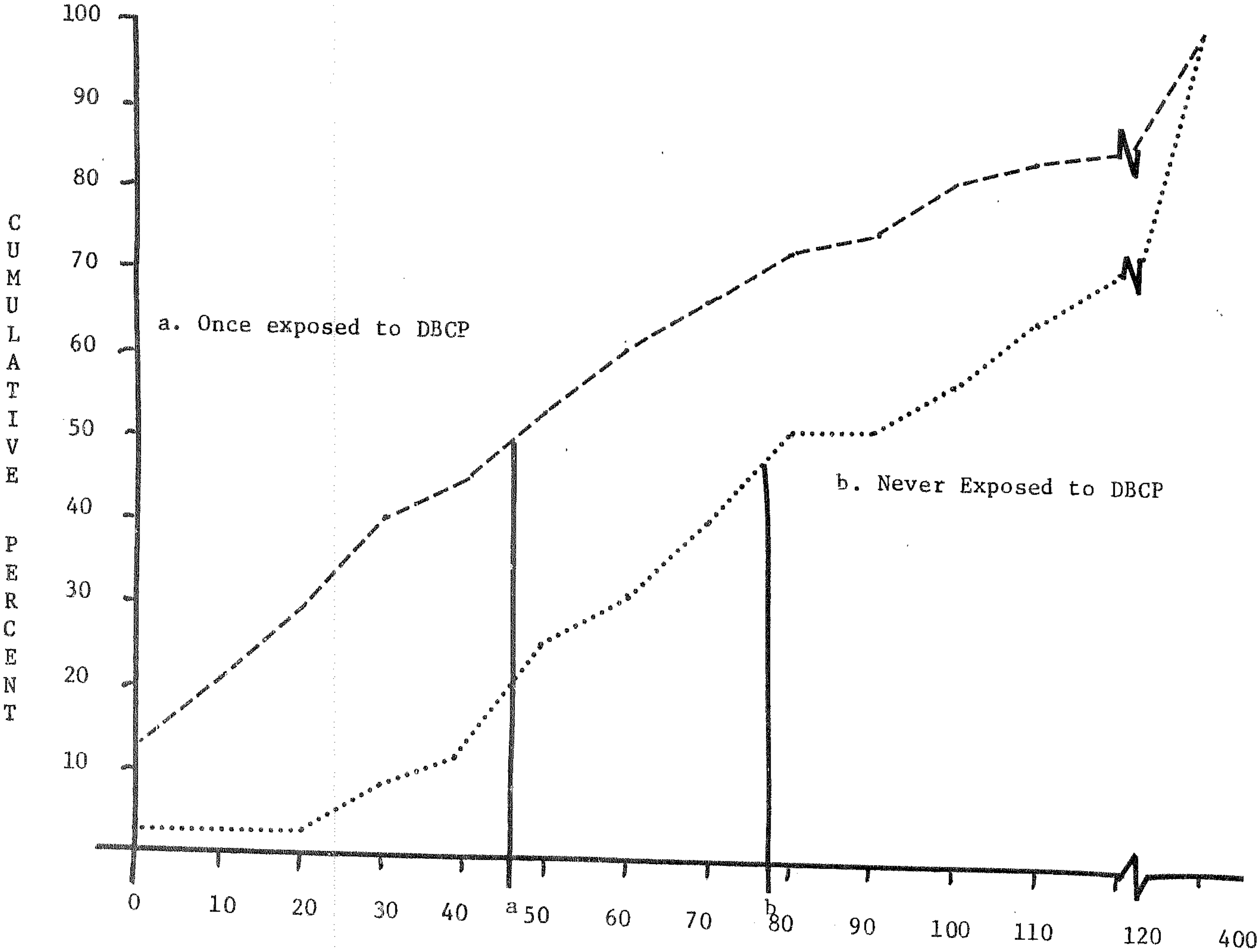
a. Median Sperm Count = 45.0 x 10^6/ml

b. Median Sperm Count = 73.3 x 10^6/m.

Figure 3

Cumulative Percentage Distributions for Sperm Count for Two Groups:

a. Exposed to DBCP (N = 107) b. Never Exposed to DBCP (N = 35)



Sperm Count in Millions:

a. Median Sperm Count = 45.6×10^6/ml

b. Median Sperm Count = 78.7×10^6/ml

Figure 4

Percent Distribution of Sperm Counts Among
142 Occidental Chemical Company Employees - 1977

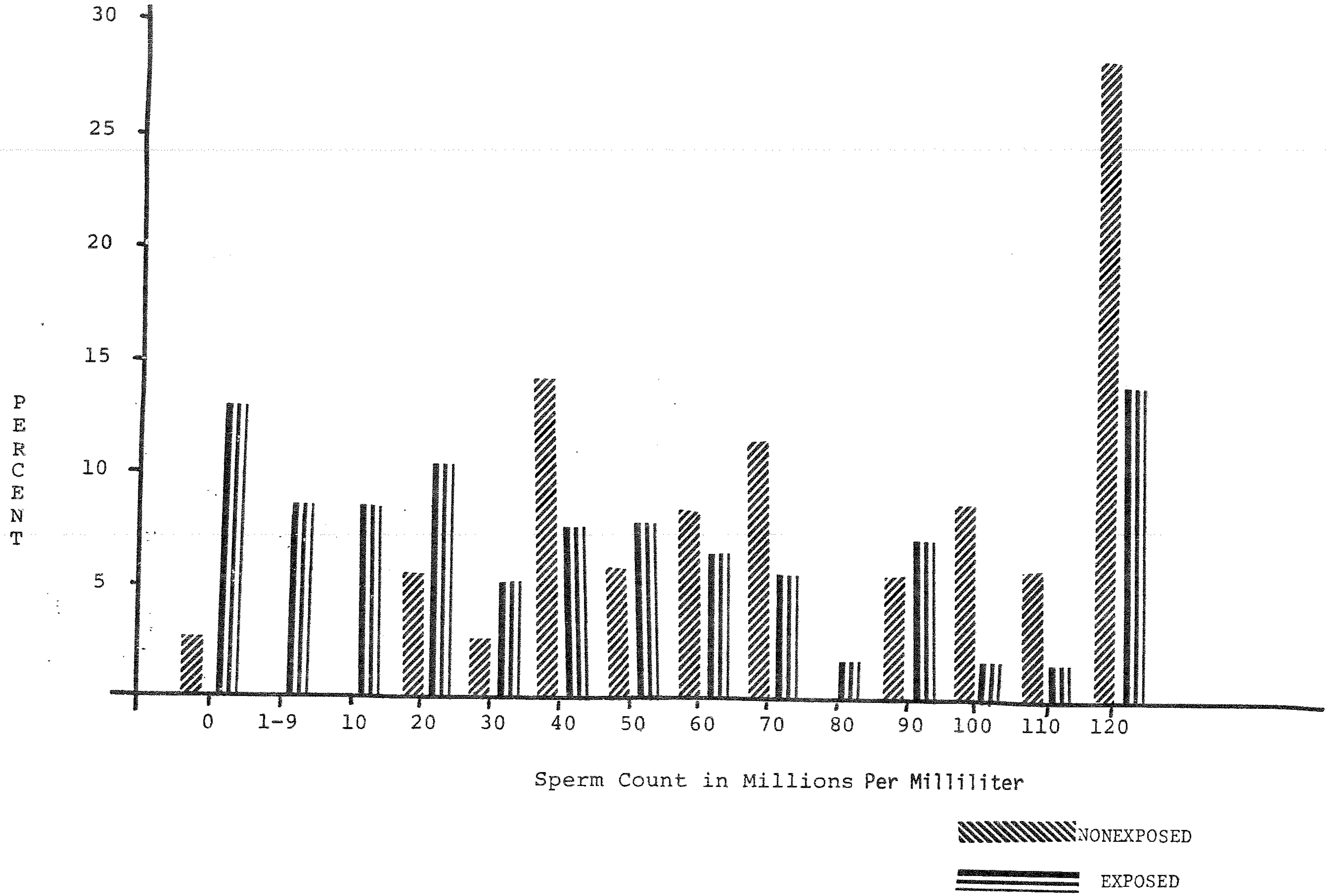
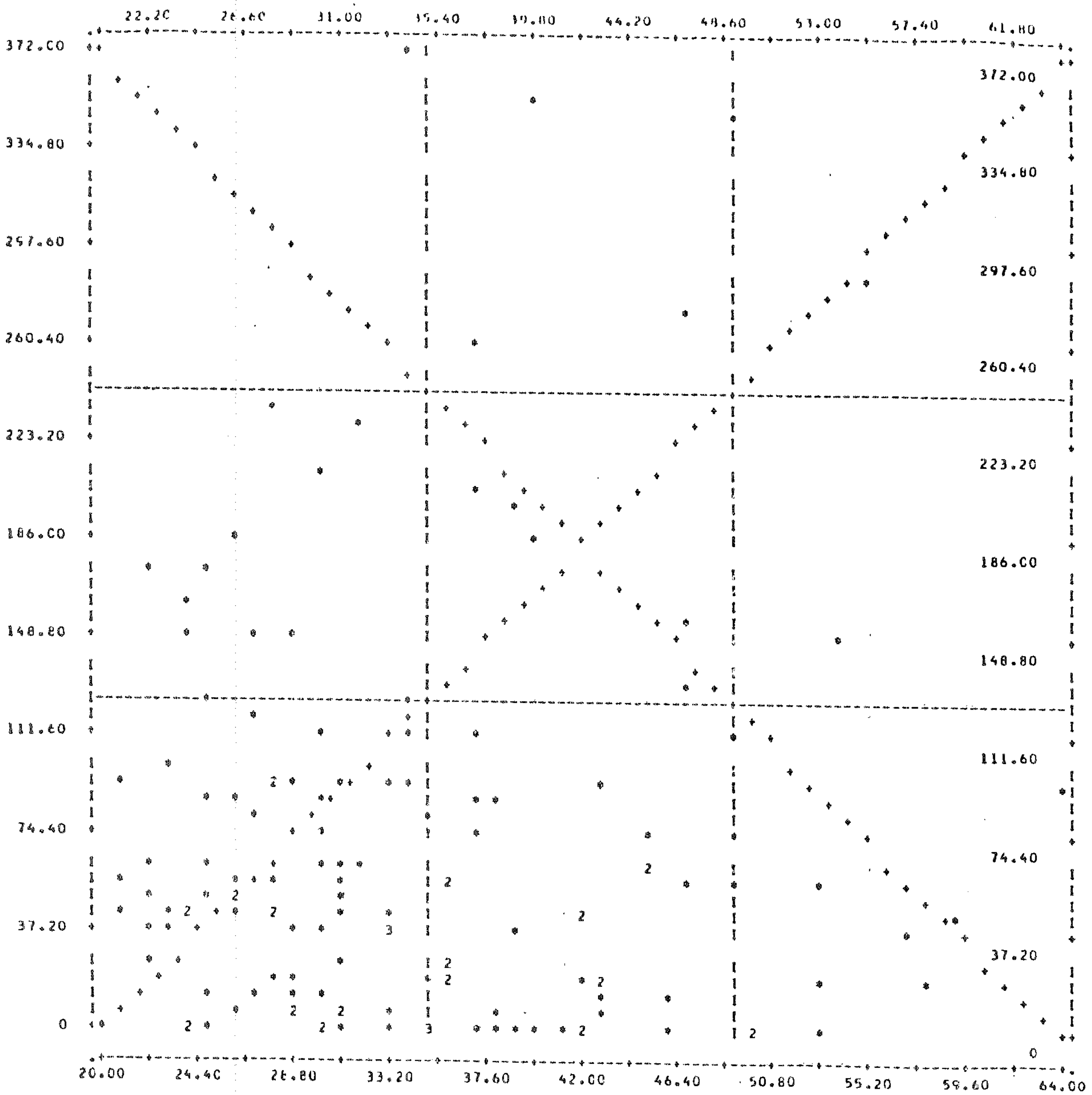


FIGURE 5

SCATTERGRAM BY AGE AND SPERM COUNT OF 142 EMPLOYEES



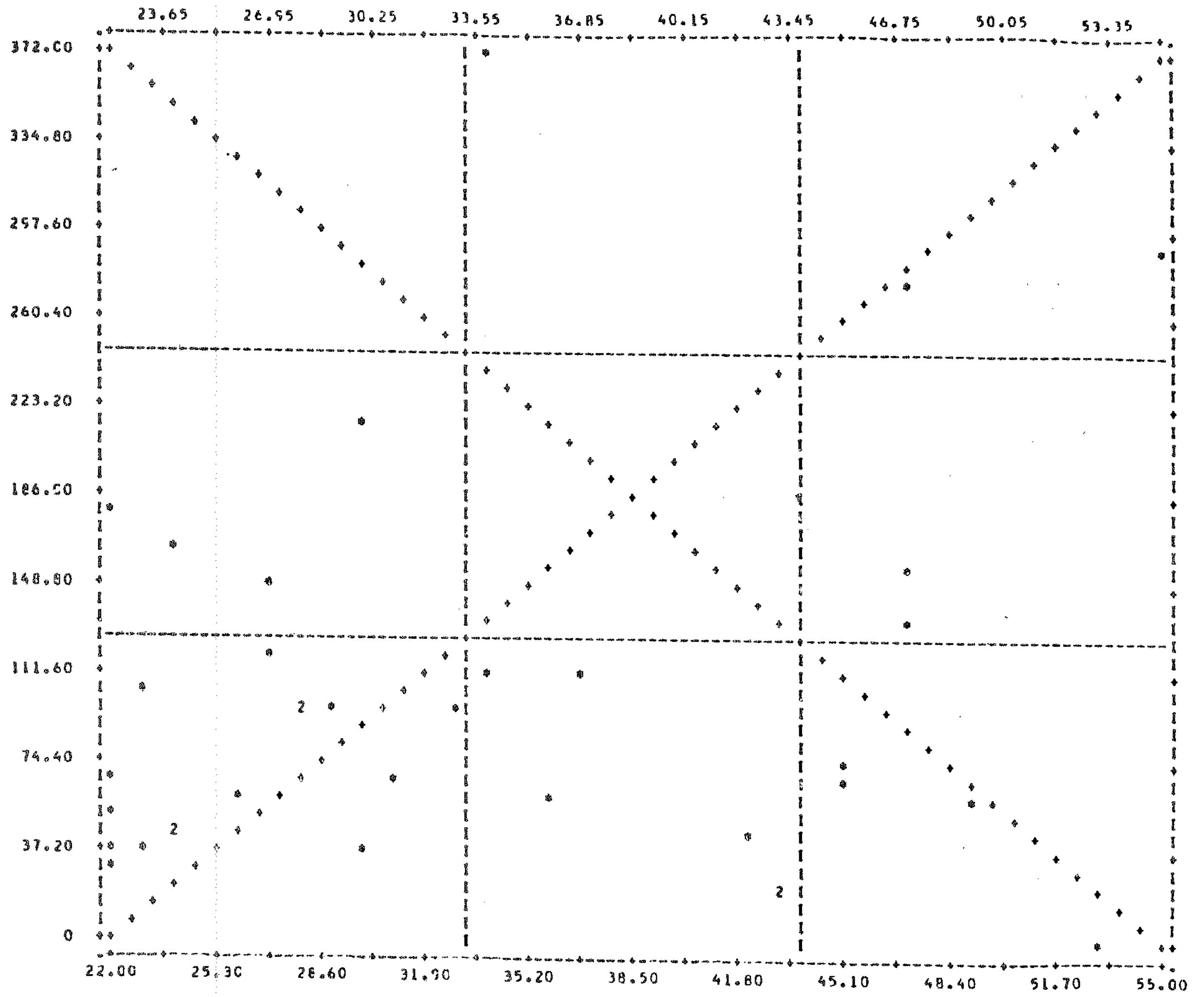
SECOND RUN OXY CHEM DATA 10/14/77 PAGE 8

STATISTICS..

CORRELATION (R)-	.06346	R SQUARED -	.00403	SIGNIFICANCE R -	.22652
STD ERR OF EST -	76.65839	INTERCEPT (A) -	56.59689	STD ERROR OF A -	24.40382
SIGNIFICANCE A -	.01092	SLOPE (B) -	.51363	STD ERROR OF B -	.68262
SIGNIFICANCE B -	.22652				
PLOTTED VALUES -	142	EXCLUDED VALUES-	0	MISSING VALUES -	9

FIGURE 6

SCATTERGRAM BY AGE AND SPERM COUNT OF 35 NONEXPOSED EMPLOYEES



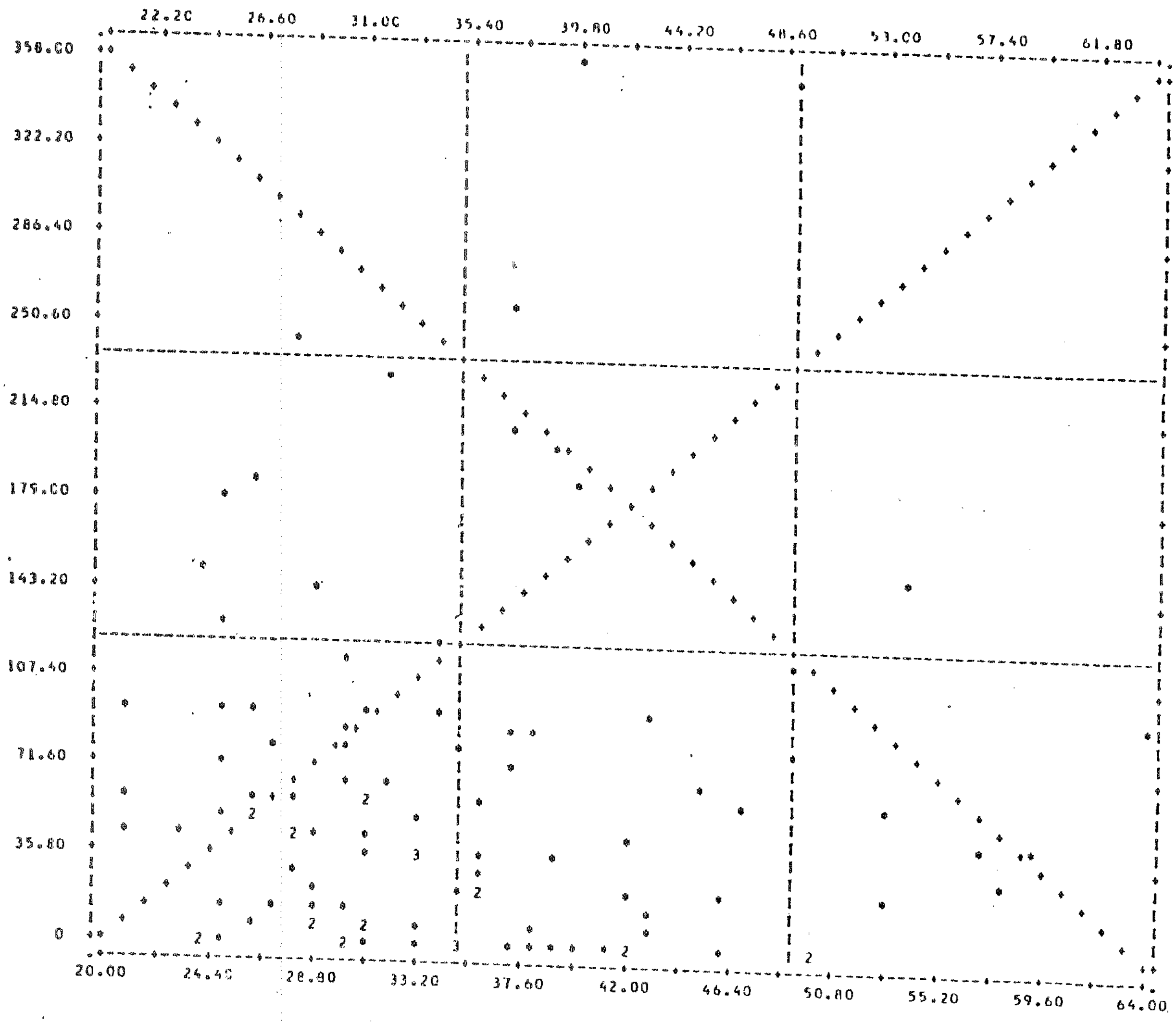
FINAL RUN OF OXY CHEM DATA 10/12/77 PAGE 3

STATISTICS..

CORRELATION (R)-	.17323	R SQUARED -	.03001	SIGNIFICANCE R -	.15983
STD ERR OF EST -	82.40270	INTERCEPT (A) -	59.52115	STD ERROR OF A -	48.30735
SIGNIFICANCE A -	.11330	SLOPE (B) -	1.39332	STD ERROR OF B -	1.37900
SIGNIFICANCE B -	.15983				
PLOTTED VALUES -	35	EXCLUDED VALUES-	0	MISSING VALUES -	0

FIGURE 7

SCATTERGRAM BY AGE & SPERM COUNT OF 107 EXPOSED EMPLOYEES



FINAL RUN OF OXY CHEM DATA

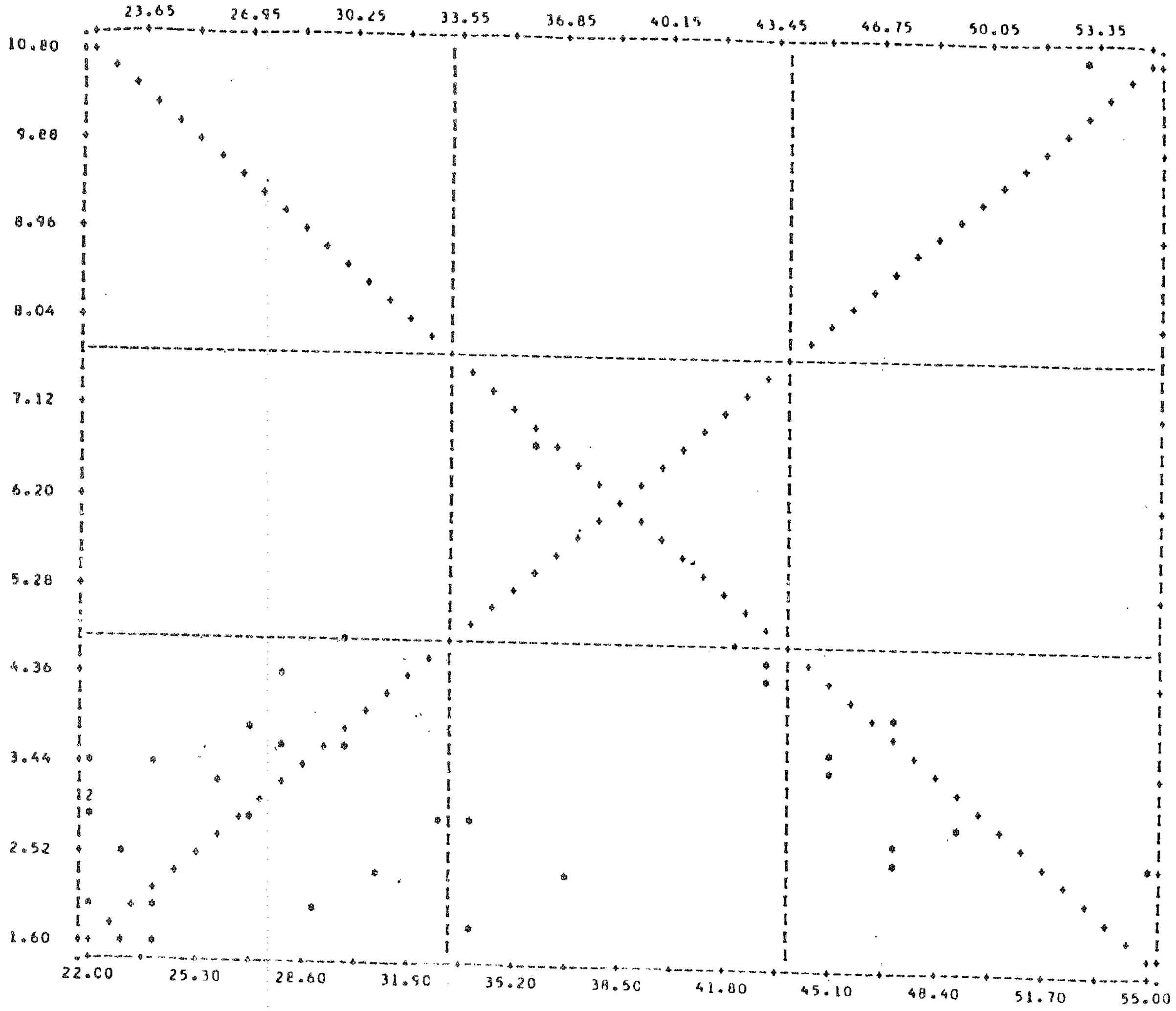
10/14/77 PAGE 3

STATISTICS..

CORRELATION (R)-	.04134	R SQUARED -	.00171	SIGNIFICANCE R -	.33624
STD ERR OF EST -	72.15639	INTERCEPT (A) -	52.64023	STD ERROR OF A -	27.36909
SIGNIFICANCE A -	.02857	SLOPE (B) -	.32245	STD ERROR OF B -	.76062
SIGNIFICANCE B -	.33624				
PLOTTED VALUES -	107	EXCLUDED VALUES-	0	MISSING VALUES -	9

FIGURE 8

SCATTERGRAM OF FSH AND AGE OF 35 NON-EXPOSED, NON-VASECTOMIZED EMPLOYEES



FINAL RUN OF OXY CHEM DATA

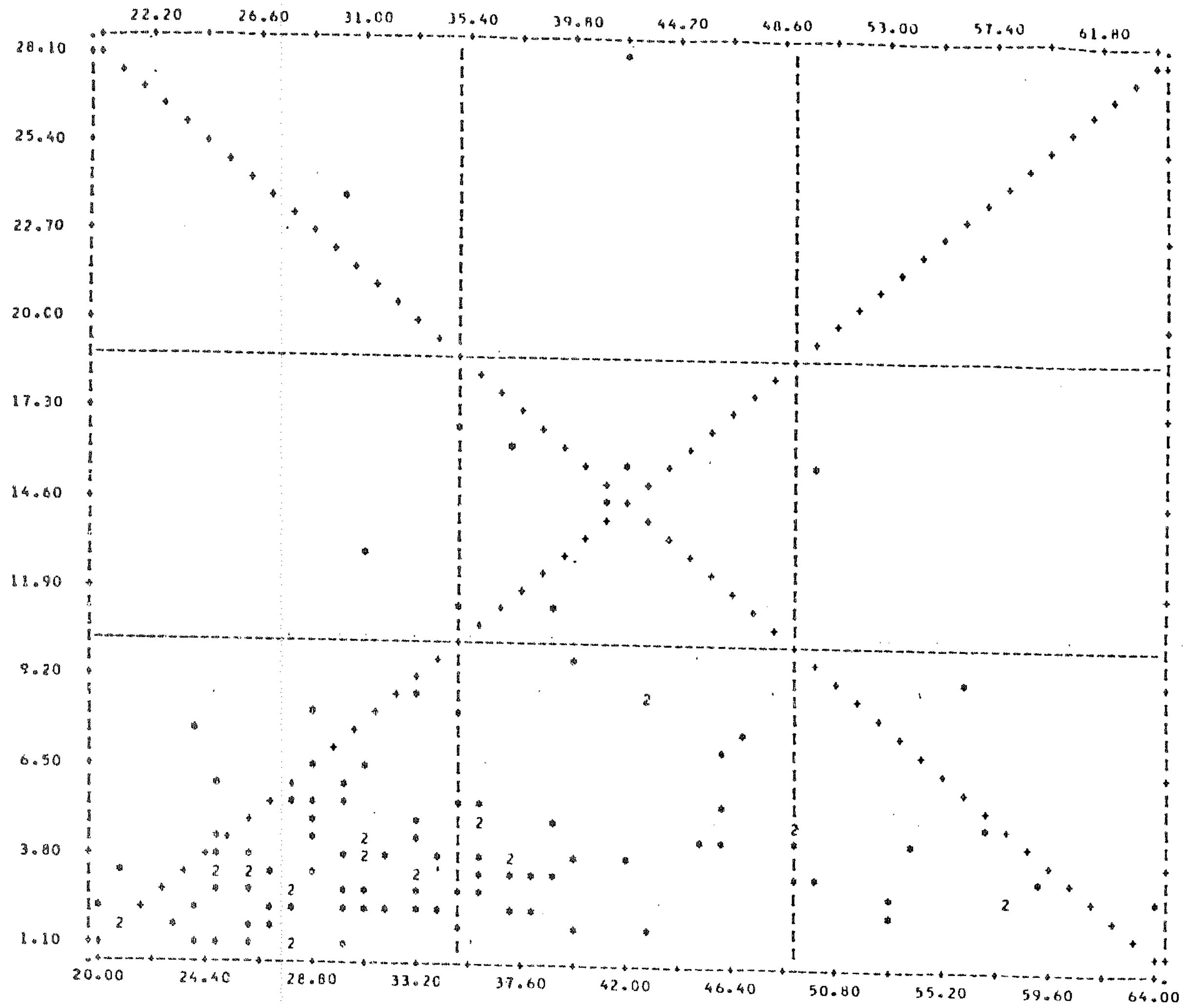
10/12/77 PAGE 9

STATISTICS..

CORRELATION (R)-	.40234	R SQUARED -	.16188	SIGNIFICANCE R -	.00829
STD ERR OF EST -	1.54555	INTERCEPT (A) -	1.28631	STD ERROR OF A -	.90864
SIGNIFICANCE A -	.08312	SLOPE (B) -	.06548	STD ERROR OF B -	.02594
SIGNIFICANCE B -	.00829				
PLOTTED VALUES -	35	EXCLUDED VALUES-	0	MISSING VALUES -	0

FIGURE 9

SCATTERGRAM BY FSH AND AGE OF 114 EXPOSED NONVASECTOMIZED EMPLOYEES



FINAL RUN OF OXY CHEM DATA

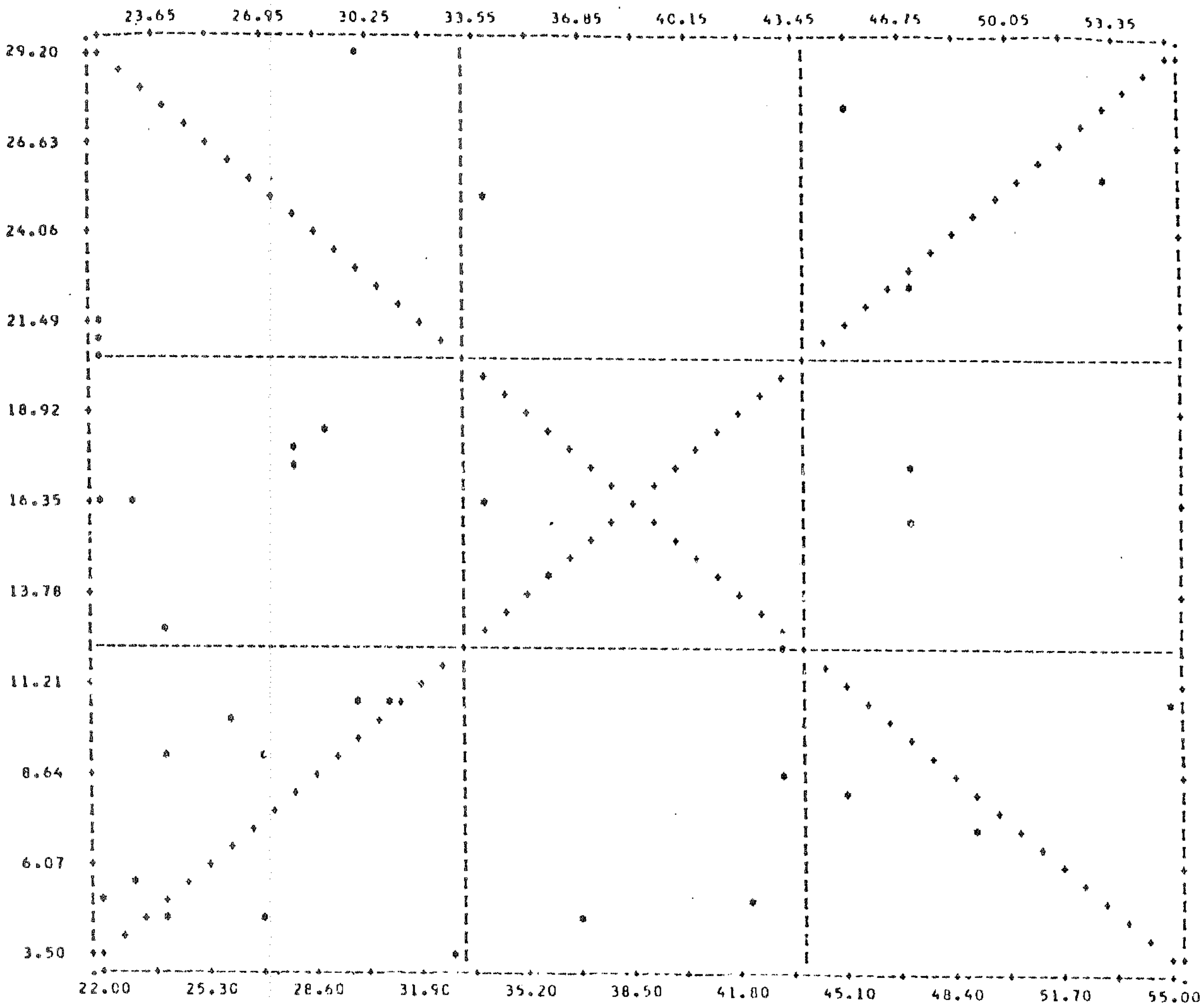
10/14/77 PAGE 10

STATISTICS..

CORRELATION (R)-	.17635	R SQUARED -	.03110	SIGNIFICANCE R -	.03026
STD ERR OF EST -	4.31410	INTERCEPT (A) -	2.39610	STD ERROR OF A -	1.54594
SIGNIFICANCE A -	.06199	SLOPE (B) -	.08042	STD ERROR OF B -	.04241
SIGNIFICANCE B -	.03026				
PLOTTED VALUES -	114	EXCLUDED VALUES-	0	MISSING VALUES -	2

FIGURE 10

SCATTERGRAM OF LH AND AGE OF 35 NONEXPOSED, NONVASECTOMIZED EMPLOYEES



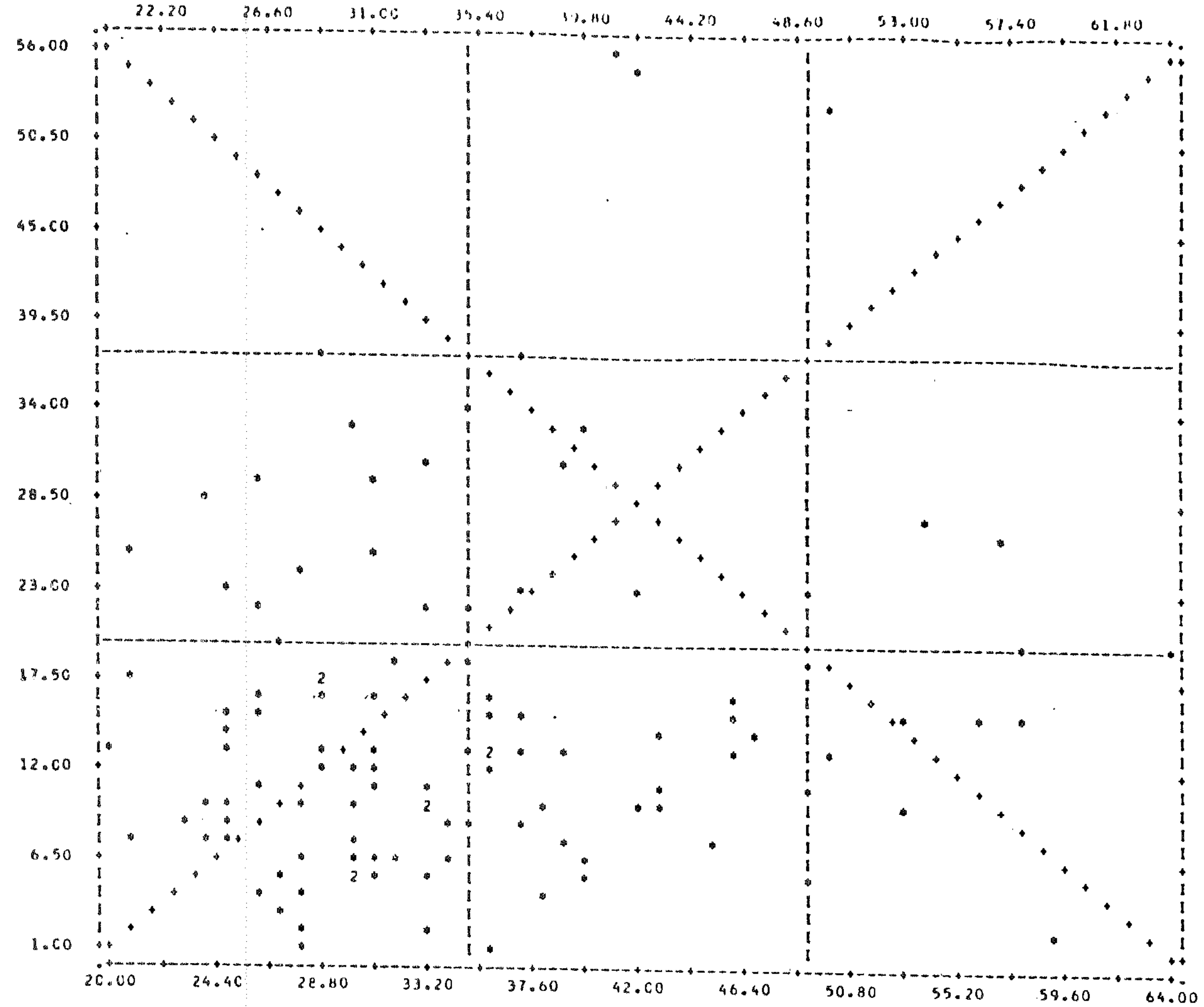
FINAL RUN OF OXY CHEM DATA 10/12/77 PAGE 5

STATISTICS..

CORRELATION (R)-	.09910	R SQUARED -	.00982	SIGNIFICANCE R -	.28556
STD ERR OF EST -	7.32139	INTERCEPT (A) -	11.73729	STD ERROR OF A -	4.29205
SIGNIFICANCE A -	.00504	SLOPE (B) -	.07010	STD ERROR OF B -	.12252
SIGNIFICANCE B -	.28556				
PLOTTED VALUES -	35	EXCLUDED VALUES-	0	MISSING VALUES -	0

FIGURE 11

SCATTERGRAM OF LH AND AGE OF 114 EXPOSED, NONVASECTOMIZED EMPLOYEES



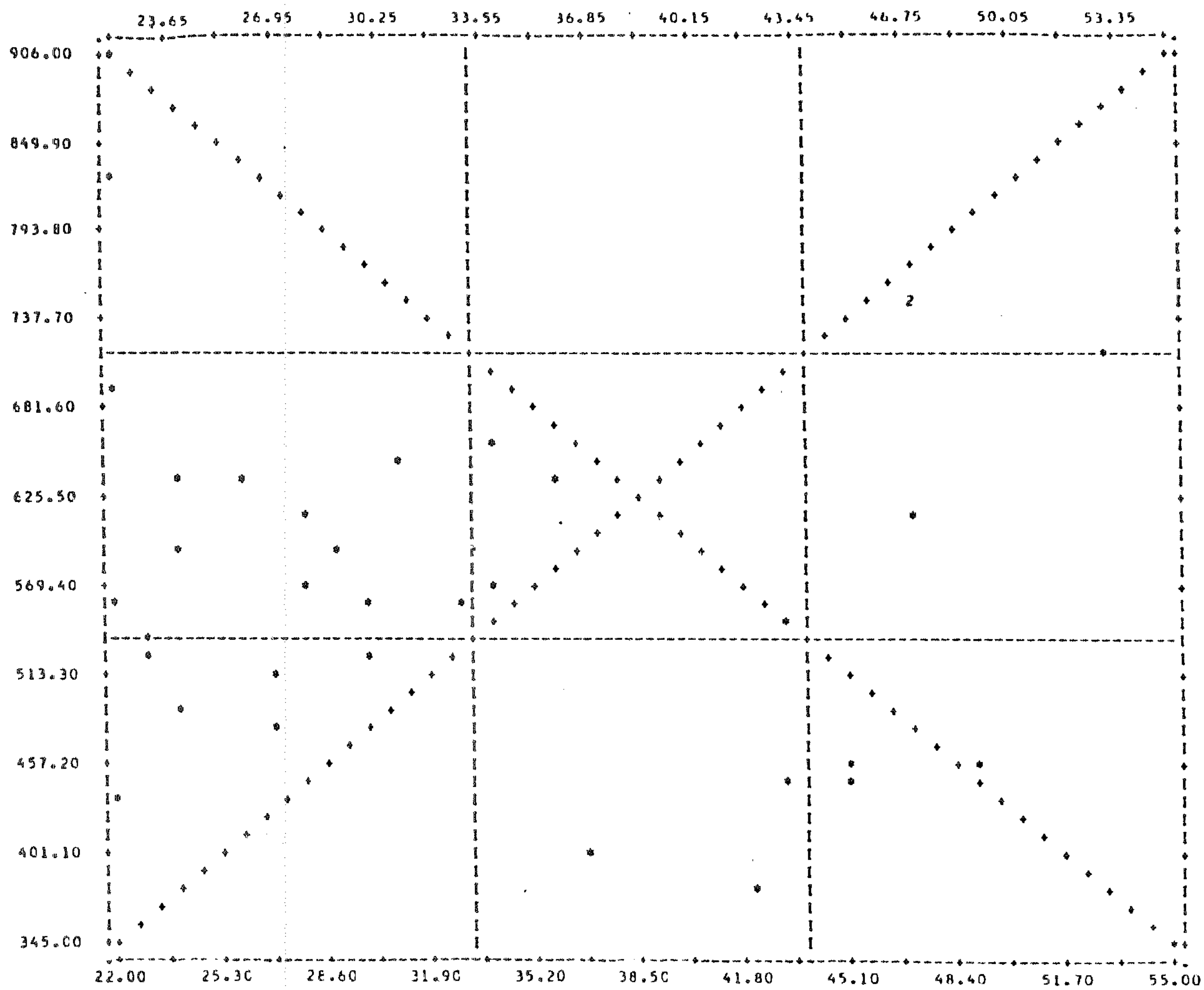
FINAL RUN OF OXY CHEM DATA 10/14/77 PAGE 6

STATISTICS..

CORRELATION (R)-	.15749	R SQUARED -	.02480	SIGNIFICANCE R -	.04712
STD ERR OF EST -	10.29976	INTERCEPT (A) -	9.77155	STD ERROR OF A -	3.69087
SIGNIFICANCE A -	.00464	SLOPE (B) -	.17089	STD ERROR OF B -	.10126
SIGNIFICANCE B -	.04712				
PLOTTED VALUES -	114	EXCLUDED VALUES-	0	MISSING VALUES -	2

FIGURE 12

SCATTERGRAM OF TESTOSTERONE AND AGE OF 35 NONEXPOSED NONVASECTOMIZED EMPLOYEES



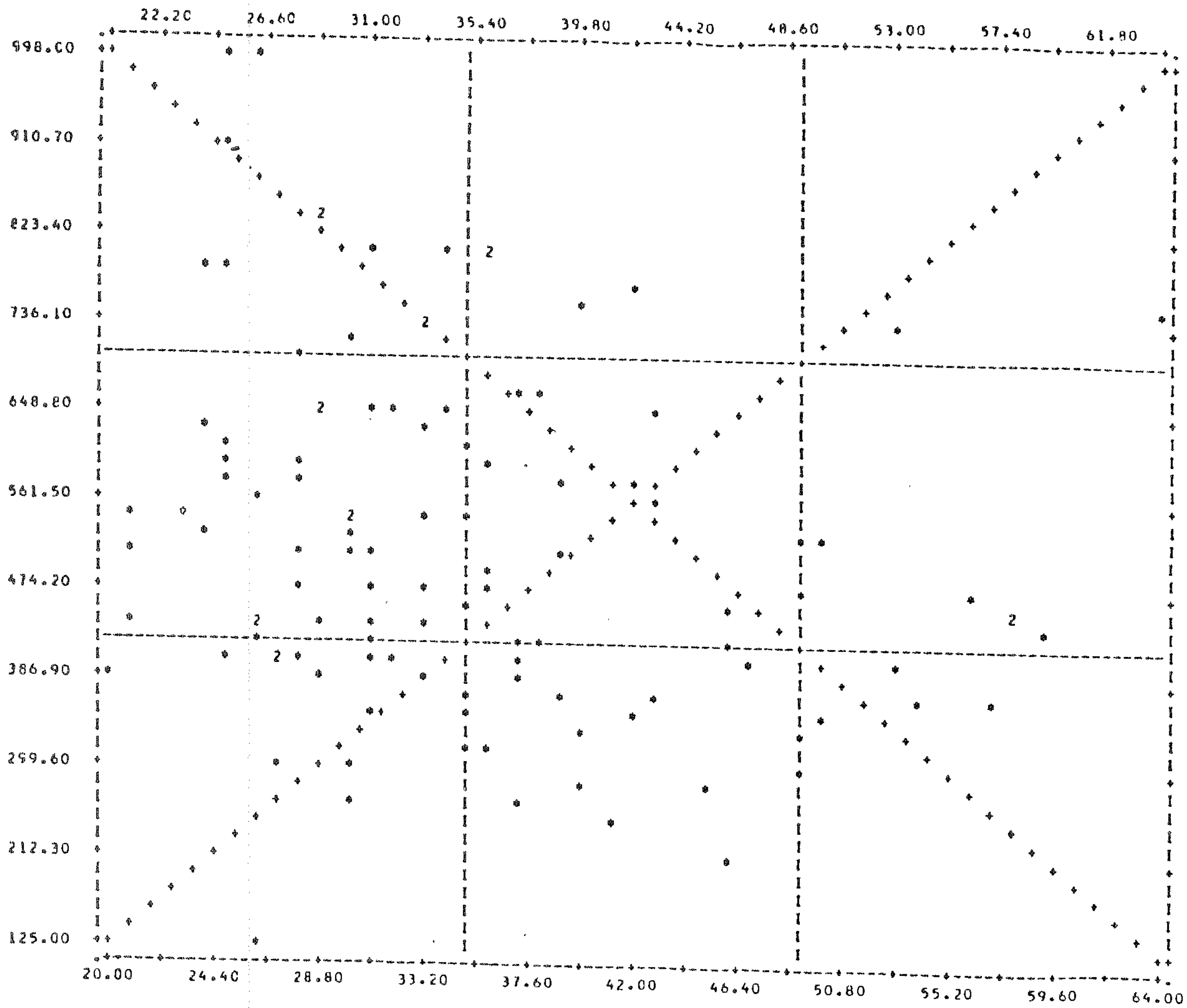
FINAL RUN OF OXY CHEM DATA 10/12/77 PAGE 7

STATISTICS..

CORRELATION (R)-	-.23223	R SQUARED -	.05393	SIGNIFICANCE R -	.08973
STD ERR OF EST -	122.32269	INTERCEPT (A) -	672.60430	STD ERROR OF A -	71.70984
SIGNIFICANCE A -	.00001	SLOPE (B) -	-2.80762	STD ERROR OF B -	2.04706
SIGNIFICANCE B -	.08973				
PLOTTED VALUES -	35	EXCLUDED VALUES-	0	MISSING VALUES -	0

FIGURE 13

SCATTERGRAM OF TESTOSTERONE AND AGE OF 114 EXPOSED, NONVASECTOMIZED EMPLOYEES



FINAL RUN OF OXY CHEM DATA

10/14/77 PAGE 8

STATISTICS..

CORRELATION (R)-	-.20142	R SQUARED -	.04057	SIGNIFICANCE R -	.01582
STD ERR OF EST -	167.88616	INTERCEPT (A) -	651.22566	STD ERROR OF A -	60.16130
SIGNIFICANCE A -	.00001	SLOPE (B) -	-3.59180	STD ERROR OF B -	1.65046
SIGNIFICANCE B -	.01582				
PLOTTED VALUES -	114	EXCLUDED VALUES-	0	MISSING VALUES -	2