Interviewee: John W. Wrench

Interviewe: Richard R. Mertz

Date of Interview: November 17, 1970

Mertz:

This is an interview with Dr. John Wrench at the Naval Ship Research and Development Center, formerly the David Taylor Model Basin, conducted on November the seventeenth 1970 in Dr. Wrench's office. The interviewer is Richard Mertz.

Dr. Wrench would you like to describe for us your early years, early training and development, what led you into mathematics as a field of endeavor?

Wrench:

My interest in mathematics was essentially motivated by an excellent teacher that I had in high school in one of the suburbs of Buffalo, Hamburg, New York. I was encouraged to go beyond the regular course work at that time and when I entered the University at Buffalo as a freshman, I found that I had sufficient preparation in the college subjects that I could anticipate sophomore courses and actually pass the freshman courses without going to formal class. In the University of Buffalo, I was particularly fortunate in having access to the files in the library stacks and files as a freshman--and I subsequently found that that was not a regularly approved procedure--so I did have the advantage of reading widely even from the first year that I was in college.

Mertz:

May I ask you to go back one step before this. In your family have there been any mathematicians before or scientists?

Wrench:

Not to my knowledge. I did have an uncle, my mother's brother, who was mathematically inclined; however, never formally in the field.

Mertz:

But you had pretty well fixed on mathematics as a subject you wanted to pursue in high school?

Wrench:

I'd like to amend that by remarking that I also took chemistry in high school, and when I went to college I had initially planned to major in chemistry. However, I found that after taking a year or so of chemistry, I was more interested in the theoretical than in the laboratory-oriented subjects. So I went into mathematics concurrently with chemistry, but in my sophomore year I made the formal decision to change to mathematics.

Mertz:

And you had some--you indicated that you had some advanced standing in mathematics. Was this--did this enable you to go--had you had calculus at this point?

Wrench:

No. These were the years, many years ago, when elementary calculus was not taught in high schools. However, I did go into calculus in my sophomore year. In my freshman year I did not stick to freshman courses. I took a sophomore course in college algebra, so I did not take calculus until my second year, really because at that time the curriculum did not permit it. This was approximately thirty-nine years ago, forty years ago.

My--I was about to say that my interest in mathematics was also encouraged by the fact that the head of my department, Professor Harry Gehman, now retired--

Mertz:

G-A?

Wrench:

G-E-H-M-A-N, Harry Gehman, who was the Secretary of the Mathematical Association of America for many years. Still very active in the Association though he does not hold formal office at this time. He encouraged me throughout my undergraduate career, and I was able to finish the, most of the undergraduate courses in mathematics within the period of three years, so then in my fourth year of college I took primarily graduate work. I took one language course, German; so I was able to accelerate my graduate work by getting a master's degree in one year, where the usual pattern at that time ... was two years. Then, following the conferral of my master's degree--

Mertz:

Excuse me. At that time there was only course work was required for the master's?

Wrench:

No, there was a thesis also required, course work and thesis and normally two years preparation.

Mertz:

I see. What did you, what field was your thesis in?

Wrench:

In my master's work I had concentrated on point set topology and wrote a thesis on sequences of transformations, principally homeomorphisms. However, at that time, I developed an interest in number theory, algebraic number theory took a course with Professor Gehman on that subject. I was fortunate to win a fellowship to Yale, entered Yale in 1935, following this work at Buffalo--I might add that I did continue in Buffalo for a year beyond my masters, because I had a scholarship for two years, the fact I had a fellowship for two years got my masters in one year courses so when I entered the graduate school at Yale in 1935 I had received my degree in 1934 following my bachelors in 1933

Mertz:

In that connection was there any, were there any outside interest that you had, hobby or interest in pursuit that had for instance, things like chess or music

Wrench:

Music, yes. For a long time an abiding interest in my life ever since my 1928, say, teens would have been music and I had taught myself piano formal lessons rather memorable series of lessons, in number with Alexander [Scalevsky?] who taught at the Peabody Conservatory for a number of years, head of the piano department, now deceased, I still indulge in that particular hobby classical music principally pursue that formal a year or two. I might say that was my principal hobby and interest at that time I was musically inclined. I was a commuter, no living accommodation on campus at that time, no dormitory, so, I had to commute forty miles each day. courses bachelor twenty-seven cents an hour terms freshman year.

Mertz:

Did you study while you commuted?

Wrench:

Not too much. In those days we took first either street cars or automobile transportation and I don't remember studying so I had…

Mertz:

These were, if I recall, rather lean years in the United States the Depression. Did this have any particular impact oin your choice of schools or on your school life?

Wrench:

Yes, it did certainly in my initial choice of the University of Buffalo because this work as you know the year 1929 was the year of the crash the depression deepened as I recall in the thirties and even the year I graduated throughout the country. So, the choice of the campus was strongly motivated by this consideration. I had at one time thought of going to Cornell I tried examination for a scholarship at Cornell, it was taken by a great many students in the Buffalo High Schools, the examination was held in one of the schools there and we in the suburbs had not been properly trained. We had not seen previous examinations of this type. Consequently, it was very difficult and I did not place among the first ten people. I just missed I think by one or two positions getting a fellowship at Cornell which would have cost me in effect it was hard, especially on the science

Mertz:

And did you have any outside employment?

Wrench:

No, my tuition was paid effectively by scholarships throughout the years. I was fortunate in getting a teaching fellowship at the University of Buffalo an assistantship. At Yale I had a teaching fellowship also, so that I spent most of my time studying and also in teaching or assisting taught myself One or two summers I do recall now I worked in the registrar's office University of Buffalo salary at that time so I was able to, effectively, support myself

Mertz:

Increased expense though when you went off to Yale…

Wrench:

Yes, but surprisingly what surprised me at Yale fellowship no considered small a year I was able to live relatively comfortably in my room and still saved money, which seems extraordinary now. In retrospect.

Mertz:

And when you arrived on the scene was there anyone particular reason why you went to Yale as distinct from any other school

Wrench:

First of course I had been offered a fellowship. My mentor and teacher, Professor Gehman was a former professor, assistant professor, at Yale and that fact interested in my acceptance also the course I took in algebraic number theory in Buffalo. So, you can say that I was strongly led to this choice of fields through first the high school preparation which first year for my first year there

Mertz:

So once on the scene at Yale there, now this was in the fall of 193-

Wrench:

1935 and I continued there for three years and received my doctorate in June of 1938

Mertz:

And what with whom had you pretty much fixed on a field in mathematics which you were concentrating on.

Wrench:

Yes, you might say I had I my third subject was in Diophantine Analysis, which is of course an aspect of number theory I didn't get into the applications of algebraic numbers to that particular subject you know the study of what we call arctan relations but the procedure, approach, of that initiated by Karl Friedrich Gauss who was one of the great mathematicians of all time, I used algebraic numbers, now called Gaussian integers in my study., A paper based upon that thesis was published in the American Mathematical Monthly early in [193?]. The thesis itself was never published.

Mertz:

Under whom did you work at Yale

Wrench:

I worked with Oystein Ore, the last name is spelled O-R-E. Just died in 196 a few months before with Oswald in the summer of 69 following his retirement had stud so I had known him for a period of about 34 years.

Mertz:

And was he one of the younger faculty members.

Wrench:

Yes, he was. At that time, he'd been on the staff I think for a period of about half a dozen years or so he was fairly young. He was very brilliant and had a professorship. He was one of the top men in the department at the time. Another man on the faculty with whom I became very well acquainted, shaped my life was a professor in the physics department, Horace S. Uhler. U-H-L-E-R. Horace Uhler was a physicist by training and avocation. However, he had a hobby; he liked computation designing

I had met Professor Uhler in the fall of 1936, I think it was about the year I entered the university and at that time he had heard about me in the department and he wanted to borrow a book and I remember loaning him this book. We discussed computation together then after that I got very much interested in the computation of the logarithm of pi to the base e and it turned out that that was a real interest of Professor Uhler because of his interest in factorials He published a monograph in the Connecticut Journal of Science or Proceedings in 1937 and it turns out that the Stirling asymptotic formula for the factorial requires, in the logarithmic form, the logarithm of pi, natural logarithms. So it turned out that my expression of interest in this particular computation struck a very responsive chord. rather surprised me picked up on the problem almost immediately at that time worked on desk machines.

Mertz:

Marchants, Fridens?

Wrench:

That type of computer, I think he used that. I think at one time he had a Monroe, then he had a Marchant; I think he had a Friden at one time. He used several kinds. Sometimes he was dissatisfied with one machine he essentially calculator person

Mertz:

And you were then interested in computational problems. Now this was in what era? The same time…

Wrench:

This was at the same time I was still working on my doctorate. In fact, in my doctoral dissertation I had table of factors of numbers of the form $n^2 + 1$, which had 10000 entries in them. It was an original table and unique except for the fact that there existed a manuscript of comparable size in England, which was destroyed subsequently in the Battle of Britain; so my table which never compared with this unpublished table in England had become unique. Subsequently I extended this work on an electronic machine here at the Model Basin on the 704. The year was in 1960, approximately ten years ago, this table which formerly consisted of 10000 entries, was actually done by me in long hand. And then I had a desk calculator; I did not even have a desk calculator at that time. Uhler had the desk calculator in his office.

This was done in long hand. Subsequently, in 1960, as I say, on the 704, Dr. Shanks programmed and ran the problem effectively an extension of this table so that a new table which shows only a largest prime factor of numbers of the form $n^2 + 1$ now extends to 185000 integers. And the reason for that termination is simply that we took the numbers within the word size of the 701 for that time which was comparable for the subsequent and the 709 which of the So we can trace then this particular thread from the dissertation this interest in number theory to the to using prime tables. Now my table which Dr. Shanks and I had been which was published; however, we have unpublished tables journal.

So, my interest in computation stems from the early days in high school and college. I might say that the--in retrospect my interest in computation possibly stems from the fact that as a youngster I was reading the Encyclopedia Britannica, the 9th [edition?] goes back many years, in the 1800s, my grandparents had this particular encyclopedia, and when my grandfather died, we inherited this particular set of some twenty volumes and I read, I think, all of the mathematical articles in those volumes and a number of others and I became interested in the computation of pi because of this article. I think by Hobson.

In 1929, in the summer before I entered the University of Buffalo, I conceived the idea of calculating pi to some sixty-five places or so in long hand, and I did accomplish that, not in that single summer, I had to complete it in subsequent summer, however that extraordinary experience in computation, especially in long hand. I found afterward that Abraham Sharp anticipated me about 70 and beyond in the year 1699.

However, subsequent reading of course revealed that places in time. I had not anticipated going further but in 1945, when I first came to the Model Basin, I was then in correspondence with Professor Archibald of Brown University. He in turn was corresponding with the gentleman called D. F. Ferguson in England, who was an amateur computer and Ferguson, in 1945, had announced that the value of pi was…for 75 years 73 was indeed in error beyond the 527 places. Professor Archibald asked me to compute this constant independently of Ferguson and at that time I was in correspondence with a Eli B Smith a small town in Georgia, Eli Smith was an electrical engineer at that time who was an amateur computer. He had started such a calculation using a formula of Machin. Machin's formula was discovered as early as 1705. Mister Smith and I pooled our resources. It was a two-term formula four tans and one fifth minus arctan 1939.He completed the evaluation of the series associated with the arc tangent over 239. I worked out the series of pi. We carried our initial calculation to 820 places and confirmed the work of Ferguson who had at that time taken his work to about 720. So, Ferguson continued his work and about a year after we had published ours in 1947, he found a few little slips in our calculation did this wrong because of copying, that was all. Didn't have automatic division at point. So, the whole junk calculation by Smith and myself and independently by Ferguson agreement 810 places in 1948 so we did publish a corrected, extended value at the time. Ferguson desisted from any further work in this field. Smith and I persisted. We wanted to reach a thousand places. We knew of the book Mathematics and the Imagination by Kasner and Newman who said it would take a human being with a desk machine year to calculated by places and we did not believe that. In fact, time.

So, in 1949 we had obtained 1120 places of the pi, that was in the summer of 1949, Labor Day weekend of 1949, ENIAC was used to compute this particular number to 2000 places in 70 hours pi. That marked you might say the end of desk computation in this? particular department and the advent of the electronic computer

Mertz:

Did ENIAC actually do it correctly

Wrench:

It did, yes. They carried it out There must be a slight mistake there. 2040 and as I recall the answer was correct to [2047, 2037] that was my deduction, so that particular record remained unchallenged for some years I did have a series of that [? ?dates] which I'm going to have to refer to in my lecture but I can say that my interest in pi remained somewhat dormant until 1961 when Dr. Shanks and I recognized that we could use the 709o with its memory of words to compute pi to probably 100000 places within the high-speed memory of that machine. We received permission from IBM to use their IBM 7090 at the Computer Center in New York City.

We did accomplish this calculation with one formula due to Carl Shermer, with a running time of 8 hours and 1 minute. shift. which involved a formula of Gauss with some overlap took only 4 hours and 20 minutes revealed a discrepancy which we subsequently proved machine error single pulse 40 million calculations.

Mertz:

40

Wrench:

40 million calculations. The whole run was repeated here in Washington at the Goddard Space Center in August of that same year. We found the source of the error incomplete check 100265 and that was published, in the following year, 1962, in Mathematics of Computation. But this paper, which you have, the paper 1000 published the final 265 published. interestingly enough we kept those so that two years later when French computer Paris at the Atomic Energy Commission there, on the STRETCH IBM 7030 computer calculated pi to 250000 places we were able to verify the subsequent figure previously. Then, a year later, the same people there, using however a CDC 6400 computed pi to 500000 places. I believe that year was 1967. So, the record this time does stand I have not heard of any further effort to go beyond that but no doubt there will be some serious effort made perhaps with a new generation of calculator

Mertz:

One question in that regard: These beyond 100000 were not published?

Wrench:

They were only published internally. Reports. I do have copies of the reports, but they are purely internal reports never appeared in the professional literature. I daresay most mathematicians haven't published, to my knowledge haven't been in the literature.

Mertz:

So that conceivably someone does go to, say, a million places is it certain that certain percentage

Wrench:

percent I can be reasonably confident reliable some checking equations incidentally, the work was motivated by our paper…the formula which they used two formulas spoke of by Schermer and Gauss and were used by calculate errors so effectively an extension of our work their program attempt to So we now have calculation three computers each with IBM 7090 New York also the IBM 7030, the STRETCH, and subsequently the CDC 6400. And also, there are calculations incidentally between the work of the ENIAC and the work did however the accuracy obtained 20000 places a few calculations 10000 but now we can see really numbers

Mertz:

To go back ahead in your career interest in the computation of pi: when you were at Yale as a graduate student or teaching assistant, you mentioned two faculty members who were influential, an influence on your own career, were there any others whom you would consider, would single out?

Wrench:

Well, I had the pleasure of having Einar Hille, who has written a number of books in recent years, function theory I would say that the number of teachers who had some effect on me somewhat limited number theory courses Howard Engstrom taught me courses in group theory and he later became one of the vice-presidents of Remington Rand, UNIVAC, and Yale.

Mertz:

You completed your doctorate in '38, June, and what then were the possibilities.

Wrench:

This, of course, was again in '38 I was very fortunate to get a job at that time at Wesleyan University in Middletown, Connecticut where a faculty member was on leave, sabbatical leave Princeton, and I was fortunate to be assigned to take his place. He was one of the most popular and effective teachers on campus it was a very difficult challenge to try to replace him. it was almost impossible.

Mertz:

Was he in algebra?

Wrench:

No, he was actually not a strong mathematician. in fact, I heard it discussed in faculty, Herbert Arnold his name was. He was not promoted on the basis of any profound scholarship whatsoever teaching he was extraordinary teacher trying to take the place of a man of such caliber, also had experience of having the son of the head of my department in my class teaching??EXTRA IGNORED

Mertz:

Was this a one-year appointment?

Wrench:

A one-year appointment, yes. Then, following that, the possibility of some appointment was rather limited indeed, in those years. In the summer of 1939 possibilities of teaching in Chicago in a junior colleges also…

Mertz:

Was this Wright?

Wrench:

I think it might have been Wright Junior College. Yes, in years. Also I had an offer which I decided against at that time when jobs seemed to be almost impossible to get fortunately, I got a call from George Washington University here in the District of Columbia and I reported for that job in September at almost the last possible moment so I had the experience and pleasure of teaching at George Washington from 1939 to 1942.

In 1941 of course the United States entered World War II and a number of us planned to enter the armed Forces or geting into defense work, so I had a chance of going to the National Defense Research

Committee, NDRC, and I worked with them a project? on campus, Professor Van Ever the chemistry department, and subsequently that project was transferred, as I recall, to Cumberland, Maryland, and I decided to stay in the area I went to the geophysical lab on a similar project in interior ballistics, and worked there until the end of the War, 1945.

Mertz:

Was this--the radiator sounded just as you mentioned--was this the Naval Resarch NRL?

Wrench:

No, this was simply a National Defense Research project at the Geophysical Lab in Washington

Mertz:

The geophysical lab

Wrench:

I worked there from 1942, the fall of '42 till the fall of 1945. Then, following the termination of the contract at the geophysical lab early in the fall of 1945, I continued for a few months longer with a similar contract at Catholic University. And I had the pleasure and very fine experience of working with Professor Carl Herzfeld, one of the outstanding physicists in the country, at Catholic University.

Mertz:

In that regard was the basic nature of your work computational.

Wrench:

It was and also theoretical in the evaluation process associated with the interior ballistics' tables. We actually, computed such tables we had working tables; I'm not sure they were used in the field but we had working tables for several projectiles

Mertz:

these were different from the types of things, the ballistics tables that were being computed at Aberdeen

Wrench:

Yes, that's true. Aberdeen tables were normally exterior ballistics tables and the interior ballistics--Incidentally, I worked directly under Professor Hirschfelder, who has been for many years professor of chemistry, I believe, at the University of Wisconsin, I believe he's still there, and he was on leave from the University of Wisconsin in World War II. So, it was principally the evolution of an improved theory system associated with in those days you had two do machines we evolved tables that we subsequently discovered were identifiable with incomplete beta functions but the tables that we did evolve after so much enormous labor we found were still unique went back studied the literature more deeply discovered what we did that we were not fully cognizant of was in the original tables which certainly, became useful and important

Mertz:

Approximately how many people were involved in the computations

Wrench:

In this particular group laboratory, there were only three or four of us doing computation professor Hirschfelder and Richard staff more into the theoretical research involving formulas When Professor Hirschfelder left to go back to Wisconsin I stayed on at the project and I finished the reports other members of the staff you might say I carried out the final mop-up operation and final report so I had my hand then with Professor Hirschfelder we theoretical research computation.

Mertz:

Was this on Friden or Marchant type calculators

Wrench:

Yes, it was, it was actually done on Marchant type computer. I didn't use Fridens until some years later I've used all three types. Friden calculators at a group I became acquainted preferred the others

Mertz:

Referred?

Wrench:

Preferred it because of the flexibility. I could set the numbers on the upper dials there very easily. I carried out multiple precision divisions, I must say divide by the dividend which can be arbitrarily long setting machine long.

Mertz:

This brings us up, more or less to the end of World War II.

Wrench:

Yes.

Mertz:

A little bit beyond. And was there any other activity in mathematics that you were doing on your own or conjointly with the work on interior ballistics

Wrench:

I became interested as a hobby; this was after hours by doing some multiple precision multiplication by desk machine system which I had learned from Professor Uhler a very nice system and I formed a plane of a rather large tables of powers of pi. It took me two years do this in my spare time and I did have the end of that time I had a table of the first 110 powers of pi, the first 110 powers of the reciprcal of pi to a minimum of 206 significant figures. That was subsequently extended by me for a minimum of 240 or 50 places.

Mertz:

Places or significant figures?

Wrench:

Significant figures, I'm sorry.

Mertz:

How many places did that involve?

Wrench:

We get well, you can see what that would be. Of course, pi to the 100th power would have on the order of 50 figures before the decimal place that would be there for more than 132 decimal places or subsequently these numbers were purely this table incidentally to my knowledge has never been superseded with any calculations, electronic or otherwise at least in certain manuscript in published form.

[END OF SIDE 1]

Mertz:

This is the commencement of side two.

Wrench:

Following the conclusion of World War II and the termination of the war contracts--

Mertz:

Excuse me, you mentioned that you had more or less moped up this, the end of the internal ballistics' studies and calculations. Did this reach fruit in a series of published reports?

Wrench:

These were confidential reports. It's interesting to note, however, that ... the Mark II calculator got involved, was set up to make some of our tables and th findings were that all the work that we had done by desk machines during the war years was entirely reliable and free from error...

Mertz:

I wanted to ask you one other question in connection with computers. Up until this time, your activity, if I understand correctly, was in essence in competition with the newly developing technology of electronic computers, or at least if not in competition, parallel to perhaps is more appropriate.

Wrench:

That would be more appropriate.

Mertz:

Correction. So, at that point there was in essence only the ENIAC. At the time though there were plans for a number of machines.

Wrench:

I was aware of the kinds of developments. I might say, if you want me to proceed chronologically, that I was aware of the existence of SEAC at the Bureau of Standards. I attended the ceremonies at which that was first displayed. That particular summer in 1950 I was able to get free time on the SEAC... was on the staff of the Bureau and he and I did some calculating on the SEAC and I was able to extend my table of n^2+1 that I had done in longhand in those early years on the SEAC to the order of about 26,000 entries. So, I checked the early work I had done, mostly by hand...

Mertz:

Was Dr. Miller involved in computational activities at Cambridge?

Wrench:

Yes, he was active in the Computational Laboratory at Cambridge at this time... He was one of L. J. Comrie's associates... I never met Comrie

Mertz:

When the project at Catholic University was completed

Wrench:

Then I had to look for a job again... As you know, after World War II, jobs were quite scarce. Fortunately I received a call from the Model Basin to come for an interview and they mentioned a salary approximately twice that received at the Geophysical Laboratory, which incidentally, was only $2,040 a year. The salary here was over $5,000

Mertz:

That was something like a P-3 or

Wrench:

Approximately a P-3, I'd say. So I came here at that level. I had a Ph. D. with a number of years' experience. So, I came here and I was interviewed by the Head of the Chemistry Laboratory and also by... It was decided that because of my work in physics I would probably be more effective as a researcher in the branch of the Structural Mechanics Construction Chemistry Laboratory called High Speed Magnetics. That was the study of firsts, the effects thereof on the structure of ships

Mertz:

The shock?

Wrench:

So, I worked in the Structural Mechanics Laboratory from my appointment to the staff of the Model Basin from December 1945 until September 1949, at which time there was a considerable reduction in force throughout the Navy and the David Taylor Model Basin staff was rather heavily hit. I was transferred to the Bureau of Ships and I worked down there in the mine sweeping branch of [BuShips?] from 1949 until February 1953. At that later date I transferred back to the Model Basin and accepted a position in the newly created Biomathematics Laboratory. This was in 1953. So, I was among the first half a dozen appointees in the staff of the Biomathematics Laboratory and have been now with this Laboratory

[START TAPE TWO]

Wrench:

Yes, I attended the Harvard Congress, 1950, and remember vividly the invited address, evening address, by Professor Howard Aiken [of the] computation laboratory at Harvard, who... described the popular conception of the computer at that time with a perfectly straight face, and... had the audience in… in a high state of... before he got to the anticlimax; he pointed out that the popular conceptions were, of course, completely at variance with the truth. Now his speech was very well received, as I recall, with standing room only, the audience in the large auditorium.

And I did, in subsequent years, when I went up to Harvard recruiting, talk with Professor Aiken, and he informed me that he... was working on the ideas for the MARK I computer. When he spoke of this, I believe, one day to one of the janitorial staff, and this man spoke to him about the fact that there were some strange looking gears and wheels upstairs in the attic of that particular building. And Professor Aiken went upstairs and investigated, and he found that... Charles--Henry P. Babbage, the son of Charles Babbage, had left these particular wheels and gears there in about 1909 when he had visited Harvard and gave a series of lectures. Those parts of Babbage's difference engine are now to be found in a showcase in the Harvard Computation Laboratory.

Professor Aiken said he studied Babbage's life to the point where he feels like he's almost an incarnation of Babbage, and I can say from my own experience when one reads of the life of Charles Babbage, he becomes so enthused, it is.. it is quite an experience. This man was certainly a hundred years before his time, his ideas were sound. He did further the techniques of blueprinting in the British Isles considerably, as far ahead as his time in planning. He was fortunate in having an independent fortune so he was able to play with these machines all his life. His ideas, essentially, are incorporated in the, in the later machines. The MARK I, with this machine you might say Babbage's universal computing engine... realized finally ten years after he head... Of course, successfully tried to develop it. It's true that Babbage's difference engine was eventually developed to the point where it would give usable tables. ... I believe some Swedish engineers developed the machine on the same lines simply to be illustrated on

One of the international fairs, I believe, around 1850 or thereabouts. I could be wrong, I think. All this is on this book that I cited Faster, Faster. And, of course, then you have... Lady Lovelace, the daughter of Lord Byron involved, so it's quite a, it's quite an exciting story.

Mertz:

Did you continue to keep in contact with Professor Aiken over the years?

Wrench:

I've not kept in contact with him in the past half a dozen years. I was recruiting at Harvard regularly there for a period of four or five years, and then, after I stopped recruiting, because of lack of interest apparently in the installation project, I, I've not contacted him in some time.

Mertz:

I was going to ask you, that was the next question. That was…if there were any, if there was the installation who were from, from Aiken's.

Wrench:

I don't believe we have any staff from the, the group. Howard Aiken told me he had no business replacing his men with he was training graduate students in his laboratory.

Mertz:

He did, however, have the, the consulting of the traditional connection with the Navy, if I'm not mistaken.

Wrench:

Yes, he was, he was a Lieutenant, Lieutenant Commander, I believe, during the World War. And some of the…early Harvard tables were computed...at that time...I believe Grace Hopper, who is a Commander, I believe, in the Waves is very, very of course, renowned in the computer field, was one of Howard Aiken's associates, in the early days.

Mertz:

I meant to ask you if you have ever come into touch with a mathematician named Gleason when you were at Yale?

Wrench:

Andy Gleason, Andrew W. Gleason. No, I've, I've, I've seen him at meetings, I've, I did not meet him.

He was, of course, one of the... outstanding young mathematicians in the country, still, of course now he's an older person, he's still outstanding, but I remember when he was, he was in the mathematical contest, he impressed me as one of the best mathematicians in the country. He still is, by the way.

Mertz:

Did he also, I believe, was in no small measure, responsible for some of the interesting association one has between the Navy itself and the Mathematics Department at Yale.

Wrench:

No, I'm, I'm not aware of any association with the Navy.

Mertz:

Well, at least with the Navy Security group.

Wrench:

I'm sure there had to be some clearance involved.

Mertz:

To go back now to others--when this facility grew, ..were there, ..do you recall, ..any foreign visitors, or for that matter, visitors from outside--in the United States,…who either used the facility here or spent sufficient time…here to be…have been more than just routinely…informed themselves about the--

Wrench:

Yes, we, we--

Mertz:

Computers?

Wrench:

we, we've had some consultants and visitors here along those lines. We had just within the last week, a visitor here from France, who has been here many times in the past few years, ..Joseph Kampede Feriet. ... [clears throat]

Mertz:

Joseph

Wrench:

Campede, K-a-m-p-e-d-e FI believe that's a capital F-e-r-i-e-t, Kampede Feriet.

Mertz:

Mhm.

Wrench:

He's an expert in ..oh, specialized mathematics having to do with..stockostic processes that ..and he's written a number of books. One of the older mathematicians is probably say about 75 years old at his time.

Mertz:

Is he in Paris?

Wrench:

No, no, he's at one of the other colleges. I can, I can find it for you perhaps in the…One of our other visiting celebrities is Professor Francis D. Murnaghan, former the head of the mathematics department John Hopkins University, who served as a consultant here at the station for a period of about 4 or 5 years. His services were terminated, oh, about 4 or 5 years ago when they, the --open heart funds were .. …reduced. But then, until that time he had given lectures here and next he had, he had been a member of the staff. He and I wrote some papers together and on polynomial approximation and diversion factors for special functions including exponential integral. And also the probability integral for area function. I've since extended some of those ideas with the functions, and carrying on some of the work that Dr. Murnaghan and I--pursued together some years ago.

Mertz:

Did he use...did he run any problems on his own?

Wrench:

It's interesting enough, Frank Murnaghan is one of the realist's people. He doesn't use those kinds of machines, he did a lot of his work on pencil and paper. He would take the work home and do it…with extraordinary perseverance and…accuracy, and a lot of very elaborate work without the assistance of...[?].

Another man I might speak of here, who...came here on several occasions and lectured and...posted at our staff at short intervals was...Professor Joseph L. Walsh, formerly at Harvard, now in the past three years, a member of the staff at the University of Maryland. Joseph L. Walsh. And active mathematics for a period of about, oh, I'd say almost forty-eight years now since he started researching. He is also interested in polynomial approximation [?] complex domain. He is one of the leading mathematicians in the country, retired at the age of, I believe of about 72 without completing the [?] Maryland, I understand.

Mertz:

Did…has he…had…good bit of... has he been…used in any of the machines?

Wrench:

No. Again..I don't think he had worked in one of the nature. He has written ..a book recently in co-authorship of two others on sine functions, that's quite a popular subject now.

I might say that Dr. Tyler and I got into some sine functions long ago, 1953 or '54 when we were applying those to the... automatization of [clears throat] ship lines. We were going to use computers to…simulate what a draftsman does with his drawing instrument, drawing board. And we have succeeded and did in those days, succeeded in devising a UNIVAC program that would...fare not only...water lines but…transfer sections and thereby effectively give a smooth hull surface, by computer, with input data only on a relatively few selective stations on the hull. So we did a--a, an effectively three-dimensional interpolation by computer using the sine function. That has been amplified and extended by Walsh and his co-workers and now is occupied a rather important part of mathematics widely reported on. It's really surprising since we first got interested 15 years ago, that suddenly conversion was something of great interest involved in a lot of the ships....

Mertz:

In the... development of the...computational facility here [clears throat]…can you, can you think of any of the, some of the individuals who perhaps are no longer here but who have come and gone over the years, who were…in your judgment…outstanding…mathematicians…in the field of…computation?

Wrench:

I've already mentioned Aaron Rice, who, of course, is one of the outstanding [?] in the field. We've had a number of... young... mathematicians, who were [?] in industry. Many of them haven't been here long enough to develop .. reputations, they certainly are very excellent people [?]. Many of these young men come and work here for two or three years and get offers from private industry, Princeton-Lee and pushed off too much better paying jobs. A number of them I'm thinking of that somebody like Howard Bromberg, who is very well-known in computer circles. I think he's very active in the ACM. You will find, I think, he's one of the arrangers [?] the Congress. I think the conference, you know this recent one here, the joint Computer Conference, I believe, just, perhaps it's in...session in this week, up in Boston, I believe Howard Bromberg Howard came here as a young man in the summer, I believe about 1954, if I recall correctly, from St. Johns College in Annapolis. [clears throat] He was on a [?] he was writing a history dissertation of the life of [?] and he was here only two or three months and he was, and he displayed considerable aptitude for writing prose and also the energy of a real comer and you know he made...So Howard has gone on to big things. [?] I won't say mathematically that he's outstanding, he's an organizer and a writer and a computer organ person. He's used to being directive. Howard Bromberg.

I can't think of anyone else for mathematicians other than those already named who...Dr. Shank, I mentioned him, a colleague, and he's done very fine work and continues to do so in mathematics. More in the pure mathematics than the applied number theory. He's invited to a number of meetings, his, some of his research has been recorded in the colloquium proceedings of the Mathematical Society in print right now. A few years ago, he gave quite a long paper. He publishes perhaps more numerous [?] this year.

Mertz:

What is his field -- of interest

Wrench:

Mostly, mostly in mostly in number theory.

Mertz:

Number theory.

Wrench:

Oh, he's gotten into class year theory, theory of computational theory factorization of numbers. He has a theory which has been proclaimed, probably so, as a real great breakthrough, theory of factorization, a technique which ..reduces a number of ..cases to be considered to the fourth root of the number investigated rather than the square root, which is a tremendous saving and he believes that it might reduce it further than the function which goes logarithmically number investigated which would be. But …his work is highly publicized, published in a number of journals. He's active on the staff, as I told you, of the Mathematics Computation program. So, I would say that he is a continuing very productive member of the staff. But he is more in the thesis of applied mathematics thesis mathematics rather than applied mathematics...

Mertz:

computational problems, per se.

Wrench:

But he, he does computational problems, but indirectly

Mertz:

And what…what do you feel in terms of problems over the years that have been some of the most important?

Wrench:

Well I, the very first problem I ever had in the laboratory, and I mentioned in my discussions with Mr. [?] is the actual real [clears throat] tables called the Armed Forces. Survivor Benefit Tables, which we worked on in the summer of 1953, a brand-new staff, as which you know. And we had a deadline to meet and, I believe, the end of October. The law went into effect the first of November, as I recall, we had to get these tables programmed and the mathematics all worked out. We had the assistance of a [?] scientist [?] in that aspect but the programming, the running, the involvement by us, the staff operating as a unit, there was no worrying about the division boundaries in those days. So we turned that out and that made a number of magazines, Armed Forces magazines and such types of magazines and was highly publicized. So, our very first big problem was making our deadline in essence of the publicity.

Mertz:

[cough]

Wrench:

And I think if involved a part, a large number of about 144,000 entries and tables of, and the printing took considerably time on low speed printers. It occupied the attention of the entire staff and the computing time for thirty some weeks. It was probably the first and only problem that in the laboratory occupied our sole attention for span of [?].

Mertz:

everyone was

Wrench:

Everyone was functioning. Yes. The staff, everyone, everyone worked on it. In later years, as I told you, in fact not too long after that, we got involved in the...in the nuclear reactor design calculations, and we did a lot of work in that. We developed a three-dimensional mathematical program called Fling which was a series of modifications, which was so elaborate that no part of industry, and this includes groups such as Westinghouse, GE never attempted to emulate it. They were content with proven conventional working models. We developed the three-dimensional model with a variable which was so intricate, so involved that it could be used generally just for a basic key calculation, a checkout calculation in a working everyday instrument, is too involved, too cumbersome. We used it on our Lark computer, in fact we justified the acquisition of the Lark on the basis of this instrument made for computer time.

Mertz:

Had any of this been run on the Norc, or part of--

Wrench:

Yes, some earlier parts, true dimensional precursor to this had been run on the Norc, but the three dimensional programmed and run on our Lark exclusively. I was never adopted by the ..[clears throat] industrial groups because they found that they could turn to us for the key check calculations but for the daily work they found were too [?] were sufficient.

Now we are getting into something that is very interesting at the present time and [?] calculations. And we're trying to simulate those mathematically and three dimensional. Something that hasn't been attempted to any extent before. Again, a tremendous computational challenge. We've used a 3691 at .. .. at... NPL Johns Hopkins Physics Laboratory.

Mertz:

[?]

Wrench:

[?] We used a 3695 up at NYU and on some of these calculations we find that the largest existing computers can barely give us the requisite capability. So, we have right now on, on the boards a problem that will tax our human and computer resources for some time to come. I don't see any end to that.

Mertz:

But this isn't true of flow.

Wrench:

[?] we feel right now.

Mertz:

And... I take it that the CDC will... the new...

Wrench:

The CDC will assist but it will not provide the final answer to a problem of this magnitude. They bestowed way beyond at least we think that the CDC 6700 is not the final answer by any means.

Mertz:

Well, what is the main area of the demand that…that…

that it seems to fall short of.

Wrench:

Probably computing speed and also... memory. We need, I think, generally not any particular brand of computer, but any computer in the present day doesn't have the, the enormous memory to speak of. We have so many space variables here [locations you have] and also the minimum [?] is time. [hardest problem]. And don't forget we want to simulate someday... swell around ship-like structures and... those are rather difficult to describe mathematically. We describe these lines but the fluid flow about and the border seas and all sorts of aspects of that are difficult. We have also a problem of turbulence. Turbulence is so involved that you can't even describe it mathematically.

Mertz:

[laugh]

Wrench:

By simple equations.

Mertz:

Are there any other things?

Wrench:

Yes. We're having a real problem with turbulence, of course, that's a more sophisticated study.

Mertz:

Right.

Wrench:

Yea.

Mertz:

Well, .. in that regard.. .. what .. what do .. think that the kinds of .. areas of .. technical development, computers, ought to be made before we can [clears throat] consider this class of problems?

Wrench:

Well, we, we, we know of [?] for some time.

Mertz:

Yea.

Wrench:

and .. we recognize, I'm sure, most of us, that the human mind can always stay in pace with the computer [?] as long as there's infinitive numbers to play with and an infinity of physical problems, we can always add another parameter or something like that.

Mertz:

Hilbert Space Conference problems.

Wrench:

Incidentally, one of our first problems in the laboratory back in 1963 was a problem in the equation of a certain, oh, [?] stability of a certain mechanism and they were talking about a .. oh, I think there may be a machine, a certain machine. They got into something like .. 10 or 11 parameters, as I recall, and the engineers that sent us this problem from Puget Sound shipyard, without thinking very seriously, gave us

100 values per parameter. All we had to do was raise .. 100 to the certain 11th power to accommodate all these parameters, and then we had something like 20 cases and obviously that was beyond any machine. And ironically enough, the equations were not correct. We were talking about dynamic stability and the equations actually direct stability and so the equations were [?]. So, we raised a point about the accuracy of these equations and also the number of parameters. We, we adopted a rather .. [?] attitude, we said "Now do y9u think that this is right." when we knew it wasn't right, but we used this approach and it worked very well. We had to admit, of course, the problem was ill supposed, and in a word, ridiculous. So early in the life, computer life, we learned to be very selective, and somewhat critical of the way problems were proposed to us. So, you can see, when a big, if you have a big computer and you have the capability, you might be duped into undertaking some enormous calculation because of the speed you had, you've got to use your brains, and for God's sakes, don't get into something that's unrealistic and may be absolutely valueless when you get the answers.

Mertz:

Well, in this area of problem formulation, I, I, I gather from your description of the activities of the the [clears throat] theory group. that, that this is one of the areas that perhaps they had preview

Wrench:

Yes.

Mertz:

Or that, that is to say

Wrench:

Yes, we, we were responsi--, that's right. We were [?] were turned over to the programmers, if we thought that the problem was not properly proposed or if the mathematical procedures suggested were not the best, we could interpolate our ideas, then perhaps we would get a reformulation improvement of the problem. And this has indeed been one of our principal roles.

Mertz:

Well, in the, in the .. in the parallel area, that is in the construction of, of .., I don't believe you've touched on the area of prime numbers and.. large primes, which I gather from what you've, from what you are telling

Wrench:

No, no

Mertz:

about me earlier .. before the interview was .. something that you are interested in.

Wrench:

Yes. I, I was, I've been interested in that, however, I can't explain why, perhaps it's just the ..just curiosity. My field has been number theory all these years, coupled with computation, and.. it is possible for a child to write a number on the board or anything for that matter, say, about thirty digits and ask for the factor of that number, and most of the computers now.. and if the number would be randomly written would have difficulty answering that question. Most of study of large prime numbers has been specialized in numbers of relatively few forms. I am referring to numbers such as the Mersenne numbers and numbers of the form 2^{n-1} which can be particularized as [?] prime to the [?]. Or the Fermat numbers, which are numbers of the form 2 to a power which itself has a power of 2 plus 1, 2^{2n+1}. Those numbers have, of course, great interest, information with perfect numbers and Mersenne nth numbers and the script case of the Fermat numbers. So they have a vast and exciting mathematical history. Interesting enough [clears throat] those are the numbers which have been most studied in connection with the existence of large primes. Fermat numbers have not been very fruitful in producing primes, the first four are primes and after that no prime has been foud. So we don't have any answers to whether we--

Mertz:

It stops.

Wrench:

are looking in vain or not, whether that's the last. However, the Mersenne prime has been rather, rather satisfactory in largest prime number known at the present time is a Mersenne prime.

Mertz:

Uhhuh.

Wrench:

To the power of a thousand which is identified, ohm about six years ago, on the UNIVAC II at the University of Illinois. With some patience investigate the reent computers because of variance in working like...I saw just the other day in a newspaper account of the completion now of, or near completion of a fourth. So, I suspect that the University of Illinois is going to make the headlines again with some more very large computations.

Mertz:

Who would you...do you associate that--

Wrench:

Well,..the--

Mertz:

with historical interest?

Wrench:

Well, historically, I would say, D. J. Wheeler. But D. J. Wheeler, of course, is in England now, I believe, and he works with J. C. Miller, by the way. He and Miller are working on numbers. When David J. Wheeler, is his first name--

Mertz:

It's Wheeler, Gibb and Wilkes--

Wrench:

Uh?

Mertz:

Authors of an early book on computers and programs.

Wrench:

Yes, that's right. Yes, that's Wheeler's book. Yea. Well, we heard one of the--

Mertz:

The Cambridge House

Wrench:

I believe he is, he and Miller published in [?] in large part. In fact, I'm going to mention directly, Wheeler was at Illinois, by the way, for a while, I think he spent about a year there [?]. Wheeler was the one who proved, for example, that two to the power he found 191-1 was [?] equally known in

Mersenne prime, that was interesting. It took him one hundred hours on the ILLIAC I, the first ILLIAC. And this is the amazing thing, the result that he got on the ILLIAC I after one hundred hours was checked and found to be right. And how a machine can operate one hundred hours and still get a right

Mertz:

get a right answer

Wrench:

answer--

Mertz:

is rather astonishing. Is there a commentary on the check--

Wrench:

Yea.

Mertz:

What would be, I think, perhaps quite useful, would be a table, if it hasn't already been done,

Wrench:

Yea.

Mertz:

comparable to the one you have done on the

Wrench:

On these large primes.

Mertz:

on the large primes.

Wrench:

Well, I had

Mertz:

I guess, oh,

Wrench:

I had a table, but I think it's in a series of papers I started, I have given a cursive account of this in this paper and I should probably put it in tabular form. But, such tables, I think exist, but they're not all that easy to come by. I have a book, a Swedish book, for example, that has a table. It's in Swedish and not every person is going to happen to have a Swedish book in their library that they can to. Other than that I have references, but I always appreciated the Swedish.

Mertz:

Yeah.

Wrench:

And that's a book that should be translated into English, by Hans Rieseo, R-I-E-S-E-O, over in, .. in Sweden [clears throat].

Mertz:

Where is he at, in--

Wrench:

I don't remember, again I'll have to look that--

Mertz:

Gotheburg, or is he at at the--

Wrench:

No.

Mertz:

Warsaw?

Wrench:

Up--Upsala. But I have the data here somewhere in my notes. I can find it for you, it takes--

Mertz:

And then there's, I believe, Abe Taub in Illinois, was he

Wrench:

Yes, yes.

Mertz:

Out at Berkeley?

Wrench:

Yes, now I haven't heard much of him lately. I don't know if you've heard very much.

Mertz:

Well, he's been editing the von Neumann, he had,

Wrench:

Yes, yes, I see.

Mertz:

he hasn't been around.

Wrench:

You used to hear a good deal of him. He was working on a book as I recall, some years ago.

Mertz:

But he hasn't been in Illinois for, I believe, quite a while, and I was interested in finding out if there happened to be anyone you knew who has been there for quite a while and sort of could--

Wrench:

No, I don't know. George Forsythe, the name in this area you could phone, George Forsythe, you ought to get in touch with him. He's at the—

Mertz:

Forsythe?

Wrench:

Forsythe. F-O-R-S-Y-T-H-E. George Forsythe. He's one of the earlier computer experts and programmers. I think he's at…I think he's at Stanford, but I have to verify that again. I think he is, yes... Last January, in San Antonio, Texas, the meeting of the American Mathematical Society had the winter meeting, and. if I recall correctly, George Forsythe and a number of others [?] were speakers at the roundtable discussion about computers and the software, and the training of programmers as such. It was a rather interesting discussion. There might have been a similar session, if I recall, the year before, I sometimes forget from one year to the next year. But one of those sessions, either New Orleans in '68 or San Antonio in '69, that we had such a , such a discussion. George Forsythe was, of course, one of the, one of the principal speakers of that roundtable discussion. He's published a number of reports in Editor of at least one journal, in the Communications of the ACM. I think he's a former president of ACM. He's one of the [?] in the field there. He is. I worked with ballistics years ago before I went to live, the Physical Laboratory. I didn't work one summer there when the very fine mathematician came out of Wisconsin, had the computer lab in Wisconsin. That's J. Barkley Rosser. R-O-S-S-E-R.

Mertz:

J. Bar--

Wrench:

Barkley, B-A R-K-L-E-Y Rosser. Now, J. Barkley Rosser .. was acclaimed at one time, one of the ten outstanding young mathematicians in the country. He was at Cornell for a number of years, and during the war he worked within the ERC, and developed the theory, the exterior ballistics for rockets, which was long before rockets became as popular as they are now. This was at the time of World War II. And he had a book on rockets functions, which was published, I believe, by McGraw-Hill, oh, about 1947. I worked with Barkley Rosser in those days, and I can remember the first day he got interested in this rocket function theory. He was quite interested in historic...Very brilliant man. He's still active, and I see him at the meeting every year. [Clears throat]. He is a head of his peer [?] Wisconsin where there is computing. There is no question right now, but he never was, he was a person you could talk with. He's more of a theoretician. I don't think he's not a programmer, don't mistake me. He's a top-notch mathematician. He just has a tremendous feeling for solving problems in mathematics. Through a number of rockets, he was able to identify the important parameters, he was able to evaluate all the discarded ones, [?] that proved by very accurate data; that certain things which were negligible, were indeed [?] as far as [?] justify his mathematical model. [?] But there is one of the top men in the country. He's not a computer expert, he's a [?] computers.

Mertz:

In the field of large…primes, you mentioned Weaver. Were there any others in Illinois with subsequent background who's active.

Wrench:

No, I don't know. I'll tell you who's active in that field and that would be D. H. Lehmer. Dick, Dick Lehmer.

Mertz:

L-E-H-M-E-R?

Wrench:

Yes, his first name is Derrick, but everybody calls him Dick. His first name is D-E-R-R-I-C-K. Derrick Henry Lehmer.

Mertz:

Mhm.

Wrench:

University of California, Berkeley. He and his wife Emma Lehmer, have been working in this school for many, many years, and, in fact, they are still active. They are still publishing function [?] tables and [?] [clears throat].

Mertz:

Is Shanks act--continues to be actively interested in large primes?

Wrench:

Oh, yes; yes. His theory is, he developed it, and the book, the program [?]

Mertz:

Mhm.

Wrench:

But another one, of course, that's very active in large prime number identification is John Grillhart. John Grillhart is at the University of Arizona right now. Grillhart. G-R-I-L-L-H-A-R-T. John Grillhart, perhaps more than anybody else, who has studied these large prime numbers. He is at the University of Arizona, over at Tucson, I guess.

Mertz:

Phoenix, Tucson is--

Wrench:

Tucson, I guess, it is. [Clears throat]. And [clears throat] he was all this summer at the University of California in Los Angeles; UCLA. And he, just this summer, factored the seventh Fermat number which has been known to be composite since 1905, and sixty-five years later we finally find the factors, using the most [?] computer, using the 360/91. That's really a big computer, of course. And he got that factor on the thirteenth of September at ten in the morning, Pacific time, and was about to go back to Arizona that day, later that day. It was the eleventh hour. He'd been working all summer on this type of problem, and the very day he was supposed to depart, he hit it like a jackpot, and he solved the problem that baffled us for sixty-five years. [?]

Mertz:

That was this year?

Wrench:

Yes, this year, September 13, 1970.

Mertz:

Oh.

Wrench:

[?] real impressed.

Mertz:

So that should be in the table. Do you have it in your--is it mentioned in this?

Wrench:

Oh, yes, yes. I mention, in fact, I say in my talk here, that this very large prime--I'm sorry, this factorization took,.. I don't know how many hours, but it was done by a method that's actually due to Legendre, which involved the [coughing] excuse me, the examination of the continued fraction of the square root and multiples of this particular number. And it took probably hundreds of hours of computer time. There's one particular problem they ran on the old 7090, you see, Lehmer has an old 7090 at Berkeley, which has very little input/output facility. But they don't need that, all they need is central core and [?], and they ran that darn thing probably, I think, two thousand hours before they got the answer. See, that means that they have to to have a computer that nobody else use, effective surplus computer, and they can play with that--

Mertz:

Well, that's error-free.

Wrench:

Yeah, well, they were lucky. They've been able to get remarkable results from this machine.

Mertz:

Mm

Wrench:

I was going to tell you that this largest prime was found on ILLIAC II, the two thou--2 11,213-1.

Mertz:

Right.

Wrench:

Two hours and fifteen minutes computer time of special test of Lucas, L-U-C-A-S.

Mertz:

Right.

Wrench:

A French mathematician who evolved this test along with successive times.

Mertz:

Mhm.

Wrench:

So, the computer time is salvaged by special tests with special numbers. It's rather reasonable, Two hours and fifteen minutes for the really largest] prime, 3,367 digits long. But to establish the factorization of a much smaller number, say thirty-nine digits, the case I just cited, the seventh Fermat number would take maybe hundreds of hours. It's just a different type of number.

Mertz:

Yeah.

Wrench:

See, it all fits in essentially the same subject when we search for large primes.

Mertz:

By using different--

Wrench:

Yeah, yeah, different techniques. Essentially, there is a different serum applied.

Mertz:

Yeah.

Wrench:

Now I want to mention another thing, John L. Selfridge, S-E-L-F-R-I-D-G-E, John L. Selfridge. And I think Selfridge, the last I heard, he was at the University of California, but he may be, he may be moving around again. He changes .. he changes locations here very frequently... I can find it here in my notes [?] here it is...Yes. He was, oh, I'm sorry, he was at the University of Illinois about two years ago. Now there's, there's your answer. John Selfridge was at the University of Illinois about two years ago, 1968. Now since that time he's moved around, and the last I heard, he was, at least this summer, I believe, he's out at the University of California, I think he's at Berkeley. Whether he's going to stay there is another matter, I'm not sure. But John Selfridge will be able to tell you quite a bit about Illinois after, after-- that's a good lead there, I'm sure.

Mertz:

S-E-L-F-R-I-D-G-E?

Wrench:

That's right, exactly; John L. And he and... he and Bill Hart published joint papers together. In fact, they're all going to be together, I understand, this winter, Christmas time, I forget if it's going to be at Berkeley or Tucson, but... Dan says they're going to be out there working. So, all these number theorists that you have are all going to be.

Mertz:

[Laugh] all

Wrench:

Orsbach, Dick Lehmer

Mertz:

Wait a minute, this is around Christmas?

Wrench:

This, this, this Christmas time.

Mertz:

I see. 'Cause I'm going out; I had planned to go out to California in February.

Wrench:

Well, I expect they may be in Berkeley together this Christmas... I believe so. [?] can verify that for me. I know he's going out West and ... working there. But these... these fellows have a sort of rapport, they like to get together. [Outside interference] and anything that they have may result in

Mertz:

[laugh]

Wrench:

But Sofford gave a very, rather, a [?] I should say, Sofford gave a very fine talk at the Mathematical Meeting at San Antonio last year, when I was present. And there was an overflow crowd. It was held in one of the regular meeting rooms for the patrons. But subjects such as this, of course, is a very popular field. Everybody there understands the problem. So, there was a crowd there that overflowed, filled all the seats, lined the walls, corridors

Mertz:

[Chuckle].

Wrench:

It was quite a sight. I was very fortunate to be there.

Bill Hart is a rather unassuming quiet spoken individual. He doesn't make any great stirring speech. Those that have studied and worked with him realize that he is a gentleman, and a very fine researcher. I have given him some problems to work on that he and not completed for me, numbers that I call repetitive numbers. Those are numbers that are formed $10^{n-1}/9$ are prime values to be of interest, in interest particularly on a number like 10^{43-1}, 49, which is 43 consecutive 1s in the decimal system. It does have factors, but we don't know all of them yet. Bill Hart is going to work on that.

Mertz:

Identifying--

Wrench:

Yeah, identifying factors. And he chose that in an area of slack time and work on that. But he has a whole list of such numbers that other people are interested in, too, so he sort of has to list the extraction numbers and out them on the machine...

[End of Side One, Tape Two]

Wrench:

Here, yes. This gentleman here, here it is, yes. This gentleman here has actually recorded in hi stencil, all the digits of these large Mersenne primes. Then at the very beginning of this report, this is by Mohan Laloas.

Mertz:

L-A-L-O-A-S. Yes.

Wrench:

The first name is M-O-H-A-N, and he's a

Mertz:

Hugarian, isn't he?

Wrench:

Hindu, Hindu.

Mertz:

Hindu, oh. Well--

Wrench:

He's more of a programmer, he's not a mathematician, but a programmer. And he's up at St. John's .. .. Newfoundland, Canada, the Memorial University of Newfoundland.

Mertz:

Newfoundland, I see.

Wrench:

Now what he's done here, is actually given the statistical study of these digits. Now how he ties each digit that appears with these numbers. And what's the pi squared--

Mertz:

Uh-huh.

Wrench:

probability of pairing and so on. So, this is a rather interesting table.

Mertz:

Yeah.

Wrench:

So now that has been done for pi also. The large cycle that you have to a hundred thousand places has been studied, and we've found that that aids as a [?] number.

Mertz:

Oh, it does?

Wrench:

Yes, there's no bias in favor of the digit. It's obviously not random, but as far as the base ten is concerned it behaves at the right number. Four is a source of round digits.

Mertz:

How about another digit?

Wrench:

[clears throat]. With respect to pi, we've looked only in the base two of Linden, L--bases in the equivalent in the base 2. However, for numbers such as square roots, they haven't investigated in respect to, say, base 8 as well as base 10. And there is no reason to suppose that they aren't functioning as [?] also. But the search for presentation in other phases hasn't been pushed very far, except for [?]. We do have pi , by the way, in [?] [cough], but never published it.

Mertz:

One of the early, early computers of the generation after ENIAC, one at MIT known as Whilrwind, one plan was to use, a, base 3 to redesign the logic of the machine. To, use the base. Which, incidentally, has, poses some very intriguing engineering problems.

Wrench:

Yes. Base 2 seems like the central go/no-go; base 3--

Mertz:

Well, if you take certain types of core states

Wrench:

Yes.

Mertz:

you can have a zero [?] plus and a negative.

Wrench:

I see.

Mertz:

So, you have a three, essentially a three--

Wrench:

That would be more reliable, maybe than base two.

Mertz:

It has..so far as error is concerned, there is an enormous improvement. Really of--

Wrench:

had not been incorporated in any working computer yet.

Mertz:

No. But the papers on the logic of the machine and what it does to error, really has been--

Wrench:

So maybe we may see--

Mertz:

at twenty years ago it was studied and no one's done anything yet.

Wrench:

That's too bad. Well, I'd say that just brings us up to date, does it, here and now.

Mertz:

Well,

Wrench:

I, I still-

Mertz:

Do you happen to have an extra one of these or--

Wrench:

I could, I could give you this one, I can get another xerox made. I had a couple of these made. Would that help you any? This is not, this is not exhaustive, this particular discussion. There's no originality claim here, merely reporting--

Mertz:

Well, it does give in a narrative way, something like--

Wrench:

Something like, yes.

Mertz:

Something that has been given in--

Wrench:

Incidentally, the way to go about something like this is to go to some of these references. I would advise to go to Dickson's History of Numbers.

Mertz:

Yeah.

Wrench:

Slavinsky is excellent. I use that quite a bit. There's a book which, thirty-some years ago, to, he is planning hi second volume, but it's never come off. And Donald Knuth's book is excellent. These don't refer to any papers, I have a selective biblio--I have papers and I don't carry them with me anymore. The selection that I have, in this journal you will find this is very rich, especially in later years, copies. [?] You'll find a number of papers here, oh, as recently as 1964. In that box, perhaps we can find one here, find another one this moment here. Looking in this paper here. Selfridge, and here we have it on page 146. You can see what I'm speaking of here. Here we have a discussion of this, which at this time was comprehensive. Since, it has been superseded. This is the sort of thing Alexander and Selfridge, and at the time they were both at UC--

Mertz:

UCLA.

Wrench:

Yes. But Selfridge moves around so. [Laugh]. He's been in a number of places. He was at Illinois.

Mertz:

Huh, well--

Wrench:

So, I can give you a copy of this. My secretary can make some more copies this afternoon, and perhaps leave a copy. At this college I'm talking, District Teachers College, like I said.

Mertz:

Well.

Wrench:

So that carries us fairly well to the present time.

I am interested in other computations that I have done for Don Knuth and his third volume of his seven-volume work. He asked me to compute the logarithm of the logarithm of 2 [?] the base e, which I did. He needed that, apparently, in some discussion of consorting, converging routine, interestingly. And he wanted very many figures because he wanted to incorporate n the table of pi. So, I worked it out on my machine to forty-eight places and two ways to check, and I ran it to about 110 later. And now I'm, going to run it to about 150 just out of curiosity. You see, it's sort of like climbing mountains.

Mertz:

[Clears throat].

Wrench:

It's probably the longest ever

Mertz:

I was going to ask you what.. what you envision the next step in the calculation of pi to be to .. do you think that's going to go up by orders of ten?

Wrench:

I doubt it.

Mertz:

of magnitude--

Wrench:

I think, I think once we get to a million. To go, you see, to go to another order of magnitude, your work goes up by two orders of magnitude, because we haven't found a way. This would be the breakthrough. If you have a wayu of computing a number, not just [?] but a transcendental number, by a technique we could oincrease only as a smallerpower than the square, deally as a

Mertz:

Log--as I say

Wrench:

Log, log

Mertz:

as it approaches the logarithm

Wrench:

Then you've got, see. But at the present time, you see how deficient we are in knowledge. We still depend upon these classical methods of the countless power series and so forth.

Mertz:

Mhm.

Wrench:

Ideally, we have to have a much more powerful method which means a new calculus, a new mathematics which nobody has yet perhaps envisioned or certainly understands. And you night ask in this same context, could you invent a scheme whereby you could predict and identify a number in the transcendental number without computing all the predecessors thereof? That would be omniscient. And you would have to be, you would have to be omniscient. You could say, I want, here's a number, you give me a digit. You give me the place and I'll give you the digit. If--if we have that arbitrary choice we have, in effect, knowledge of numbers. Any number you need, I can identify the place.

Mertz:

Well, in--are any--any, yep. Now--

Wrench:

In other words, you would be infinite in knowledge, essentially. There's no end to the--

Mertz:

Well, then, that would presuppose some concept of the inner process.

Wrench:

Yeah. Some way of computing a number, isolating a digit without going through all of the memory work, you see. And that, now you can see the real challenge to the mind. And it's so great that there's no mind, I think, now that can meet it. Very interesting. Course you can become famous in this life, you know, by making conjectures, posing problems. That's a problem, maybe I'll be famous for that. Just pose a problem,

Mertz:

David Hilbert did.

Wrench:

Yes, he did it with twenty of them, and they've got most of them solved now, more than fifty years, solved these problems.

Mertz:

Some might not get solved for quite a while longer.

Wrench:

Yeah, that's right, yeah. That's right. David Hilbert was a tremendous man. You've seen his last book out, his name as the title, David Hilbert, by Constance Reid. There's a book that's just come out within the last few months, by all means get it if you can, in the library. We have a copy. I got it from our library, and Dan borrowed it from me. And the title is very simple, David Hilbert, and I believe the author is Constance Reid. I don't know who the publisher is, right this minute. But that gives you a story of Hilbert and his school, in fact, my friend [?] with whom I studied with in Yale was.. present at his lectures and apparently was not one of his proteges, but he certainly was [?]. David Hilbert affected mathematics well beyond the realms of his university, of course, in fact the whole [?]

Mertz:

Was in mid-century, or near that, about 1950 perhaps 3,, 2 or 3 that von Neumann was invited to Amsterdam during our National Mathematical Society--

Wrench:

Mhm.

Mertz

To talk about David Hilbert, a half ventury later.

Wrench:

That is--

Mertz:

That is, after the famous posing of the problems.

Wrench:

Of course, von Neumann was remarkable [?]. He was--

Mertz:

That lecture he gave--that's wire-recorded. In--by the Dutch mathematic

Wrench:

That's, that's well, so I'm still interested in computations as you can see, and I still use my old machine. I use the new electronic computers for the most part. They have more flexibility. The old gear driven machines.

Mertz:

I meant to ask you about one thing I think I could anticipate the answer you would give, but it would be better for you…the problem of time-sharing and the idea of private consoles and the personalized access to machine in lieu of--

Wrench:

It would be all right if, of course, my problem is the software. I have very special routines for what I do, and perhaps I got myself in this tight spot because I do these [chuckle] insane things of my own precision. Most routines, of course, are single, double precision, and so on. But I'm interested in precision almost unlimited, where you might go up to one hundred full precision or something like that, which means you have to have, you can't just have fore-training, you have to have some special programming. I think the idea of the console, that's in fact what the head of the laboratory, Mr. Bryson, suggested. Maybe I should have a console here. I can do more planning with my console, if I can get the software. Maybe I can devise it, or somebody else. It would take a pretty good programmer to design a software I need, you see.

Mertz:

Mhm.

Wrench:

It's all I can do to tell another human being what to do, let alone a ..[chuckle] stupid calculator. But these .. these modern desk size machines for the most part don't give you the full-length product, or, if they do, as one that was recently demonstrated tome, it prints it. I don't want a print-out necessarily. I want a [?] of light, because I have to copy it anyways if it's on tape, I almost certainly have to copy it on a piece of table t paper, because no printing calculator prints what I want which is a standard typewriter size sheet. But everything laid out according to my format, and what [?] [?] program, edit and so on, just isn't treated to do that.

Mertz:

How do you usually lay these things out then? In groups of--

Wrench:

In groups of five or ten, or something like that. And some multiple of fifty ro a hudnred on a line, and everything's very nice. You can see from that reprint I gave you, it's very easy to follow.

Mertz:

Right.

Wrench:

Easy to read. Because we still are wedded to accounting, it's easier to see five or ten numbers more than any other number [?]. We're not used to it yet. So, it's true that most of the desk electronic machines are inadequate. You can't do what you want them to do. They can't reinsert remainders easily without some special instruction to continue. Though recently this [clears throat] this one…this one…demonstrator of the Olivetti did succeed. He went back to his office and he did succeed in getting a series of instructions and made it do what I wanted it to do, and he and to reinsert the remainder division. But he still couldn't give me the flexibility I wanted. [?] So some day we may see, but only if there's a solution made, an electronic machine, for a few thousand dollars, that will do what this machine does now that didn't really cost a thousand dollars and now you suppose value [?] so we may see a day, unfortunately, when the old gear driven machines are obsolete. There's no reason why they should be. People use electronic machines for business applications, and I insist that an electronic machine for business applications generally is too much speed. Generally, because you have a transcription normally on a problem, and you haven't got the input/output speeded up just like the large electronic machines. So I'm not sure if the young ladies adding columns figures as fast as she can add it in a tenth of a second rather than a second is going to make very much difference whatsoever.

Mertz:

Well, the only,--I suppose the only reason perhaps for that is that the machines are general purpose machines.

Wrench:

Yeah. But they haven't made general purpose machines as far as I'm concerned, because I can't do my calculations. They can do one word per one work [?] they're wonderful, I agree, but not for [?] and I say that what we need.

Mertz:

And there's no well, without special routine, but IO should think there would be enough in the way of libraries and subroutines to cope with that problem.

Wrench:

For the large, for the large contract machines, yes, you're right.

Mertz:

Do you think--

Wrench:

This size, I want a desk size for this thing. [?] Electronically, this size, what I can do, there's no reason why, if we're advancing, we're progressing, why can't we progress in that matter. We're not gaining as much as we think. For most applications, business applications. None of the salesmen come in here, with few exceptions, maybe one exception can satisfy me, and even he had a printing calculator which shouldn't--

Mertz:

I came across a man who was instrumental in developing the magnetic core memory at Harvard, Dr. An Wang.

Wrench:

Oh yes.

Mertz:

And this is one of the things his private firm is trying very hard to do. And that is to develop a very small hand, or rather desk, table, table-top calculator that will serve precisely this.

Wrench:

I think, I think, for single work, again, for single work proceedings, we've no argument, they will do it. But I've seen some rather strange demonstrations. One came in one day to demonstrate a machine and His software was [?] put in a package was supposed to generate a sine. It came out with an answer that was wrong after two figures.

Mertz:

[Laugh].

Wrench:

It was not the machine's fault. It was in the package that was giving the wrong answer. And that was that. So, as I say, if you want a real picnic sometime, come in here when we're going over a routine with one of these salesmen, and you'll get your money's worth. I could charge admission.

BOTH:

[Laugh].

Mertz:

Well, thank you very much, Dr. Wrench.

[End of Interview]