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This is Interview TC-56 in the IBM Oral History of Computer Technology, Larry Saphire interviewing Dr. Karl Ganzhoorn at Bublingen, Germany on February 5, 1968.

S. Dr. Ganzhoorn we want to start off by talking about early computer developments in Germany or as far as you knew it, in Europe. When did you first get involved with automatic computation?

G. I first got involved when I actually joined IBM in 1952. The prime orientation of my assignment at IBM was in solid state physics aimed at computer components. When I started the company was just introducing the Type 604 tube machine in World Trade and subsequently IBM also started to expand some early Design Departments existing here in Germany. This department was supposed to be expanded into a development operation and actually became in the consecutive years, one of IBM's development labs.

S. You had been a physicist before you came to IBM, is that right?

G. That's right. In fact I still would like to be one at this time, except physics has only been one part of the total involvement in this job.

S. Let me ask you a question about the prior time, in your work in physics prior to 1952, had you ever had any need for a computer or some sort of hook-up with an accounting machine or had you come accross them?

G. The only occasion when I ran into the need for a computer was during my own doctor's thesis in theoretical physics and solid state, where I was supposed to explore specific electron states in transition metals. During that time it was virtually impossible to calculate these states of electron waves because of the complexity of the computing involved without any computing equipment and during that time it first became obvious to me that without major new concepts in computing machines, there would never be a chance to explore this field although this was in no way an initiative for me to go into the computer field. It just was felt as an early need and much later I realized that by now we are in a position to fulfill these needs actually and it is being done, except I'm no longer involved.

S. I take it you were doing it for the university.

G. Yes after I had finished my studies at the technical university in Stutgart, I was an assistant in theoretical physics at the university from where I then was hired by IBM.

S. And there had been the development of computers like the ENIAC in the United States, and as you had mentioned to me, Dr. Duzer had made computers in Germany.......... To what extent was there a climate for using these kind of machines, or desiring these kind of machines that you might have heard of outside of your own particular work?

G. I was not aware of any of these developments until I joined IBM. There was very little known in Germany before 1952 or even '53 that a development in the field of computers had taken place and so my knowledge about these early computer developments by Duzer and of the universities in Germany and of course those early developments in the United States, my first knowledge was only in 1952 and '53 when I, from a business point of view, had to get interested in this.

S. Well what kind of work did IBM do, components?

G. Yes we were starting out in developing components for a computer and also for I/O and punched card equipment. In particular we started out here in photo electric sensing of punched cards with the first solid state sensing elements, we tried a number of them. In particular we got involved in early cadmium sulphide cells which we investigated for two or three years and also built some special products where we used them as photo conductors for the sensing of punched cards and printed marks on punched cards. A few special programs within World Trade had been developed. Some products had gone out .... some early products had gone out in the field. Although today we must say an almost negligible number of machines each time in the magnitude of 20 to 30 of these early devices, this on top of what we know.... on top of the usual......

well let me say it differently. These devices in those early days were not at all explored to the extent we are used to today in semi-conductor components and they needed a lot of special treatment, adjustment and customer engineering service to maintain their operation in the field.

S. Well don't we have a photo sensing card reader now?

G. Oh yes now almost all of our high speed card sensing devices are somehow or other on a photo electric basis.

S. Do any of them utilize any of the work that you did then?

G. The answer is no because much later .... four or five years later the silicon devices all of a sudden turned out to be acceptable from a technology point of view. We learned how to handle them and then the superiority of the physical aspects of silicon photo sensing cells became obvious and clear and therefore the company abandoned, not only our company but the entire technical world, abandoned most of the earlier sensing devices considered before. Following this photo electric development, or even to some extent in parallel to this, a small group of physicists and electrical engineers starting in '53 here in Germany, got involved also in the design and layout of ferrite core memory in parallel to this photo electric work. Some early thinking, in particular the two and three dimensional organization of ferrite core memory, was conducted hree and in particular early ideas and as far as I can see today, they

.... they even have been the origin for later development ..... early ideas on transistor switching of ferrite core memories, addressing these memories over transistor switches has been picked up here and has probably stimulated some other work which went either in parallel or consecutively in this company.

S. Let's look at the magnetic core work. That was just about getting started in '52 and '53 in Poughkeepsie.

G. We acutally got very early in the act here. A number of patents which out of the ferrite core area have been filed from the German lab too, I would not dare to say we had any major break through. But by that time we were participating in developing the entire art. There was a lot of mutual exchange of ideas and ways to handle the storage device and the ferrite core memory. I believe that the mutual ideas have stimulated this entire art to a great extent. It was merely a matter of putting the right ideas together to really achieve the major advance in the ferrite core memory in 1955 and '56 ....

S. Can you give me a little technical background on the approach that was being taken by the German lab?

G. If I just list some of the ideas and the design concepts which have been considered here, whether they were the first ones or maybe I shouldn't really judge..... but some of these ideas ..... one was the world organization in two dimensional ferrite core memories which have been applied since many times. In particular also ten years later in the film memories again. Another one was the entire field of magnetic logic which was very close to the ferrite core memory such as biased magnetic cores, biased ferrite cores, rectangular .... loops, working from a different working point and a 0 magnetization. Then multiple wiring, multiple windings on cores. Inhibit principles were investigated here.

S. This is just going over the spectrum of possible.......

G. That was in the early development ferrite core applications and I should add also that after '56 and in '57 and '58 even, here in this laboratory we went much further than this, trying to develop an entire set of magnetic logic circuit devices which are all based on the ferrite core rectangular .... loop. We even went as far as designing an entire magnetic circuit family with which we were able to build an entire small computing system and we actually simulated an entire machine in magnetic logic here in this laboratory ..... it was a two address WWAM type machine which we really completely built up in this new circuit family. But later on we finally discontinued the entire magnetic logic program as by the way, everybody in the world did by this time, and the reason for this was actually the existence of a complete transistor technology already. The logic behind this is well we do have a useful technology in transistor circuits which does everything we need, which achieves the cost of former targets. There's very little incentive in developing a parallel new technology which does essentially the same on different principles and on different technological problems. For instance, in the magnetic technology, we had to go as far as developing a very complex core winding machine which allowed us to wind multiple windings on these tiny little cores in ordet ot make them .... to fill them up for the magnetic circuit family. Such things were really very difficult to develop in the technology. Also in these early days for the first time we faced the problem of packaging which has never left us since, in particular because we had to take care of so many, many wires in the magnetic logic. But at least we could show that the machine worked and that it demonstrated the principal usefulness of such a technology. Except as I said, when you have one technology which is good and serves the purpose, achieves cost performance, there is no justification to duplicate it in another technology and that's probably the reason for everybody in the world to abandon this parallel effort in magnetic logic which was just overrun more or less by diode and transistor logic.

S. I wonder if you've ever spoken to Mike Haines who told me he wroked on his thesis, mostly on magnetic core logic.

G. Yes we did have contact in those years. In fact we had quite a number of contacts on magnetic logic here in Germany as well as in the States. And so it must be said that during those years information flow and information exchange between the United States and Europe was not nearly as intensive as we are used to today. So that's why this information was much more sporadic and was mainly for literature.

S. Just as an interesting historical sidelight, let me ask you this question. The basic advances in magnetic technology as I understand it, originated in Germany during the war when the Germans were sending some sort of radio signals and made an amplifier which used a magnetic apparatus which gave a very clear ....

G. That's right.

S. To what extent was this a war secret that kind of got taken away by the United States Army or Navy and wasn't known in Germany? Was it known in Germany?

G. It was known in Germany. I conclude you are referring to what is called here the New Method in Germany. It is a .... which has .... loop .... and a number of efforts have

taken place here in Germany as you say, during the war, to develop these magnetic causative materials.... several of these materials. I was not aware of the development of course before 1952 when I got interested in the field after joining IBM. I cannot really say what the impact on U. S. development was, based on early developments here in Europe or in Germany. But I do know that some German companies did have available high quality material, magnetic material which was quite powerful compared to what everybody knew right after the war. Except that they were not really useful for computer purposes mainly because either the speed ...... the speed was too low ....
....

S. Were there any further technical results from the components work in those early years, besides what you've just discussed?

G. I have discussed the early photo conductive work which gave us a number of patents in the cadmium sulphide field. .... where the field effect transistor is coming up again and cadmium sulphide becomes an interesting material again. Maybe we have given up too early, although in between there were ten years of intense research in the semi-conductor field which probably was much too far reaching in those old years to foresee that cadmium sulphide could become an important material again. It was doubtful until today. (?) So aside from some patents, I don't think we got much out

of it except some general experience on photo sensing circuits...........
However, I think this memory work really was contributing to the art, although the origin of some of the work as usual in these fields is very difficult to trace. .....to trace where the ideas really came from. I would say today it is just the fact that so many people were actively working in the field and contributing, which finally gave us a break through in this ferrite core memory.

S. Was it the German lab or the German factory that was getting some fairly good competence in things like the printing machine........up the part the German lab played in the development of the WWAM?

G. The WWAM was right in the middle of this core memory development. This system development request came up in the Spring of '55, and the German group which really wasn't a lab at that time was a group of five or six people, this group was asked to think of a proposal for an electronic accounting machine and the group worked for several months, using this ferrite core memory work on a lot of things and during the summer of '55, I guess it was June or July, '55, we had a combined group of two French engineers, Maurice Papo and Gene Estrenz, several engineers from the domestic organization.... ....and from the actual marketing side Bill Christensen. I think Jacques Maison-Rouge was participating in the group for a certain time too, Rene .... from France with the marketing people. This goes together with two members of the German group, namely Dr. .... and myself. We were together here in Germany for about six weeks. Walter ...., the head of the German Design Department, was the host of this group and we were working toward establishing two or three alternatives of design possibilities for an electronic accounting machine. And in fact we came up with I think it was three approaches. Strangely enough by that time, we were strictly oriented on a national basis. There was an approach from the French group, one from the domestic group and we two fellows from the German organization tried to make a proposal too.

S. You and Walter .... ?

G. Ted .... and myself.

S. I see. How did you view the problems at that time?

G. Well we had a strong belief that it could be done during those days. Except we were working from all ends at the same time. While we were trying to explore the market requirements, we also were trying to resolve the systems aspect, and at the same time were trying to define the technology which we should use for it. So we had to really work in all directions simultaneously and from today's view point it was an almost sub-critical effort which we started in those days. But anyway it got us into the field and the entire group rejoined back in Poughkeepsie in September, '55 and carried the design phase for several alternatives further on. Finally in December we came up with a joint recommendation to select the approach which was proposed by Gene Estrenz and Maurice Papo, which was based on a variable word length concept and transistor technology, together with ferrite core memory. Mainly from a systems point of view, this approach was by far superior to anything else. The other approaches were based on a fixed word length mainly stimulated of course by those early days of computer concepts. But I think it was the merit (?) of Gene Estrenz and Maurice Papo to really recognize that for commercial data processing and accounting in particular, a variable word length concept on a tow address basis was the optimum. Later on the proof for their assumption was given by the unique success of the 1401, which actually applied their principle.

S. Were there American engineers in that group as well?

G. Oh yes. In Poughkeepsie to be correct and fair to history, the group actually was working under Pete de George who is now in Lexington. It was closely associated as I recall, with Max Pele (?) who is now in the ACS Computer System. I must say during those months in Poughkeepsie in the fall of '955, we had a very active and frequent exchange of ideas, almost a permanent discussion on the way the machine could be designed or should be designed. By that time for the first time we also saw the first prototype of the 608, which was the first transistorized machine, we saw all the difficulties in those early days and that had another impact on the design of the WWAM.

S. Can I ask you what kind of technical impact that had?

G. Well it gave us a lot of hints how a circuit family can be developed and what had to go in the specs of a circuit family for a computer. By that time, the definition of a circuit family was not at all at the level which we are used to today. Today we know that we have to set up an entire collection of specifications and we know pretty well what they must contain. But in those days it was very unusual even to work toward an entire family of circuits which are all characterized by a set of specs.

S. Could I just ask you one question. On this family of circuits, was that when it first got going?

G. No, as far as I can recall, the 608 circuit family, the so-called ...... one of the so-called MAC circuits.... the Actual...... the MAC Program. Maybe Max Pele still recalls what the abbreviation means.

S. I can't recall either.

G. I recall it was the very first approach toward a circuit family in the company. Anyway later on the WWAM design went its own way and developed its own circuit family, to a certain extent influenced by the former experiences of the 608.

S. Well what was the key factor in the idea of a circuit family? What was the relationship between the circuits........

G. Well the actual idea was to have a set of circuits which could be connected to each other, logical functions or storage functions, could be connected to each other in a way that each output signal was a valid signal as an input signal for the next circuit. In previous electro technique, this was not at all a common practice. Before in those days every electrical engineer had to design a circuit one after the other, taking the output signal and adapting the next circuit to the output signal he got. And the idea was to standardize the signals so that each output could be connected to the next input. And more than this, ... today, namely the idea of having a number of input signals into one circuit, and at the same time have the output with enough power to provide a minimum output.... a minimum number of outputs lead to consecutive logical circuits. So the standardization of signals for input and output was the essential first point. And of course immediately following this, the tolerances of these signals has become one of the major issues in circuit design.

S. Well do you feel that these were considered as basic ;n the design of the WWAM. The WWAM did develop a circuit family.

G. The WWAM developed its own circuit family as I can recall, but also as we later on abandoned the WWAM in favor of the 1401, I must say I think the circuit family was not followed up further on. Really I'm not in a position because I was no longer on the program then. To what extent the WWAM circuit family also had an influence on the later 1401 circuits....... but certainly the experience in the early design approaches and the experimental design which took place during 1955 and '56 was a good base of experience for the 1401 design in '57 and '58.

S. What about the mechanical approach of the German lab............?

G. Oh yes. Starting in '56, we split the total responsibility of the WWAM System, World Wide Accounting Machine System in such a way that the French development organization developed a CPU, a central processor, and the German lab which by that time had a substantial mechanical design department, had to develop the card reader and the printer.

S. Was there any reason that the German lab developed the mechanical designs?

G. Well the reason of course was the German lad had a substantial mechanical design capacity with around sixty or eighty people all together. So they were charged with doing the mechanical development work.

S. And why were they there to start with? Of course Germans are noted for being excellent mechanics and so forth.

G. I wouldn't say that. The nucleus of this group had always been here. Even before 1952 there was a Mechanical Design group already here doing essentially what we call Special Engineering today. But also doing some specific World Trade design work for specific World Trade products. Some of them had even been on the market for quite some time. The most prominent one in the early days, long before my time, was still making a lot of money during my time, was the so-called D-11 accounting machine which was designed in Germany if I'm right, even before the war or during the war. It was one of the very successful World Trade products. The design group which designed that machine had been maintained and a lot of the people were available again after the war, and they continued designing mechanical equipment of various kinds. So they also took over the design of the WWAM I/O equipment in particular, the high speec card reader and the .... the high speed line printer. ...... to say one word on this high speed printer was based on the idea to somehow share the electronic speed of the processor. In order to do this, the so-called multiple stick printer was developed. You do have stick printer or stick printer principles in many ways around in the company, at least in the engineering designs for line printers. But the most prominent printing device which we have today on this principle is the IBM 72 typewriter which doesn't have a stick exactly but a print head which operates in a similar way like the earlier stick speed, namely a two-dimensional positioning of the print position, one position which rotates the head and another one which aligns the head in different cylindrical .... no, cylindrical aspects or rhythms. In the case of the 72 of course it deviated a little towards the 403 head.

S. Did they have any inter-relationship -- the development of the Selectric and the German stick printer?

G. I guess there was very little relationship except the principle itself is very old. It just happened that the other day I saw one of the very old typewriters which was actually operating on a single stick principle.

S. Right. As a matter of fact, I think we have one from about 1890 or 1887.

G. That is correct. That one had been around during those early days when we designed this multiple stick printer too. Certainly the ideas came from there. So it is not at all a new invention.

how did that proceed before the WWAM?

G. Well from today's judgment, I should not say it proceeded very well. The group was able to come up with an engineering model of a line printer. I think it was 300 lines a minute if I'm right. 300 lines a minute I guess it was. It was a multiple stick printer, thirteen sticks working in parallel and sweeping the entire print area back and forth.

S. By sticks you are referring to ....

G. No, the sticks were essentially cylindrical shaped sticks like a pencil.

S. And they would revolve?

G. They would revolve to fantastic tape drives............ ..... unit remotely located were positioning the sticks.

S. Just to go back for a second, when we talk about the basic idea of that cylindrical or spherical printer going back to the early typewriters, this was abandoned but I don't know for what reason back in the early days, single sticks in typewriter development. Of course there was a difference in 1964 with the German work and later on at Lexington..............

G. Well the difference is a very interesting one. Essentially it goils down to the question of mass inertia. In the old days, the stick was a heavy metal piece of metal and to move it around it took quite some energy and momentum. When we designed the stick printer, it was already much easier tomorrow.... to come up with a relatively light metal stick but still the inertia of this stick was high enough to push the technology to the very limits which was possible during those days. And personally I believe that the break through which the IBM Selectric typewriter finally achieved was based on the fact that we could use plastics which were plated with metal later on. They were very lightweight, very light momentum.

S. So that even with easy power, the weight of even such a small thing was crucial.

G. Yes. In order to use this principle, you have to think in terms..... as in the Selectric for instance, 15 or 20 characters per second. That means 20 positionings during one second. In the case of the stick printer we find it even went further and asked for 50 positionings per second which puts quite high requirements .... on the movements of metal. (?)

S. Quite a lot of physics went into the solution...........

G. It's one of those principles which has always been around but the right technology never was available until finally we got to the metal-plated plastics.

S. To you then that's the key, the continual reduction of the weight of the elements?

G. I hesitate to say it's the only key. I'm sure there is a lot of other design work, especially in the in the set-up mechanisms which goes along the same line. If I recall the heavy, bulky magnets which we had in the first set of units, it would have been impossible to think of such a set of units in a Selectric typewriter. But the entire art of mechanical design went into a new phase during those years. Sometimes I'm even inclined to say it was a non-classical mechanical design approach which we had to undertake, namely to push the speeds in mechanical movements down to the microsecond region which we do these days all the time in our printers development. But it was completely new then. And only by pushing every component involved in this mechanical design towards higher speeds and using only principles which inherently had a capacity or a potential to be pushed into different speed ranges, by only using those principles we finally could refine this whole mechanical design art into a .... into techniques which allow us today to really go to micro-second mechanics where we have to be today.

S. The very reason that I'm asking this question is because frequently people tend to separate the CPU and its own structure and speed from the input and output and of course since they are all part of the same system, the input and the printer are part of the computer, even though some people I guess feel that they are just mechanical attachments that we are forced to put on. Nevertheless, they are a limited factor in the way that you've just been saying. The microsecond and greater speeds that were developed in computers forced the technology to its limits in mechanics.

G. Maybe also the entire thinking of mechanical engineers changed during those years. They always saw the high speed potential of electronics and they never really thought of pushing mechanical technologies in a comparable speed range. Everybody was aware and today still is aware that electronics will always be three to four magnitudes ahead of mechanical design in terms of speed. But nevertheless, ... higher speeds also stimulated new design efforts in the mechanical area and only after we saw that the conventional magnets working in the 10 millisecond range really couldn't serve a computer in a decent way any more, they pushed that art and also tried to push the energization of movements.... mechanical movements towards higher speeds with a number of principles, some of them such as .... effect or also better magnets have contributed to different mechanical principles which enabled us to push the mechanical devices beyond the millisecond threshold. Today we can control for instance, the flight time of print hammers down to a very few microsecond .... If I may just add one more word to this and that is I recall the difficult task to get mechanical engineers acquainted with using an electric oscilloscope, or electronic oscilloscopes to measure events in the microsecond range. And only after they really learn this, they also dare to design devices which were operating in these speed ranges. So to a large extent, it is also a change in thinking of the mechanical engineers. And unfortunately this thinking has not everywhere entered the schools for mechanical engineers yet nowadays.

S. This is one of the areas and one of the questions that I think it is important to explore in computer development, the reason why the mechanical........ lagged behind the electronic speed explained in physical terms and what people have been doing to push it ahead. When I've asked this question in the United States, I've gotten intoo philosophical discussions about why this should have been and you've been adding a good deal more than I've gotten in the past about how the mechanical engineers in Germany realized that they had to push, develop and push ahead. Has there ever been any thinking about matching, instead of leaving mechanical speeds three or four magnitudes behind?

G. Of course in many ways. Also here in this area they have tried a number of things on how to push, how shall I say the human interface between the computer and the user into technologies where we could use the high speeds which we were able to use in electronics. Let me say it a little more clearly. We tried to find new technical or physical principles which allowed us for instance to print at very high speeds, far beyond any mechanical moveexcept.... movement or how to punch cards at very high speeds. And a number of these principles are at the very border between electrical engineering and mechanics on one side but also a number of other physical principles have been used or at least we tried to use them, such as for instance, I mentioned already .... electricity or .... or deflection of particle beams. For instance at one time we thought of creating a beam of ink particles and using an electronic deflection of charged particles. At first everybody thought it was quite crazy to let a beam of ink jump around and in fact in the early investigations, the early trials I would even say, were given up when the entire lab turned blue due to this spreading ink. But strangely enough, ten years later actually one company half a year ago announced a print (?) on this very same principle which we gave up because we didn't like to be spattereed all around the place with ink. That's just one example that really can push a technology if you are really trying hard enough. Whether it pays off is a different question of course, and we have other means today on how to print at least as fast with less ink spoliing in the place.

S. Is the German lab still working on this?

..... it was more or less an experimental development. There were other developments too. One which was substantially better developed was making restrictive printing where the energized vibrations of a magnetastrictive material in a longitudinal direction like a .... but on a magnetastrictive basis, the same principle as some of the magnetastrictive delay lines used it were for an electrical pulse............displacement of a piece of wire was energized. This principle could be demonstrated very well except for a secondary reason. Let me put it this way, because other technical principles became available too which did the same thing and this principle again has been given up. I'm still not sure whether one day somebody will find a way to use this method of printing again. I don't think it is at the end of its potential and it is probably a question of enough effort to make a useful product out of it. There's no principal area which would forbid us to think this way.

S. Well from your point of view, is there some way that you could characterize why, what either the psychology of the company has been, the psychology of the mechanical engineers or just the situation has been that has not brought forth the effort or the success in building printing ahead or is there some physically impossible problem?

G. No, I would say those years between '54 and '62, were years where not only IBM but quite a number of the larger companies, in particular the companies in the electrical field have maintained a substantial operation in exploratory development in all directions. .... really physics as a source of new principles for mechanical and electrical design was exploited and everybody tried to find as many different possible ways to go as he could. So it's no wonder that we had quite a spectrum of different approaches, not only in mechanics but also as I mentioned before in electronics where we tried magnetic logic and such things. Another thing in this context by the way, we also tried for some time was ...... electric storage means .... early investigations in these fields. It all belongs to the extended effort of almost everybody in the field to explore as many physical phenomena as we could think of for their potential use in computers and the related I/O equipment. So it's no wonder that very few of those technologically feasible principles could only be followed up with the actual victory of the transistor. A number of these technologies just had to disappear because there was one which was by far the most promising one. Second, it was the one which had been explored most in the entire world. Many companies working in the semi-conductor field .... and it finally turned out that it did everything which a number of other potential technologies would have been able to do too. But as I said before, if you find ultimately one technology which is useful for the purpose and start concentrating on that one, that's just too bad for some other potential technologies because no company is going to do ..... is willing to do one development .... technologies. So there are .... of that type in the field like for instance for quite some time we got involved in fluid logics and schematic logics and the sheer reason why they never achieved a major break through aside from some specific applications is because the relay technology happened to be there since .... and this essentially .... these devices did too.

S. Cryogenics is another one.

G. Cryogenics is a very problematic one. It still has some potential in a number of fields and I would say it is not fully exp,ored. In cryogenics there is a secondary technological effect which made it so difficult to remain competitive with ferrite core memory. I should also mention in connection with the printing that in order to get away from the mechanical movement, we also tried a strict electro-optical printing principle here in Germany. I think we started out with this one for a short time. The idea was to use electro-optic materials which changed their refractive index upon application of an electrical field thus being able to be used as control devices fof allied fields. By using masks to shape a light beam in the character shape, you could switch between how shall I say, a matrix of characters which presented a mask, switch the light beam from one to the other, or switch the beam from one element of a character from one print element to the next one. So what we really did, we came up with a device which composed the characters of individual segments..... marks and circles on which the whole character was composed, and the compositive elements were controlled by these electro-optical crystals. We were able to demonstrate the feasibility of the principles of this principle showing an engineering feasibility model printing at 15,000 characters per second and the capability would go to about 100,000 characters per second. Of course, today looking backwards, the same thing can be achieved with cathode ray tubes again on an optical device. Other principles have been developed further in this respect. But there was a secondary fallout of this particular program, namely as we had to develop electro-optical switching devices here and also had to develop the optical art for it, we developed a certain capability too and this capability consecutively in the following years between '61 and '64 or '65, was carried further with the same people which we transferred and went to Poughkeepsie and by then they came up with the very first actual digital light beam refraction system which has been demonstrated in the world and IBM was able to demonstrate this to the U. S. Government and it went to a number of government contractors as far as I know.

S. Was this at a rate of 50,000 chafacters per second?

G. Well it operates at a mighty high speed today. But it is not for printing any more. It is essentially for controlling light beams in order to illuminate the photographic store or other elements where in a small area if you want to have controlled light beam deflection, for instance scanning a picture or such things for video purposes.

S. Let's go back to the printer. You've mentioned 50,000 letters or.....

G. Characters per second.

S. Why was it abandoned?

G. Well because by that time with the charactron approach on one hand and cathode ray tubes on the other hand, displaying an entire printed page on the screen and a photographic picture could be taken, essentially it did the same thing. And really the other reason was we didn't really see a market justification going in this direction. The only thing it subsequently could have done possibly for instance is print character by character directly from magnetic tape. And as we can do this with line printers in the same way, just by having an electronic buffer in between, using our regular printer, the interest from the marketing side or the marketing potential didn't seem to be attractive enough to really start the program. .... really start the program in a way which would have allowed us to go after a real product development. Also it must be said the result of this work hit us at a time in IBM .... when IBM and the rest of the technical world had to cut back already on the almost uncontrolled exploratory development and go back to a very few principles which they really were willing to pursue to the very end.

S. In line with what you just said again about there not being a real market reason for developing such a fast printer, are you really saying there that what we had was good enough for the market at the time and therefore if the market wasn't after 15,000 characters per second there was no use in developing it?

G. Well we could achieve the same output, the same kind of output with parallel printers on one side and with a cathode ray charactron device o n the other hand in the same way. So essentially we had something which satisfied the need.

End of Track #1.