90

good!

LEAD POISONING DURING CONSTRUCTION
OF
THE GOLDEN GATE BRIDGE, 1934-1937

4-15-64

Dr. Kehoe -

I could find no record in our library of this epidemic + thought you might like to have this extra copy.

Phil Kronenfeld

I INTRODUCTION: THE HOST, THE ENVIRONMENT AND THE AGENT

The subject "Plumbism among Golden Gate Bridge Workers" was chosen for the term paper for Epidemiology as the writer has done some research on this particular epidemic in connection with his employment. In addition the information, though incomplete, comes from the unpublished files of the California Division of Industrial Safety and may have special interest and record value to the Kettering Laboratory, which has concerned itself extensively with this disease.

In industry lead is encountered as metallic lead as well as various compounds, principally oxides, carbonates, sulphates, chromates, sulphides and disilicates. The hazard is not the same for all compounds, but varies from almost nothing in the case of the disilicates and sulphides to considerable in the case of the oxides.

The three avenues of entrance of inorganic lead compounds into the body in order of importance are the respiratory tract, mouth, ~~and skin when it is broken~~. In this epidemic the incidence was due to inhalation of the oxides, PbO (litharge) and Pb_3O_4 (Red Lead).

One hundred and thirty cases were documented as lead poisoning and symptoms are so similar in almost all the cases that they can be typified by the following two cases diagnosed by L.H. Cotter in another epidemic when an elevated railway in New York City was cut down. Cotter states (1) that incidence of inhaled lead poisoning ran as high as 80 percent when respirators were not used.

Case 1. "G. M. A 44 year-old American born iron worker engaged in burning painted steel for four months. Pain and constipation whole period. Became nauseated by smell of paint. Unable to sleep last two weeks. Showed lead line* and abdominal rigidity. Urine 1 mg/liter, blood .2 mg/100 cc, basophilic stippling 0.9%, reticulocytes 7.2%, blood count: HGB 14 gm., RBC 4,000,000, WBC 6000, neuts 60%, lumphs 31%, monos 1%, eos 5%, basos 3%.

Case 2. "A.B. A 40 year-old French Canadian. Burned painted steel two months wearing cannister respirator. Increasing constipation, loss of weight, abdominal cramps, nausea. Showed lead line and tenderness and rigidity of epigastrium. Urine 0.1 mg/liter, blood 0.6 mg/100 c.c., basophilic stippling 1%, reticulocytes 7.5%, blood count: HGB 10 gm., RBC 3,000,000, WBC 4,000, neuts 65%, lymphs 26%, monos 6%eos 2%, basos 1%."

The beginning of the epidemic, which extended over four years, was in January 1934, when 5 employees of the subcontractor erecting the Marin bridge tower complained of lead poisoning symptoms. The peak was reached in

* A characteristic dark line on the patients' gums.

February of that year when 55 cases were reported and it tapered off through December 1937. See Charts 1 and 2. It appears the epidemic ended because the jobs ended, rather than due to effective corrective action. In fact figures stated in this study are likely to be minimal because of the apparent reluctance of the contractor, the contractor's doctor and state authorities to ascribe the illnesses to lead. This reluctance is understandable from several view points.

1. Most of those affected were engaged in riveting hot rivets into bridge members painted with red lead. This work is usually done in the open air, often in a stiff breeze. *

2. The wearing of forced-air respirators, the only really effective preventative measure, would be difficult to enforce because men working several hundred feet above the water and in precarious positions would probably be uncooperative.

3. Air supply lines would be lenghthy, costly and cumbersome.

In only 17 of the cases is enough information provided in the form of accident reports and correspondence to determine the subclinical process, or what might be termed the incubation period. This information is shown graphically on Table I. The mean length of time for the subclinical process was 57 days. In calculating the mean, the individual who reported sick after 302 days on the job, was omitted. There is no discoverable reason in the file why this person (a riveter) should have had so much longer an incubation period, and so because of statistical variance he is considered a sport. The means for individual trades is as follows: Bridgemen - 47, Riveters - 61, Painters - 61. Estimated * variances between these groups are as follows:

	Bridgeman (5)	Riveters (7)	Painters (4)
$S^2 = \frac{\sum_1^n (x-\bar{x})^2}{n-1}$	583	892	34

Estimated standard deviations are:

$\sqrt{s^2}$	24.2	29.9	5.8

Estimated standard deviation of the means is: 4.7

$S_{\bar{x}} = \frac{S}{\sqrt{n}}$

Estimated 95% confidence levels $(\bar{x} \pm (1.96)(s)$ are: $47.8 < 57 < 66.2$

From the above calculations one would conclude the bridgemen [illegible] are unrelated. However, other imponderable factors might tend to invalidate

*Red lead paint is used as it has the property of expanding and contracting with the steel during temperature changes, and it would appear reasonable that the fumes would be blown away before being inhaled.

* see p.19-20

these statistics. Some men had been working with lead paint for years and others just a short time; canniester gas masks were supplied, and though they were ineffective, they would tend to prolong the incubation period. Only in one case does the file show that a man habitually wore his respirator (see Chart 1). Some men were repeaters. This is noted only once in the sample (see Chart 1) Nor is it ascertainable what men and to what extent worked inside or outside of the towers.

To the industrial hygienist, probably the most interesting aspect of this epidemic would be the attempted control methods, and this constitutes a ~~disease~~ history in itself. The first entry in the file concerning control is in May of 1934 by a consultant, M.K., PH.D. Bio-Physicist whose letter head shows him to be Technical Director of an organization called the "Institute of Physio-Therapy." He seemed to feel discipline would solve the problem, and as a matter of interest his letter to the California Industrial Accident Commission is quoted in full.

"Dear Mr. R.....

Considering the existing avoidable deleterious health hazards faced by workers called upon to paint the small cubicles within the Sausalito Tower of the Golden Gate Bridge, the following is recommended to be rigidly enforced by you, as the Safety Engineer on the premises, for the benefit of all concerned:

PERSONAL HYGIENE:

Every worker on this job is selected for his present physical fitness and his readiness to co-operate with the constituted authorities and his superiors on this job to keep him so fit. This, in return, will safeguard his health, strength and endurance. This is done not only because it increases his capacity to do his work right, but to enable him to stay on the job uninterrupted and satisfactorily without incurring preventable disabilities too costly for all concerned.

THE JOB:

Three shifts at two hours each with forty minutes of rest in the open air between each shift constitutes a day's work of eight hours on this special paint job.

SPECIAL PLEDGE:

In order to keep the men in best physical fitness, the workers selected for this special job pledge themselves to appear for work in a strictly sober condition and with clean and well-aired garments upon their bodies, and that the overalls, shoes, gloves and cap which they put on before starting to work have been well aired during the preceding night and are free from

the noxious odor of turpentine, so harmful in its cumulative effects for their physical well-being. The workers selected for this special job pledge themselves upon their honor, after working hours, to rest up and to wear light, loose and porous clothes and to prevent catching so-called "colds."

Further, to seek outdoor recreation and sleep out of doors, if possible, or at least, in a room well ventilated with an open window. They will avoid all needless muscular excesses and organic strain and other imbalances of living. They will avoid over-eating and partake sparingly, while on this job, of meats and eggs. They will eat some hard, some bulky and some raw foods, also fruit in season and they will eat slowly and masticate well.

They are cautioned to evacuate thoroughly, regularly and frequently, and they will be cautious not to allow poisons and infections to enter their body. They will keep their teeth, gums and tongue clean. Use sufficient water internally and externally. In short, they will work, play, rest and sleep in moderation. While away from work, they will judiciously do everything that will keep themselves in a "fighting trim" for the next day's labor and they will report to the Medical Director on the job at once for whatever symptoms may arise in the day's work. Above all, they must be cheerful and not worry.

The poisoning from turpentine can become a serious matter for them, but no one on this job needs to become sick from the fumes of this material. Their health can be easily preserved but their co-operation in so doing is essential. Only through consistent, constant vigilance and wholesome activity can this be attained and maintained with safety."

The next entry is by the same consultant under the title of "Turpentine Poisoning." As he describes the symptoms of such poisoning, they seem to conform remarkably to the symptoms of lead poisoning. The third and last contribution by this doctor is an eleven page discourse on lead poisoning. This is followed by an informative and valuable pamphlet issued by the National Safety Council. (2)

Had the practices recommended in this pamphlet been enforced, especially the use of positive pressure gas masks, the epidemic would have been ended. Another pamphlet, this one by the U.S. Navy Department follows, which strongly recommends positive pressure gas masks, in particular the Willson mask sold by the Bullard Co. in San Francisco. Careful perusal of the file indicates to the reader that recommendations, good and bad, from the informed and from the ignorant, were treated in the same way. They were not discredited, and they were not acted on. And one keeps turning the pages and seeing casualty after casualty.

The next germane entry is titled, "Rules for the Elimination of Lead Poisoning Cases" by someone identified only as E.G.S.....,C.E., Chief Engineer and Superintendent of Safety. This benighted missive says in part, with seeming authority and no substantiation of quoted statistics, "the control of lead poisoning (from the oxyacetylene flame cutting of steel coated with lead paint) as an occupational disease is principally a matter of hygiene....." "Theoretically, by far the greatest percentage of lead poisoning cases result from the introduction of lead solids or gases into the stomach, a very small percentage by absorption through the lungs, and a still smaller percentage by absorbtion through the skin. The average of the various authorities on the subject place the values of these percentages at 85 percent, 10 percent, and 5 percent." "There is no reason for men getting lead poisoning who take care of themselves and use the facilities provided for them by the company, as has been demonstrated by the experience of other industries, that (sic) these measures are successful." He then goes on to list various musts for cleanliness, smoking, proper clothes and gloves, rinsing the mouth, drinking of citro carbonate instead of water, drinking of milk, keeping the stomach full, avoiding constipation and taking of calcium sulfate pills. He ends with the statement, "Any employee not observing these rules should be subject to immediate dismissal." In justice to E.G.S., his recommendations have some merit, and one concerns gas masks. However he recommends the cannister type which has little value for lead fumes in the two micron magnitude. The value of the positive pressure mask is that it maintains a pressure between the face and the mask greater than ambient pressure, and so prevents any outside fumes or gases from entering the lungs.

At this point in the file there is a 15 page reprint of a report by a Dr. McCord made at the 1929 meeting of the American Public Health Association. (3) This report adequately and comprehensively details preventative measures and outlines an effective safety program.

Without laboring the point further or introducing other legitimate advice contained in the file, it is evident that information necessary to prevent this epidemic was in the hands of those responsible for preventing it and in retrospect is if difficult to understand why it was not used.

On February 15, 1934, the California Department of Industrial Relations sent a telegram to the U. S. Public Health Service in Washington D.C. requesting aid in an emergency study of lead hazards. In the return telegram, the Surgeon General offered to send a man on condition that the state pay his travel expenses. The State wired back that the offer was appreciated but "we are unable to secure funds for traveling expenses." And so the ugly head of buresuocracy was raised and the state continued processing componsation claims for lead poisoning.

On this some date the Golden Gate Bridge Advisory Committee requested the Industrial Accident Commission to take legal steps to see that the tower for the San Francisco end which was being fabricated at Pottstown Pa., be shipped and erected free from all lead paint on splices on parts

where field riveting would be necessary.

On March 1, 1934 two more cases were reported. In one case there were 24,000 stippled cells in one c.c. of blood. A 'Show cause' was issued by the state to the Golden Gate Bridge and Highway District and to the responsible subcontractor for Bethlehem Steel, the McClintic Marshall Company. The order required those employers to show cause why work should not be stopped until the hazard was removed. As is often the case following show causes, the hazard continued and reached another peak (28 cases) in May of that year.

About this time (March 5th) it was decided to clean the offending holes with wire brushes. Every wire brush in San Francisco was purchased and an order was wired East for about 400 more. This effort met with doubtful success as the brushers were then exposed to red lead dust, and not all the paint could be brushed out.

On March 28, a newspaper article reported that the business manager of the iron workers union made charges that the contractor was ineffective in eliminating the hazard.

The following month Trades exposed to lead fumes were limited to a 45 minute working hour and given an hour long lunch period. In addition the contractor was ordered by the Industrial Accident Commission to mechanically ream all rivet holes containing lead. It is probable that the latter order was imperfectly enforced, but this coincided approximately with the completion of the North (Marin) tower, and the epidemic temporarily subsided.

It was stated earlier in this report that responsible parties were reluctant to blame lead for the repetitious sickness among bridge workers. This will now be substantiated.

1. A previous attempt to exonerate lead as the culprit was made on December 31, 1933 when the General Manager of the Golden Gate Bridge and Highway District sent the following letter to the Industrial Accident Commission. Subject; Acetylene Gas Poisoning.

> "Symptoms which were first suspected of being lead poisoning have been noted in the case of R.D.M.... and G.I.H... who were both kept under observation several days. Lead poisoning was not indicated. Investigation showed however, that it was probable that these two men, who are employed by the McClintic Marshall Corporation on the Marin Tower erection, were exposed to the fumes from the acetylene lights which were being used inside the column sections in confined spaces. As a result the contractors took immediate steps to supply electric lamps, in lieu of the acetylene types. It was thought at first that lead poisoning might be resulting from driving these heavy rivets into materials previously red leaded in the priming coating.
>
> I thought this might be very interesting to you for your files on the above subject.
>
> Very truly yours,
>
> J.R. _____"

Hamilton and Hardy have this to say about that. (4) "When an acetylene welder suffers an attack of 'gassing' the cause must be sought either in the metal he is welding or in some accidental impurity in the gas.....if he is helping to scrap battleships by cutting through steel sheets which are painted with red lead, he will be likely to have lead poisoning."

2. Parts of several paragraphs of a letter dated January 5, 1934 from the supervising construction engineer of the Industrial Accident Commission to the General Manager of the bridge are quoted below:

> "....in regard to the case of G.I.H., Dr. Barrett tells me that his case has been diagnosed as ulcers of the stomach, and no signs of lead poisoning were indicated. The case is not compensable."....."one other case has been reported as lead poisoning, namely J.E., but this too has proved to be a case of stomach trouble and not lead poisoning."..... "Dr. Barrett informs me that it is almost impossible for a man to take enough lead into the elementary (sic) canal through fumes to cause lead poisoning."

3. The voice of ethics was heard crying in the wilderness on April 2, 1934 in the form of a "Physicians Report of Injury." This is a standard form submitted by law when an injury is reported. Under item 8, "State briefly how injury was sustained" is the following; "Inhaling lead fumes whilst riveting. Picked up from the street unconscious and taken to house. When I saw him at 9 p.m., he was unconscious, cyanotic, groaning, doubled up in extremis, feeble pulse." Under "Remarks" on this form is stated, "After giving patient digalen and adrenalin hypodermically, I took patient to Ross Hospital where he was placed in a tub of hot water and stomach washed while in tub. Gastric lavage was clear. Awakened in tub and complained of pain in abdomen and weakness." Signed. Dr. C. F. Larson, Sausalito, California. Dr. Larson then sent the follow-up letter reproduced below:

> "April 2, 1934
>
> To the Medical Director*
> Industrial Accident Commission
> San Francisco, California
>
> Dear Doctor:
>
> Herewith you will find reports on two patients who consulted me privately for illness which proved to be industrial. The delay in sending the reports is due to the fact that the men were referred to Dr. Barrett, Chief Surgeon for McClintic Marshall.

*Unfortunately this agency had no medical director. Safety order enforcement has now succeeded to the Division of Industrial Safety, which also has no medical director or doctor. The letter was probably referred to the Supervising Construction Safety Engineer of the Industrial Accident Commission.

Cannot the commission insist upon the installation of powerful suction fans, connected with hoses, which I am told is the only effective way to avoid these cases of serious poisoning. It is quite evident that gas masks and present methods are quite inadequate.

Very truly yours,

C. F. Larson"

One would expect a doctor who took this much interest in and care of a patient would have noted a state of intoxication. This is pointed out in light of the following quote from an Industrial Accident Commission interoffice communication dated April 8, from the Supervising Construction Safety Engineer:....."As to the report of Dr. Larson that this man was picked up from the street unconscious and taken to the house where Dr. Larson saw at 9 p.m. (sic) and he was unconscious, cyanotic, groaning, doubled up and extremis and feeble pulse.(sic) The McClintic-Marshall has no record of such a condition, but did state that the man is a heavy drinker, and it is possible he was in a state of intoxication on the night of March 10th, referred to in Dr. Larsons report."

4. On about May 10, 1934, a Dr. Moody at St. Francis Hospital, San Francisco received four samples of drinking water used at the bridge, from Dr. Barrett, the company doctor for McClintick Marshall Company. Dr. Moody found B. Coli counts per cc of 1848 in one case and 3,000 in another. A local newspaper commented on this aspect as follows, under the headline, "Bridge Crew 'Lead Poisoning' Scouted." "Contaminated water rather than lead poisoning, was the cause of 26 men being ill on the Marin pier project of the Golden Gate bridge. This report will be made to the bridge directors tody by Chief Engineer Strauss.

"The report will say that an investigation of the two main sources of drinking water disclosed that one was definitely contaminated. It will also point out that the men disclosed no lead in their system." On May 22, Dr. Barrett wrote the Industrial Accident Commission, "On the positive findings of Dr. Moody of the St. Francis Hospital, the infected sources of supply were cut out with a decided improvement in the bowel condition of the various men at work."

However, the water supplier, the Marin Water District on hearing of this took five samples of their own from five different locations, and wrote the commission as follows: "...the analysis in our own laboratory showed all samples to be negative or no trace of any contamination.

"We also communicated with Prof. W. F. Langlier of the University of California who is our consultant on all matters pertaining to water purification. Mr. Langlier made a personal inspection and collected three more samples and the result of his analysis is reported to us in a letter dated May 14." "The letter goes on to say the highest count Prof. Langelier found was 0.02 B. Coli per cc, and quotes his conclusions: "The results of all three samples collectively confirm analysis made in the Districts office

in San Rafael and prove conclusively that the water supplied by the District mains conforms to the highest standards of purity. A trace of contamination such as is indicated in the water from the contractors storage tank is of little or no hygienic significance, and I doubt very much that it could be the cause of the symptoms of illness displayed by some of the men working on this job, which are characteristically not those of water borne disease."

5. On June 25, 1934 the turpentine issue was revived with a note from the Industrial Accident Commission to the Golden Gate Bridge and Highway District saying that the use of turpentine would not be sanctioned for painting the interior of the Marin tower. This in spite of the fact that on June 21st the Industrial Accident Commission received a copy of a letter from the U.S. Bureau of Mines quoting Dr. Alice Hamilton as saying, (5) "it is considered safe to state that paint thinned with pure gum spirits of turpentine is non toxic from the standpoint of vapors of the solvent used."

6. These excerpts are from a letter dated September 19, 1936 to the Industrial Accident Commission engineer from W. E. P., special representative to the McClintic Marshall Corporation:

> "You have requested certain information relative to the supposed lead or lead absorption cases on the Golden Gate bridge...."
> "....71 cases were claimed lead cases with a total lost time of 6,570 days. On several of these cases I learned that the days were not lost as the parties were actually working in steel construction for contractors while drawing compensation from the McClintic Marshall Corporation. I cannot give you the full figures regarding this matter except to say that 71 cases and 6,570 days includes even the false claims."

Despite the decision of the Industrial Accident Commission on February 15, 1934 to have the splices or parts that required field riveting left clear of paint before being shipped to the site, a public health inspector noted on February 21, 1934, "The elimination of the lead paint around the field-riveted joints seems necessary. On steel which is already in place or on the ground this seems doubtful of accomplishment except as the last resort." On March 24, 1934 the Industrial Accident Commission Engineer notified this inspector, "Considerable of this steel has been erected and I would roughly estimate that possibly one-third of the tower, when completed, will have had the holes cleaned of red lead paint. On the steel actually erected, approximately one-third is riveted, leaving one-third unriveted and uncleaned of the red lead paint."

Despite the inefficaciousness of the commissions' ruling, it probably was largely responsible for reducing disease incidence from 35 in February to 18 in May, 1934. Incidence continued to drop until construction of the Lime Point tower on the San Francisco side the next year.

Susceptibility and resistance were not considered of major importance in this study. From the literature it appears that anyone is susceptible

given sufficient exposure, and that the body is not capable of building resistance to continually increasing increments of lead fumes. However, one important aspect of susceptibility should be considered in this type of work. "No one under the age of 21 should be subjected to lead exposure." (6)

"The general clinical conclusions of appointed surgeons in the various lead factories would be, we believe, that the susceptibility of young persons is at least twice that of adults, and there is some ground for supposing that the tissues of an adult, when growth has ceased, more readily adapt themselves to deal with the absorption and elimination of poisonous doses than do the tissues of a young person." (7)

"No female under 45 years of age should be permitted to handle any dry substance or dry compound containing lead in any form where the lead content is in excess of 2%". (8)

The Physiological Action and Toxicity of Lead: "When lead is ingested, much of it passes through the body unabsorbed, and is eliminated in the feces. The greater portion of the lead that is absorbed is caught by the liver and excreted, in part, in the bile. For this reason, larger amounts of lead are necessary to cause poisoning if absorption is by this route, and a longer period of exposure is usually necessary to produce symptoms. On the other hand, when lead is inhaled, absorption takes place easily from the respiratory tract and symptoms tend to develop more quickly. From the point of view of industrial poisoning, inhalation of lead is much more important than is ingestion.

Lead is a cumulative poison. Increasing amounts build up in the body and eventually a point is reached where symptoms and disability occur.

Lead produces a brittleness of the red blood cells so that they hemolyze with but slight trauma; the hemoglobin is not affected. Due to their increased fragility, the red cells are destroyed more rapidly in the body than normally, producing an anemia which is rarely severe. The loss of circulating red cells stimulates the production of new young cells which on entering the blood stream, are acted upon by the circulating lead, with resultant coagulation of their basophilic material. These cells after suitable staining, are recognized as "stippled cells". As regards the effect of lead on the white blood cells, there is no uniformity of opinion. In addition to its effect on the red cells of the blood, lead produces a damaging effect on the organs or tissues with which it comes in contact. No specific or characteristic lesion is produced. Autopsies of deaths attributed to lead poisoning and experimental work on animals, have shown pathological lesion of the kidneys, liver, male gonads, nervous system, blood vessels and other tissues. None of these changes, however, have been found consistently." (9)

II History and Status Report:

Lead poisoning is the oldest recorded occupational disease. Pliny the elder in the 1st century described masks worn by lead workers. Hippocrates in the 4th century described adverse effects on miners and metallurgists. (10)

Greek, Latin and Arabian physicians knew of lead colic following lead ingestion. Dioscorides in the 2nd century described lead colic and paralysis from swallowing lead and breathing its fumes. (11)

Phillippus Paracelsus, "Bombastus", the redoubtable Swiss physician, in the 16th century described diseases from digging, smelting and washing lead and described lung consumption, asthma and dyspnea. He pointed out follacies of contemporary medical theories and taught the use of specific remedies rather than bleeding and purging. (12)

Around 1696 Stockhausen described the "Colic of Poitou" endemic to a region in France where wine fermentation was promoted by adding lead to it. A similar syndrome was noted in the early days of France and England caused by lead in cider and by lead lined cooking vessels.

In 1830 Tanquerel des Planches wrote his famous treatise covering 1217 cases. He was one of the few to note that lead poisoning can be traced to the inhalation of vapors or emanations. After Tanquerel, a vast amount of clinical data was collected in England, France, and Germany. It is interesting to note that an analysis by Kaye and Roznikoff of street dirts collected in 1924 before ethyl gasoline was introduced had 50% less lead than in similar samples collected ten years later. (13)

Aub has shown in 1924 that injection of lead in the trachea leads to rapid intoxication. As much lead may be absorbed from one such injection as from G. I. administration which lasts for months. This is due to rapid phagocytosis and to lead entering directly into the circulation instead of passing through the liver as in G. I. absorption. Also excess phosphate ions in the G. I. tract keep lead insoluble and further depress absorption. (14)

As early as 1912, Legge, a recognized authority in the field of lead intoxication makes this statement which is of special importance in reference to the Golden Gate Bridge epidemic, "There can be no intelligent control of the lead hazard in industry unless it is based on the principles of keeping the air clear of dust and fumes." (15)

In 1948 Patty had this to say: "Next to the smelting industry, the most danger from suboxide fumes would come from the burning of lead, as in the application of a blow torch to a lead surface or one coated with lead paint." He gives the maximum permissable dose as 1.5 mg per cubic meter.

To establish background amounts, in 1933 Kehoe, Thomann and Cholak obtained excretion and absorption samples from primitive communities in Mexico which were isolated from natural and industrial lead contamination. They found lead in urine in amounts from .02 to .08 mg/lit., and .02 to .39 mg/24 hours in feces. Blood samples ran from .00 to .06 mg/100 grams of blood. (16)

More recently in 1951, Wissenschaft and Studt showed that anemia following lead poisoning is probably due to poisoning of the enzymes, interferring with the catabolism of the anti-pernicious anemia factor. (17)

Fried, Schubert and Lindenbaum, are doing productive work in this field now at the Argonne Laboratories. (18)

Pernis, Gairati and Siobiles at the University of Milan have been studying changes in erythrocytes by electron microscope observation. Ultra thin sections of erythrocytes of guinea pigs poisoned with lead acetate were examined. Some of the erythrocytes showed swollen and altered mitochondria and clusters of dense granules of about 50 Angstrom diameter with high electron scattering power. Those were not reticulocytes, and were not observed in control animals. Lead interferes with the syntheses of heem. Since much of this synthesis occurs in the mitochondria, it is believed these alterations are induced by lead. This confirms work done by Bessis and Breton-Gorius in 1957.

Robert Riegfeld (19) lists the 1962 consumptions of Litharge and Red Lead at 87,000 and 23,000 tons respectively and states 29,000 tons was used in paint and varnish alone, but that this is nowhere near the amount used 40 years ago. However Red Lead is still the world's standard for metal protective paints.

Cholak states that sampling of air from 1941-55 was random and intermittant and in 1955 continuous sampling was introduced, though in relatively few locations. Kehoe says "The accumulated evidence of our observations made from time to time during the past 20 years substantiated by intensive investigations of human subjects in the Kettering Laboratory justifies the categorical statement that there is no hazard to the public from lead content of the ambient atmosphere.

IV Summary and Conclusion:

The glaring deficiencies the investigator becomes more and more aware of as he follows this four year epidemic to its conclusion, are misinformation, apathy and lack of education. The latter two work hand in hand. Adequate information was available long before the bridge was built, but for the most part it was ignored for worse counsel. What effective measures were enforced appear to have been enforced haphazardly and without conviction. Management attitude even for 30 years ago, seems to have been singularly unenlightened. A tendency to call a compensable disease contracted on the job by another name is quite apparent, in the bridge engineer, the contractor's doctor and in the State inspectors.

Since those days, the California Department of Industrial Relations has been reorganized to include a Division of Industrial Safety consisting of over 140 field engineers and supporting personnel, including a subsection for industrial hygiene consultation, called the Environmental Engineering Unit. Four (and hopefully five) out of the seven engineers in this group have Masters degrees either in Health Physics or Industrial Hygiene. In addition the Chief of the Division is an industrial hygienist. Needless to say work

of the type leading to this epidemic is no longer permitted without positive pressure gas masks. The need for long air lines and compressor pumps has been obviated by portable air supply units such as the Scott pack. It has been found necessary in many cases where a worker needs unobstructed vision, to require masks with a single large viewing area.

It is no longer necessary in California, to ask for long distance help. The State Department of Public Health is well staffed with experts in industrial hygiene and has well equipped laboratories, and indeed the environmental unit works more closely with this Department than with its own. In addition many counties throughout the state, have health departments comparable to the State's, and a few are possibly better. An interesting observation at this point is that at least three California counties have been judged competent by the Atomic Energy Commission to take over pre-licensing inspections of isotope users, at a time when many states have not yet done this.

The unions too are better equipped now to combat abuses such as resulted in this epidemic, and the writer can state categorically from four years of close association with union business agents that union action alone would stop such an epidemic today.

Therapy consists in preventing absorption or resorption of lead from the alimentary tract, promoting the urinary and biliary excretion of lead without damage to the excretory organs, and accelerating deposition of lead in the bone. Chelating agents hold great promise here, and may provide a complete cure for those afflicted with what has been regarded previously as a life-long insult.

At present (1963) the most effective single therapeutic agent appears to be the calcium disodium salt of ethylene diaminetetraacetic acid (EDTA) or calcium disodium edetetate (20). This compound forms a stable, soluble, non-toxic, virtually nonionic complex with lead ions. The result of administration is usually a considerable rise in the urinary excretion of lead and at least a transient suppression of toxic signs and symptoms, including even the manifestations of lead encephalopathy. (21)

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18. AMA Archives of Industrial Health 1959, 20/6 (473-6).

19. Lead Symposium, February 25-27, 1963, the Kettering Laboratory.

20. Bessman et alle 1954; Chisolm and Harrison, 1957; Cotter, 1954; Lechio and Tompsett, 1958; Sidbury, 1955; tanis, 1955.

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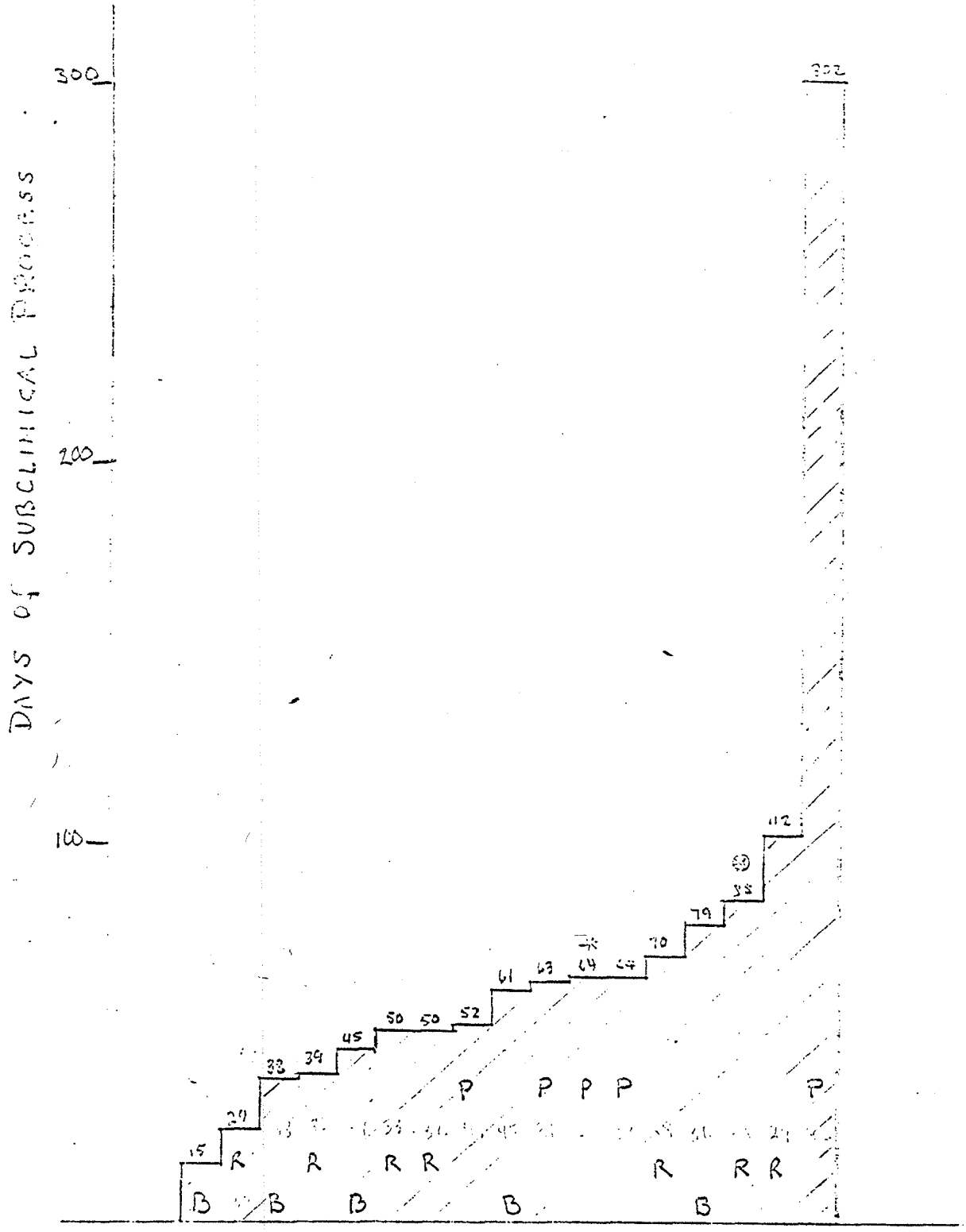
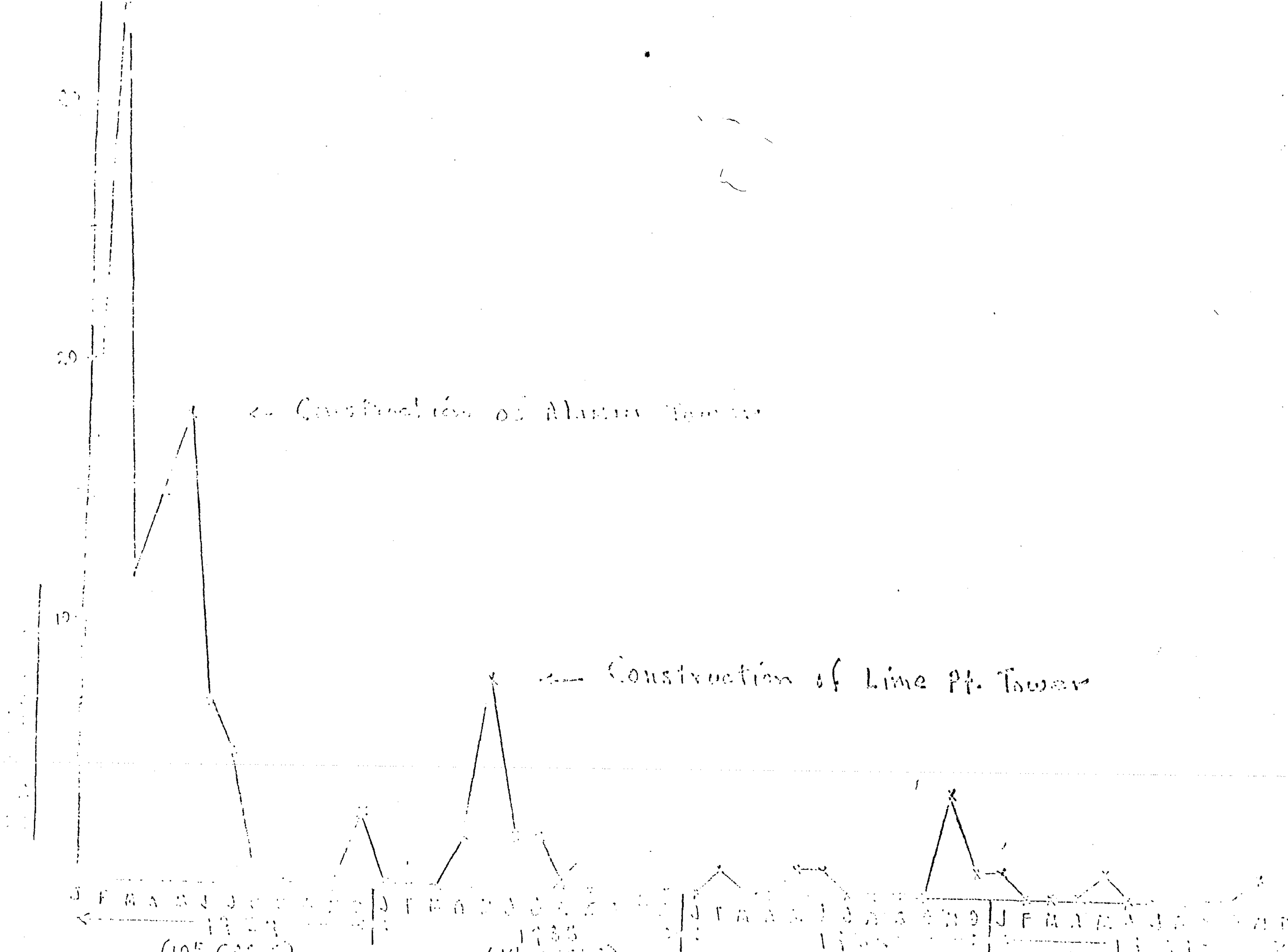
GRAPH I



INDIVIDUALS R.A. - indicates age

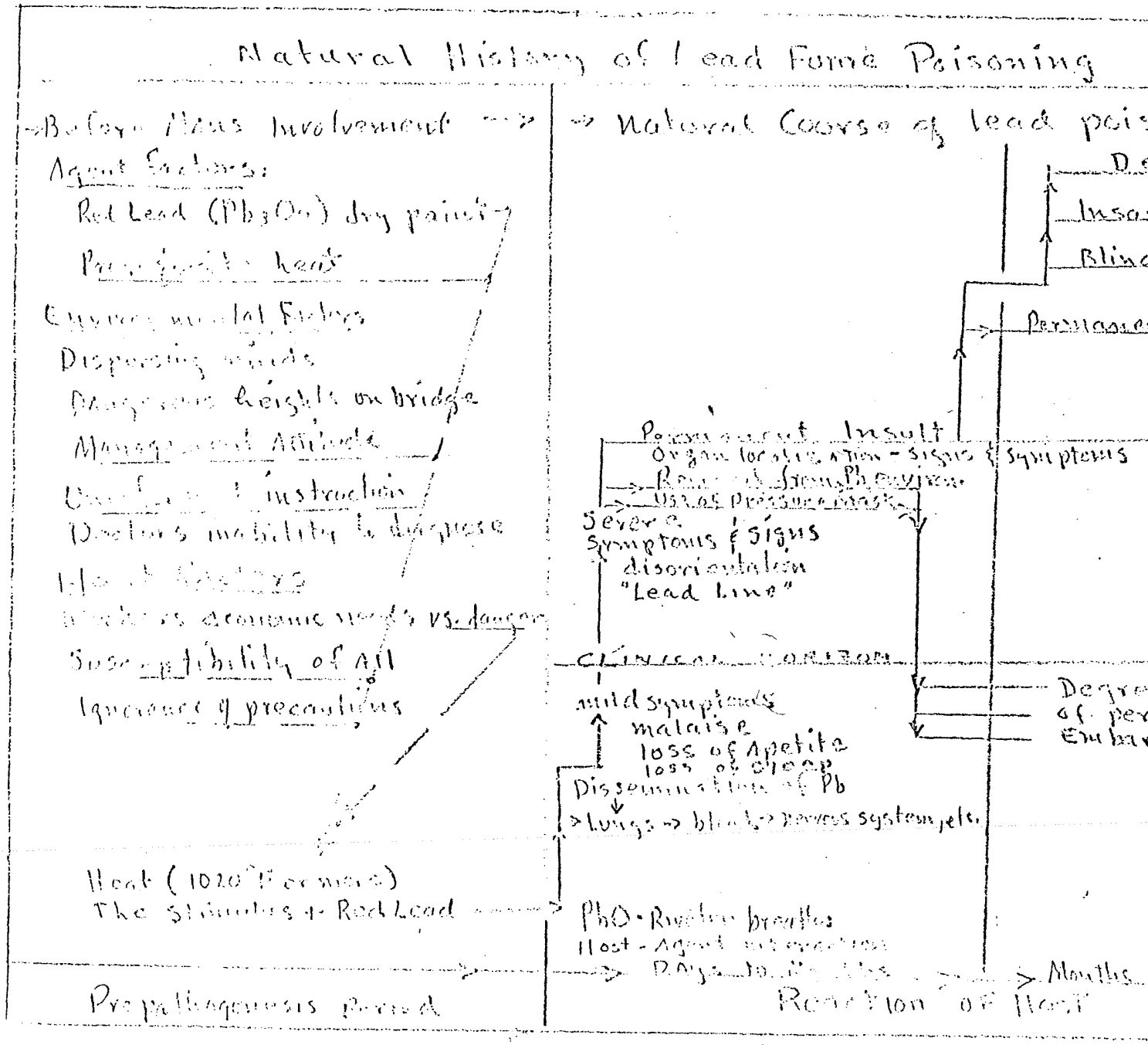
LEGEND

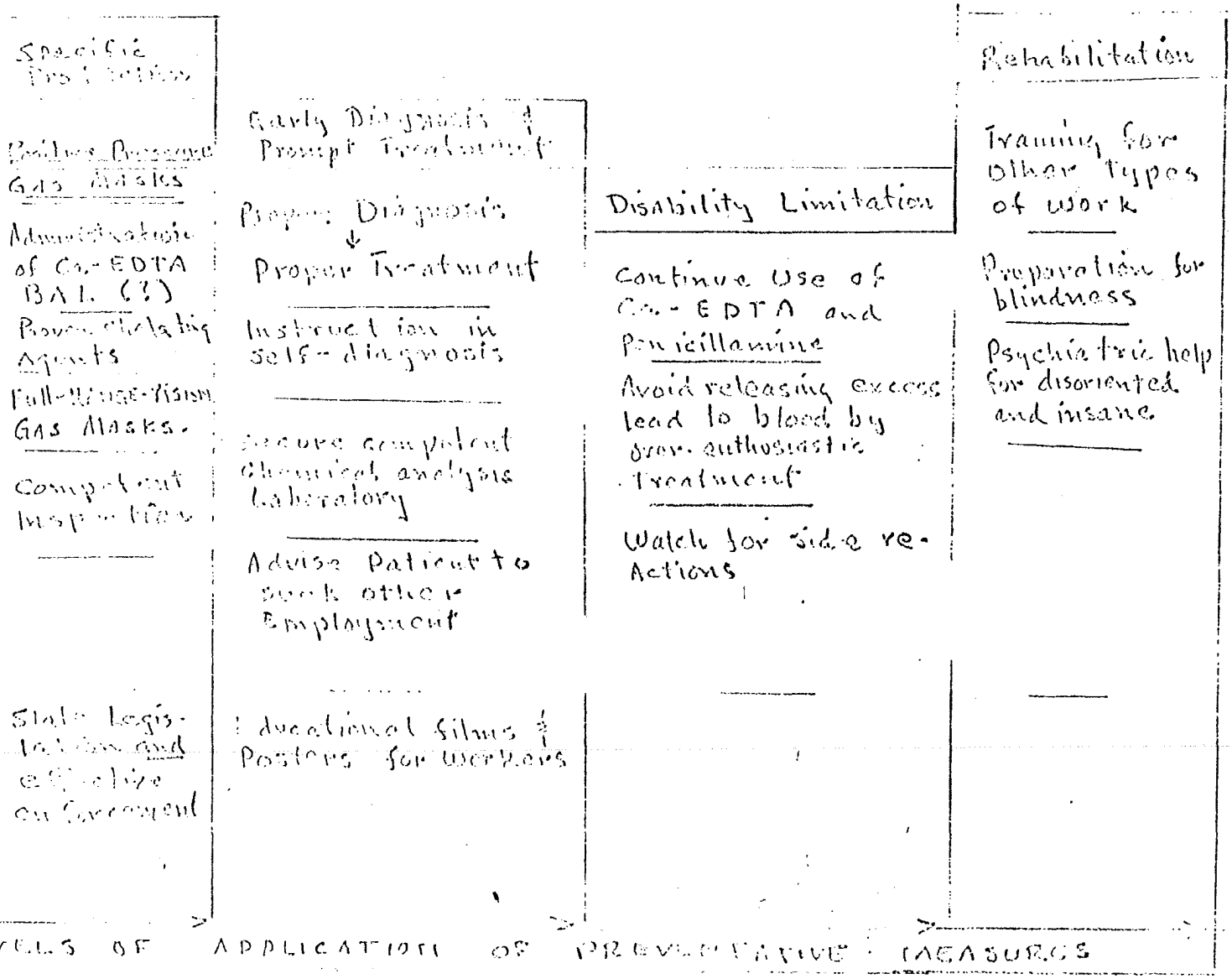
P Painter
R Riveter
B Bridgeman
* Repeater



Disease Incidence by Month

Natural History of Lead Fume Poisoning




Specific Protection
Positive Pressure Gas Masks
Administration of Ca-EDTA BAL (?)
Proven chelating Agents
Full-Visage-Vision Gas Masks.
Competent Inspection
State Legislation and effective enforcement
Early Diagnosis & Prompt Treatment
Proper Diagnosis
Proper Treatment
Instruction in self-diagnosis
Secure competent Chemical analysis Laboratory
Advise Patient to seek other Employment
Educational films & Posters for workers
Disability Limitation
Continue Use of Ca-EDTA and Penicillamine
Avoid releasing excess lead to blood by over-enthusiastic Treatment
Watch for side reactions
Rehabilitation
Training for other types of work
Preparation for blindness
Psychiatric help for disoriented and insane
LEVELS OF APPLICATION OF PREVENTATIVE MEASURES

Calculations:

Variance in Incubation Period

Bridgeman

x	$x-\bar{x}$	$(x-\bar{x})^2$	$\frac{(x-\bar{x})^2}{n-1}$	s^2	s
15	32	1024	2334/4 = 583		24.2
38	9	81			
45	3	9			
61	14	196			
79	32	1024			
$\bar{x}=47$		2334			

Riveters

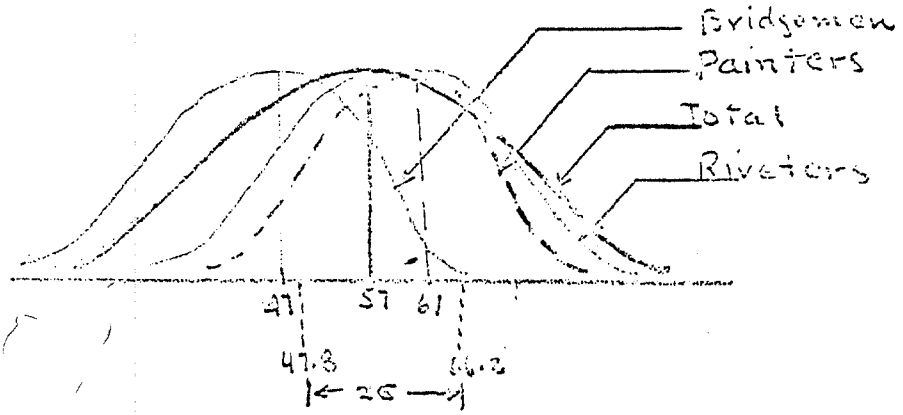
24	37	1369	5353/6 = 892		29.9
39	22	484			
50	11	121			
50	11	121			
70	9	81			
85	24	576			
112	51	2601			
$\bar{x}=61$		5353			

Painters

52	9	81	103/3 = 34		5.8
63	2	4			
64	3	9			
64	3	9			
$\bar{x}=61$		103			

$\bar{x}$	$\bar{\bar{x}}$	$\bar{x}-\bar{\bar{x}}$	$(\bar{x}-\bar{\bar{x}})^2$
57	47	10	100
57	61	4	16
57	61	4	16
			132 $= \Sigma(\bar{x}-\bar{\bar{x}})^2$

$$s_{\bar{x}} = \frac{s}{\sqrt{n}} = \frac{\sqrt{\frac{\Sigma(\bar{x}-\bar{\bar{x}})^2}{n-1}}}{\sqrt{n}} = \frac{\sqrt{\frac{132}{2}}}{\sqrt{3}} = \sqrt{22} = 4.7$$



$$\bar{\bar{x}} \pm 1.96\, s = 57 \pm 1.96(4.7) = 57 \pm 9.2 = \begin{cases} 47.8 \\ 66.2 \end{cases}$$

$$47.8 < 57 < 66.2$$

∴ At the 95% confidence level, The only group who are significantly different are the bridgemen.