Telephone Collectors International

Singing Wires

Newsletter

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Inside this issue . . .

Wishing you and yours a safe and happy holiday season!

Who Really Invented the Transistor?
Other claims to the invention...
By Andrew Emmerson

(Editor's note: This article, which challenges the belief that the transistor was invented by Bell Labs, first appeared in Radio Bygones magazine, www.radiobygones.com, and is reprinted here by permission from the author. Special thanks to David Massey for compiling this and other bonus material in honor of the 60th Anniversary of the Transistor this month.)

Before the fall of the Soviet Union the state educators of the old USSR were kept busy rewriting history, either deleting from the roll of honour all reference to heroes of the people now fallen from grace or ascribing the credit for every modern miracle to obscure communist pioneers.

This time, however, it's the Americans under fire for falsifying history and the subject is the invention of the transistor. The received wisdom is that William Shockley, John Bardeen, and Walter Brattain invented this device in 1947 and of that there can surely be no doubt. But there is and the colourful claims and counterclaims make some fascinating reading.

One fact is not in dispute, that the achievement of Shockley, Bardeen and Brattain was responsible for kick-starting the solid-state electronics revolution and the age of computerised informatics. To decry their role in transforming electronics would be both churlish and crazy, but the claim that they pioneered solid-state amplification has no substance at all.

Received version

Before we go back to the dark ages, let's examine the standard version of transistor history, courtesy of Andrew Wylie, who has set up an excellent website devoted to early transistor devices. He states:

> *"The transistor was invented at Bell Laboratories in December 1947 (not in 1948 as is often stated) by John Bardeen and Walter Brattain. 'Discovered' would be a better word, for although they were seeking a solid-state equivalent to the vacuum tube, it was found accidentally during the investigation of the surface states around a diode point-contact. The first transistors were therefore of the point-contact type. William Shockley, the theorist who was leading the research, knew at once that this was not what he was seeking: at the time he was trying to create a solid-state device similar to what we now call a junction field-effect transistor."*

Bell Labs kept their discovery quiet until June 1948 (hence the confusion about the date of discovery). They then announced it in a fanfare of publicity, but few

Continued on page 9

IT'S MEMBERSHIP RENEWAL TIME!
SEE PAGE 5 FOR MORE INFORMATION

The President's Column
Our Archives: Making it Fair

By Jonathan Finder, M.D., President, TCI

A new member recently raised an interesting question: why don't we make our past issues freely accessible to all members? This provoked an interesting question among members of the board.

We all take "PDF" (portable document format) files for granted now. So many journals are available in this format, such as the majority of medical journals (like the New England Journal of Medicine). In reality PDF's did not take hold until relatively recently. Many journals began to convert early articles (especially those deemed important) in to PDF format. We started releasing Singing Wires as an emailed PDF file in 2004. Editor emeritus Paul McFadden, with the expert help of his wife Beverly has taken nearly 20 years of Singing Wires issues and converted them to PDF files. Paul (reachable at singwires@aol.com) sells the Singing Wires archive CD containing an indexed file of SW from 1986 until 2004 for a very reasonable $20.

Although we do not have additional costs incurred in making our >20 year archives freely accessible to paid members on a website, we also must reflect that we gain nothing, either. So what *does* a member get by joining? All members get the usual discounts at shows and from affiliated businesses (such as my own) and password-protected access to the "members only archive." This site contains the past year's Singing Wires newsletters in electronic format. At the turn of each new year, we create a new site, which gives the member access to the final 4 months of the previous year, with the newly added issues added. Our webmaster, Paul Wills, takes good care of the maintenance of this valuable resource.

So what becomes of the previous years archives? At this time there is no access to them. One could argue that every member deserves access to the entire archives. The issue is simple: is this fair? Should the person who joined in 2000 and who has carefully kept each issue (either electronically or in a paper form) and has 84 issues preserved have nothing more than a new member who joined in 2008, who would have access to the past 4 months of 2007 plus all of 2008? It just doesn't seem fair. Unlike a daily newspaper, our newsletter contains historical articles, which really do not lose value over time. We are, after all, a historical organization! We do offer new electronic members who join during the last month of 2007 access to the last 4 months of of 2007 as well as all of 2008, in essence getting 16 issues for the cost of 12.

This does not really solve the larger problem, however: where does the 2006 archive go on January 1, 2008? Right now if you did not receive either the paper or electronic version, it's not easily accessible. We are working on creating a new archive CD that will be updated annually, and available through Paul and Bev McFadden. A portion of the sales will go to TCI. Paul has to have some "work" done and so will not be able to get to this right away. We wish Paul all the best for a quick recovery! I look forward to reporting to you about the availability of the updated CD with our archives within a month or two.■

History of the Bell System Telephone Numbering Plan - Case 3893I (Part 2)

By W. O. Turner, Bell Labs, April 28, 1958, Edited by Gary Goff

In toll operating practice it is customary to maintain on the switchboard keyshelf adequate information to permit the operators to determine the route for 90% or more of the calls they handle without reference to the special route operator. If the boundaries of numbering plan areas were to be purely arbitrary, without relation to any natural or political boundaries, the job of determining the area code for a particular called point would be immensely complicated and would almost certainly increase the delay and cost involved in handling toll calls by making it necessary to refer to the route operator on more than 10% of the calls. Moreover, there are definitely outlined local calling areas around the larger cities, and numbering plan area boundaries should not be drawn to cut across these areas.

As an aid to memory in determining the area code of a called place the device obviously most useful was to establish a relationship between the area code and the state or province in which the office is located. One area would cover each of the less populous states, while the larger states would have to be divided into two or more areas each. This was the plan adopted; early estimates indicated that the number of codes needed over a 40-year period would be about 100.

The form of numbering plan area code adopted was dictated, in the last analysis, by past history. Because of the decision, back in l9l8, not to assign letters to dial positions one and zero since these digits would not be used to start office names, it followed that the second letter of office codes never corresponded to the numerals 1 and 0. Therefore, if numbering plan area codes included a 1 or 0 as their second digit, the toll switching equipment could readily be designed to examine the second digit received, and if it were a 0 or 1, to recognize that the first three digits received were to be translated as an area code, not an office code. This meant a 3-digit area code instead of a 2-digit area code; but after conflicts with codes reserved for other purposes were set aside, there remained 152 such codes available for numbering plan area use. The 100 code capacity of a 2-digit code system had seemed perilously limited, so the 3-digit code pattern seemed amply justified. Thus the present pattern evolved: From any place in the United States and Canada where the necessary facilities are available, the number CHelsea 3-1000 in New York City can be reached by dialing 212-CH3 -1000.

Hardly had the pattern been set for nationwide operator toll dialing when the decision was made to press forward with the development of facilities to permit nationwide customer direct distance dialing. Because this possibility had been kept in mind throughout the development of the nationwide numbering plan, no major changes in the plan itself needed to be made. Customer use of the plan, however, did emphasize certain difficulties which the operators had already encountered, and sparked the next stage in the evolution of the Bell System numbering plan.

This next stage of evolution consisted of two innovations; the adoption of universal 2-letter, 5-numeral numbering for all local offices reached by direct distance dialing, and the introduction of a standardized list of central office names, chosen on the basis of ease of spelling and pronunciation.

Although the rules for building up the existing 4-, 5-, 6- and 7-digit telephone numbers to uniform 7-digit numbers were relatively simple for trained operators to use, customers could not be expected to remember them. No more should be asked of the general public than to dial the called area code followed by the called number as listed. This meant uniform listings of 7 digits across the continent, in small towns as well as large cities. And as local dialing areas were expanded to conform to the widening areas of social and business interest in growing communities, the 7-digit local numbering plan simplified the dialing of calls to nearby communities as well as distant ones. By changing at one move to the 7-digit plan the gradual shifts from 4-digit to 5, to 6 and to 7, with the attendant annoyance to customers and expense to telephone companies, were stopped once and for all.

Almost from the inception of operator toll dialing, difficulty was experienced with the spelling of unfamiliar office names which may have had rich local significance but were virtually unknown away from their immediate locality. An early example of the need for a standardized list of names came at the time the Indianapolis toll crossbar switching system was placed in service. An analysis of the calls which were misrouted through the toll office showed that some 70% to 80% were due to misspelling two Indianapolis office names IMperial and RIley. The name IMperial was frequently spelled EMperial; and as for the RIley office, named for the famous Hoosier poet, it was apparent that outside his home state most people were more familiar with the good Irish name REilly than with the poet's name. There was no recourse but to give these two offices new names which would be misspelled less frequently.

Another difficulty that had to be straightened out was the existence of three central offices in different cities of the Bell System spelled HIland, HYland, and HIghland, respectively. Even the traditional office name CYnwyd, near Philadelphia, was abandoned.

As experience with distance dialing accumulated, it became apparent that another difficulty had to be straightened out. This difficulty arose from the use of town names as central office names. Lafayette, California is a relatively small town just outside Oakland. The name is in the approved list of standard central office names, so why not use the town name as an office name? But consider the plight of an operator asked to complete a call to "Lafayette, California, 3-1211." Has she complete information? Is the town name missing, or the office name? To avoid the chance of misrouting the call she must cross-examine the customer which annoys the customer and delays the call. So an arbitrary office name is added; the customer asks for "Lafayette, California, Atlantic 3-1211" and the call goes through without delay. Obviously the name Atlantic has no significance in a town overlooking San Francisco Bay, but uniformity has been achieved, and uniformity helps eliminate errors.

Much local pride in historically significant names has had to be put aside, and telephone office names, for the sake of mechanical progress, are becoming colorless and standardized.

Even with much progress in eliminating hard-to-spell names, sources of confusion remained. One of the most frequent errors was substitution of the numeral "0" for the letter "o" as the second letter of names such as "Montrose." In 1955 a group of Bell Laboratories' engineers and scientists met at the request of Mr. A. B. Clark to consider whether anything might be done to improve dialing accuracy. As a result of this meeting a program of laboratory tests was organized to compare the speed and accuracy of dialing of two systems — the existing system using central office names, and an all-numeral system. The all-numeral system was selected for comparison rather than one using arbitrary letters and numerals because it is, of course, essentially the simplest possible numbering system.

Results of the Laboratories' tests were published on April 2, 1956, in the form of a report "An Evaluation of All- Numeral Dialing" by Messrs. A. H. Inglis, J. E. Karlin and W. 0. Turner. Conclusions were that with the all-numeral system errors would be fewer and dialing faster; that customers would accept and use the new system readily; and that from a memory standpoint there was little choice between systems except that the average person would take a few days longer to memorize a 7-numeral number than one consisting of an office name and 5 numerals. With pushbutton telephones substituted for dial telephones, the speed and accuracy advantage of the all-numeral system becomes relatively greater. The tests did not include dialing of 10-digit numbers (as in direct distance dialing).

Since the establishment of the nationwide numbering plan, new numbering plan areas have been created at such a rate that in 1957 there are 113 in existence. This increase in area requirements is partly the result of inefficient use of office codes in the less developed parts of the country, and partly due to accelerated growth, particularly in the fast developing territory of the U.S. south and west, and Canada. A 1956 survey of the Companies' own forecasts indicated a requirement of some 130 area codes by the time telephone development doubles again. This estimate did not take into account three factors which by this time were definitely in the picture: The probable extension of the numbering plan to Western Europe and possibly beyond; increased numbers of office codes required for inward dialing to PBX extensions and other new services; and the possibility of greatly stimulating the demand for telephone numbers by aggressive merchandising of telephone service. Obviously the 152-area capacity of the numbering plan, which had looked so safe 10 years before, required re-examination.

This re-examination was undertaken by the writer, and resulted in S.E.R. No. 48, "The Bell System Telephone Numbering P1an," released on March 26, 1957. Conclusions of the study were as follows:

Capacity of the present numbering plan may be reached in about 20 years.

Limited additional capacity can be provided on a temporizing basis by using 3-digit areacodes beginning with the numeral 1.

For permanent relief, the pushbutton telephone, when introduced, should be equipped with a "Distance" key to be operated before setting up all 10-digit calls. With this means of identifying 10-digit calls, all combinations of three numerals can be used for area codes--a total of 1000.

Further relief could be obtained by adopting all-numeral telephone numbers. The maximum number of office codes per area would be substantially increased, which would particularly benefit the larger cities.

These proposals have the obvious weakness that long-term expansion of the numbering plan capacity depends upon the universal substitution of pushbutton telephones for dial telephones within a 20-year period. This might turn out to be uneconomical for both the Bell and non-Bell telephone companies. Discussions of this point among A.T.&T. Co. and Laboratories' engineers gave rise to a suggestion which is under review by the A.T.&T. Co. at the time this memorandum is written; that is, that when further code capacity is needed either the digit "1" or the digit "0" be set aside for use as a prefix to be dialed before all 10-digit calls. This prefix* would serve the same purpose as preliminary operation of a Distance key at pushbutton telephones, and would be applicable to both types of sets. Additional code capacity would no longer be dependent upon the elimination of dial telephones, but the total number of available office codes would be reduced. For example, use of the digit "1" as a prefix to indicate a 10-digit number to follow would preclude its use as the first digit of an office code.

Meanwhile in the Directory Departments of the telephone companies there has spread an innovation which has a bearing on the evolution of the numbering plan. As cities grow and telephone directories get bulkier, each fraction of an inch of directory space becomes more precious. The directory people looked with covetous eyes on the space taken up by the central office name, repeated for each listing in the directory. Cautiously at first, they dropped out all but the first two letters of the central office name in directories covering but a few offices, showing in a box on each page the list of office names and their two-letter codes. The saving in space could be taken in less pages per directory, or it could be translated into larger and more legible type. No adverse reaction came from the public who use the 2-letter, 5-numeral system in advertising and other displays anyhow-so the system is being extended to the larger cities, and the list of names and corresponding codes is being moved to the information section at the front of the directory.

This development may well lead to further changes in central office names or to their abandonment entirely. Consider two perfectly good central office names, ADams and ATlantic, both on the approved standard list. Now drop the names, and continue to use the code letters AD and AT. On passing these by word of mouth between customers and between customers and operators, how many times will "ADs come out AT*? Each such translation prepares the ground for one or more dialing errors. It seems inevitable that if names are dropped, letters too must be dropped, or else the list of permissible letters reduced to eight or so that are not easily confused phonetically with each other or with numerals.**

*(*The arguments for and against each of these digits have been summarized by A.T.&T. Co. engineers and discussions 1eading to agreement on a choice of digits are currently under way.*

***The Australian Post Office has already started the transition from a combination of arbitrary letters and numerals in their large cities, to a straight 7-numeral plan. In Europe, elimination of letters from local numbers is being considered as a means of minimizing the language difficulties accompanying the introduction of direct international dialing.)*

The arguments for all-numeral dialing are compelling enough so that the A.T.&T. Co., early in 1958, embarked upon a full-scale trial in Wichita Falls, Texas. This moderate-sized city has had a 5-numeral numbering plan and was scheduled to be changed to the conventional 2-letter, 5-numeral plan. Instead it has been changed to 7 numerals. Indications so far are that the customers are satisfied with the 7-numeral plan and that their performance compares favorably with that of customers in other similar places where the transition has been to the 2-letter, 5-numeral plan.

Further experience with the 7-numeral plan is, of course, desirable, and the acid test of acceptability will be to convert to this plan some city now accustomed to dialing 2 letters and 5 numerals. Plans for such a trial are under discussion.

And so central office names have become a vestige of the past, without significance to the people who use them, and a source of errors and confusion. If we try to project the lessons of 40 years of history into the future when international dialing may well be common-place, it seems to the writer, at least, that the evolution of the Bell System numbering plan will not be complete until we arrive at the ultimate simplicity of an all-numeral numbering plan.

(Note: This reviewer has learned since the publication of Part I of this article that at least one member/collector possesses this article and published it to the TELECOM Digest in the mid-nineties. One can go to the Digest archives to review this article and others related to the topic. GGoff)■

Western Electric's Earliest Calling Device

By Roger Conklin

The 407-page book "Automatic Telephony," authored by Arthur Bessey Smith and Wilson Lee Campbell was published by McGraw-Hill Book Company in 1914. According to title page information, Smith was professor of Telephone Engineering at Purdue University while Campbell was a Fellow of American Institute of Electrical Engineers. From other sources we know that both Smith and Campbell were prominent engineers with Automatic Electric Company in Chicago, both of which were personally responsible for many of the early developments and advances in automatic telephony.

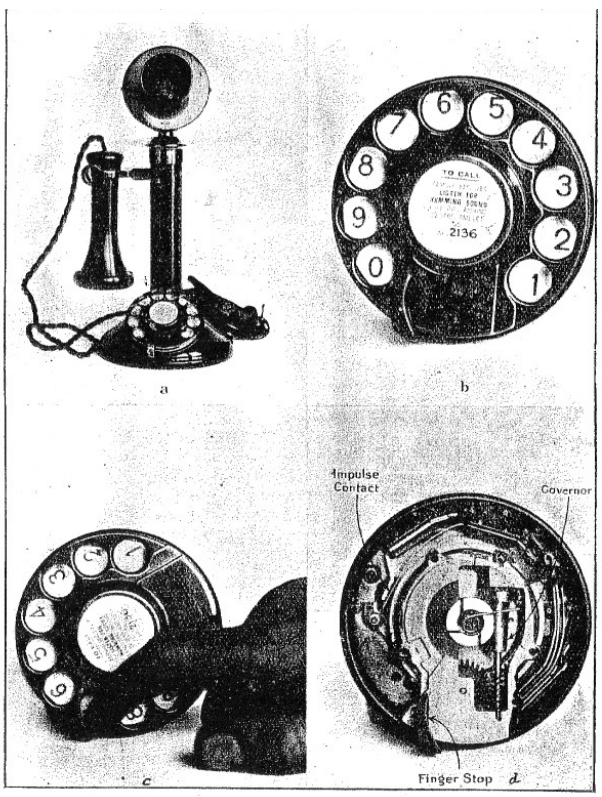


FIG. 4.

"Automatic Telephony" is almost entirely devoted to the Strowger Step-by-Step system pioneered by Automatic Electric. In deference to others, however, it does include a chapter on other automatic systems being manufactured and/or under development by other companies. The authors credit David Hulfish of Canadian Machine and Telephone Company for information concerning its Lorimer System, Dr. A. Rapp from Germany for information on the Siemens-Halske Company system and Gerald Swope for the detailed description of the Rotary System being developed by Western Electric Company. These were all erstwhile competitors of Automatic Electric Company.

The text reports that Western Electric began work on an automatic system in 1899. The first trial system with 450 lines was installed for test purposes in the general offices of Western Electric Company at 463 West Street in New York City in 1910. Maintained and operated by the Bell System's New York Telephone Company, this was, in fact, a semi-automatic system using ordinary manual (non-dial) common battery telephones. When the caller took down the receiver he was connected with an operator who requested the called number by answering with "number please?" The operator then set up the connection by pressing "push-button calling device keys" to send the called number to the Rotary System which automatically completed the connection and either returned a busy ("engaged") signal or applied ringing current automatically and intermittently to the called line until the called party responded. The telephones remained connected until the calling party replaced his receiver on the hook switch causing automatic disconnection of the call.

The Rotary System was a register-type common-control switching system where the impulses received did not directly drive a switch, but were received by and stored in a register. It employed single-motion rotary switches under the control of the register and driven by an exchange electric motor. The text indicates that the Rotary System design included the concept of fully-automatic operation, as well as semi-automatic, and that where fully-automatic service was desired that the calling station would be equipped with "a calling device of the type show in Fig. 196." This calling device was not a conventional-type telephone dial, but a table-mounted box equipped with 5 wheels and a handle. No information is given on how this device was used, but from its appearance it is assumed that there was one wheel for each of up to the 5 digits of a telephone number. Apparently the subscriber moved the individual pointers associated with each of the 5 wheels to set them to the number to be called, lifted the receiver to listen for what it describes as the "office sign tone" as the indication that the "apparatus is ready" and then pulled down the lever at the right to cause the calling device to send impulses to the central office. In the central office the Number Register (Fig. 196) received and recorded the impulses from the subscriber's station in the same way that it received impulses from the pushbutton calling device keys used by operators with the semi-automatic system.

The writer has neither seen one of these automatic calling devices nor heard or read about anyone else that has either. Quite possibly none have survived. It seems quite probable that this concept was never actually placed in commercial service and that the device in the Fig. 195 photo never got beyond the prototype stage. Compared to a rotary dial calling device, the impression is that it would have been rather costly.

We know from other sources that the first commercial fully-automatic Western Electric Rotary System was manufactured in Antwerp, Belgium by International Western Electric's subsidiary Bell Telephone Manufacturing Company, and placed in service in Darlington, England for the British Post Office in November 1914. We also know from printed information describing this system presented by B. O. Anson titled "The Western Electric Company's Automatic Telephone System" at the London Centre meeting on December 11, 1916 of the Institution of Post Office Electrical Engineers that the telephones

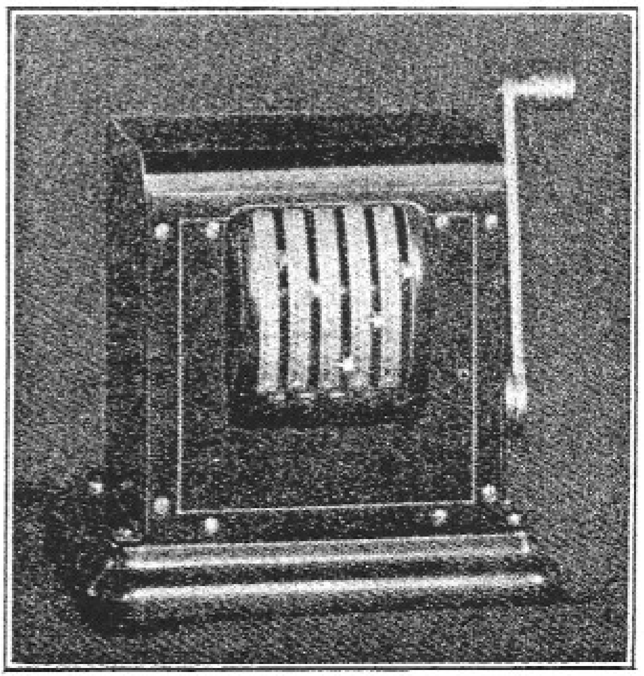


FIG. 196.—Calling Device.

for Darlington were equipped, not with these table model calling devices, but instead with Western Electric Type 7001 rotary dials. A photograph of this dial and a telephone using this dial, with the designation Fig. 4 from this Institute's publication of this presentation, is provided herewith.

We do not know for certain the type of impulses generated by this table mounted calling device, but there is reason to suspect that they were not the "normal" 66.6/33.3 break/make ratio pulses that were the generally-accepted Automatic Electric standard. The Type 7001 dial used in Darlington, sometimes referred to as the short-long pulse dial, produced both 18/82 and 82/18 break/make pulses. The last pulse of every dialed digits was a long 82/18 pulse, whereas the prior pulses of that digit were always the shorter 18/82 pulses. The final long pulse identified to the switch that it was the last of a series of pulses for the digit and that the next pulse received would correspond to the first impulse of the subsequent digit. The interdigital time between digits produced by dials used on Strowger Step-by-Step systems was used by those systems to identify the end of the pulses from one digit and the beginning of pulses from a subsequent digit, but not with the Rotary System. It therefore seems within the realm of possibility that this same short-long pulse method may have been the type of pulses generated by this desk-mounted calling device. Such a method of producing and sending pulses would have permitted the impulses sent to the central office in a continuous stream, without any interdigital interval between digits. This would have provided more rapid dialing of a complete telephone number because the inter-digital time would be zero.

More information on the Western Electric Type 7001 dial will be provided in a subsequent article.■

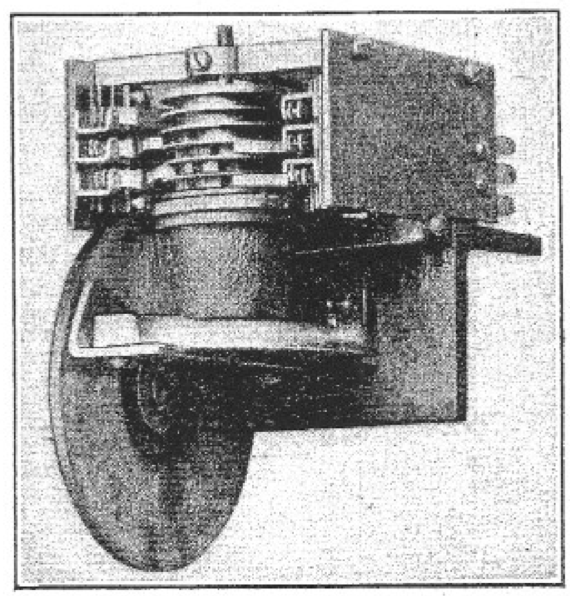


FIG. 197.—Number register (full automatic).

Address Change, Membership Questions, Delivery Problem?

If you have a question about your membership or if you have moved and need to notify us of your address change or if you have newsletter delivery problems, please contact our Membership Chairman,
Gary Goff
3805 Spurr Circle, Brea, CA 92823
membership@telephonecollectors.org
or call Gary at 714-528-3561.

The 5th Annual Northern California Telephone Collector's Show

San Jose, California - November 10, 2007

By Gary Goff

The San Jose show staged earlier this month (November) was the best of the past five years. Why? Well, for starters, three collectors brought plenty of their rare and beautiful items to share with others. Another reason was the number of tables covered with items ranging from publications to telephones of all types and shapes.

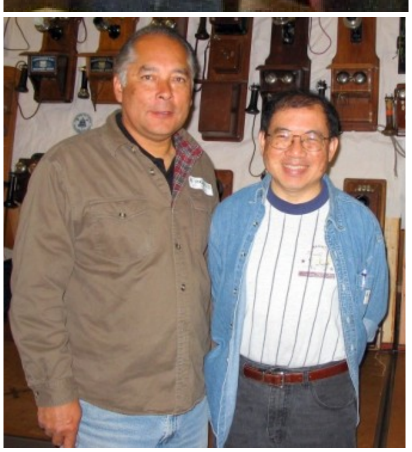
John Dresser of Salinas and John Tipo Hui of San Jose, with the help of Jerre Hui, built an 8' high, 16' long display of wood sets, many of which are seldom or ever seen. There are pictures of this display in this issue of SW and some have appeared on the internet over the past month or so. The construction of the display took several hours as did the dismantling at the end of the show.

Another collector newer to this hobby of ours, Rod Lanthier, displayed 10 or 11 restored AE three slot payphones, one in each of the original colors issued by Automatic Electric. Rod has acquired original parts, plastic and metal, to restore these sets, and has had original paint colors matched. It was a very colorful display.

Another feature of the show is the silent auction. Although it's not as big an affair as we would like, it is an opportunity for collectors to pick up some good deals at very low prices as well as providing a way for others to make a contribution to the clubs as the proceeds for the most part, go to the clubs. A collector can also sell his own items in this manner if he wishes. $100 was raised to be shared by the clubs.

We are indebted to the St Francis Episcopal Church of San Jose for permitting us the use of their social hall every year. It's the perfect location, and very affordable. Russ Cowell flew from Virginia to the show, and was impressed enough with the entire affair that he went right home and scheduled a Virginia area show early in the new year.■

Rod Lanthier's (pictured below with Jack Worley) Automatic Electric Coin Phone display.



John Dresser and John Tipo Hui (above) built this 8' high x 16' wide display of wood sets.

Who invented the transistor? *(continued)*

people realised its significance, and it did not even make the front page of the newspapers. Shockley basically ignored the point-contact transistor, and continued his research in other directions. He modified his original ideas and developed the theory of the junction transistor. In July 1951, Bell announced the creation of such a device. In September 1951 Bell held a transistor symposium, and licensed their technology for both types of transistor to anyone who paid the required fee of 25 thousand dollars. This was the start of the transistor industry that has changed the way that we live, in the Western world at least.

Alien efforts

However, an entirely different origin has been proposed by Jack Shulman, president of the American Computer Company. Frankly, his theory is pretty fantastic but it makes a rattling good read if nothing else. Here's what he says...

> *"I grew up in the household of the head of Bell Labs, so I knew that there was something strange about the transistor because I knew Bill Shockley, and Bill Shockley was something of a witless buffoon. There's no way he could have invented the transistor.*
>
> *The symbol for the transistor is made up of three pieces: positive, positive and negative; or negative, negative and positive...silicon dioxide doped with arsenic and boron, in 1947. Now, in 1947, doping things with boron was not easy. It required the sort of equipment that even Bell Labs in 1946 did not possess. They had this type of equipment at Lawrence Berkeley Laboratories, but it would have taken thousands and thousands and thousands of man-hours to invent the transistor.*
>
> *If you look back at it historically, what AT&T was claiming was that one day this "genius", William Shockley, was working with a rectifier; he looked at it and he noticed it had unusual propensities, and there, bingo, he invented the transistor! He figured it out right there!*
>
> *Anybody believe that story? Me neither. And I knew, because the administrative head of the transistor project was Jack Morton—the man at whose house I was staying to go to school and whose sons I was friends with. He often commented on the fact that it was really a shame that those three idiots got responsibility for the transistor and he didn't."*

Mr. Shulman goes on to claim that the transistor's real origin lies in technology recovered by the US Air Force from an alien spacecraft recovered at Roswell, New Mexico in 1947. It's extremely controversial stuff and contrary to all received wisdom—but quite amusing of you don't take it too seriously. Let's move on rapidly, back down to earth and to minerals in particular.

Start of silicon

It was in 1906 that the G.W. Pickard of Amesbury, Massachusetts perfected the crystal detector and in November of that year took out a patent for the use of silicon in detectors. Arguably this was the start of the silicon revolution and it did not take long before experimenters achieved amplification using crystal devices, long before the term transistor was devised.

Solid-state electronics were born even earlier, when Ferdinand Braun invented a solid-state rectifier using a point contact based on lead sulphide in 1874. But it's to Pickard that the credit goes for discovering that the point contact between a fine metallic wire (the so-called 'cat's whisker') and the surface of certain crystalline materials (notably silicon) could rectify and demodulate high-frequency alternating currents, such as those produced by radio waves in a receiving antenna (what Pickard called a 'wave-interceptor'). His crystal detector (point-contact rectifier) was the basis of countless crystal set radio receivers, a form of radio receiver that was popular until the crystal detector was superseded by the thermionic triode valve.

By its nature the crystal rectifier was a passive device, with no signal gain. But radio historian Lawrence A. Pizzella WR6K notes anecdotal stories of shipboard wireless operators in the second decade of the 20th century achieving amplification using a silicon carbide (carborundum) crystal and two cat's whiskers. He cites a taped interview made in 1975 with Russell Ohl at his home in Vista, California in which claims of signal gain were made. This is an excerpt from Ohl's testimony:

> *He gave me a copy that he had of… I think it was The Electrician. It was a British magazine, one of these big-paged things, you know. In it was a translation from a Russian paper in which they had used carborundum with two contacts and a battery supplying one of the contacts and had gotten a power gain of ten times. And this was way back in the 1910s, so the fact that you could get a power gain had been known, but it was never put on a controlled basis. I knew about it because an operator of the Signal Corps back in 1919 had told me that some of the operators used carborundum as oscillators for receiving. When I had seen*

this article that Curtis gave me, I was not astounded because I had known about this before I ever saw the article. I had heard about it. I knew a former first sergeant in the Signal Corps who had lived in the boarding house that I lived and he was an expert radio operator. He told me a great deal about the use of crystal detectors on ships. He told me that professional operators carried two crystal detectors with them. One of them was made of carborundum them and one of them was something like galena or something of that sort. He said the carborundum was used for two purposes. They used it in the harbour when they were close to a transmitter to prevent burnout. They also used it at long distances with two points. One point was excited with a battery and they were able to get long wave oscillations out of it and in that we were able to be in long wave telegraph stations.

Ohl, it should be noted, was the man who invented the silicon solar cell in 1941 and discovered during World War II that semiconductors could be doped with small amounts of impurities to create useful new properties. Born in 1889, he was bitten by the radio bug at the age of 16 and devoted much of his life to making simple radio receivers employing semiconductors. His accidental discovery of the P-N barrier in his work at Bell Telephone Laboratories led to the development of solar cells

Oscillating crystals

A fascinating letter to *Wireless World* in May 1981 under this title came from Dr Harry E. Stockman of Sercolab (Arlington, Mass.) Then 76 years old, he had lived through the era under discussion and provided a valuable summary of 'prior art' preceding the re-invention of the transistor. His letter had been triggered by a 'Sixty Years Ago' item in the same periodical) recalling an article by W. T. Ditcham on crystal oscillation in its May 1920 issue.

This effect, he stated, was discovered by Dr W. H. Eccles in 1910, and remarked: "It is hard to realize that it took about ten years for practical active crystal-diode circuits to appear, in spite of Ditcham's reminder—circuits that included both RF and AF amplification. The last one, at the time, was totally unknown to most 'affectionados', one of them being the author of this letter. Most of the credit for creating practical devices [of this kind] goes to O. V. Lossev of Russia, whether or not he knew of Eccles' pioneer work a decade earlier. He should have known about it; one has the right to expect that he as a qualified scientist was familiar with the world's scientific literature."

Clarification comes from Lawrence Pizzella, who explains how these experimenters created successful amplification techniques using mineral crystal devices. Lossev, he says, used zincite and a steel cat's whisker with bias to make an oscillator and even a low-power transmitter in the early 1920s. This was reported in considerable detail in the September 1924 issue of *Radio News* and in the 1st and 8th October 1924 issues of Wireless *World.* Hugo Gernsback, the editor of *Radio News*, named this the 'Crystodyne' and predicted that crystals would someday replace valves in electronics. All details needed to duplicate these circuits to make a tunnel diode oscillator are in these articles. A German book by *Eugen Nesper described an oscillating detector circuit in 1925 too, using zincite material and a bias voltage of 8 to 14 volts.*

With so much information in print it's inconceivable that the Bell Labs team were unaware of these techniques. But in any case Pizzella says Russell Ohl showed William Shockley his radio using crystal amplifiers several years before the transistor's alleged invention in 1947. Shockley is also quoted (in **Crystal Fire** by Riordan and Hoddeson) as saying that seeing Ohl's radio convinced him that an amplifying crystal could be made.

First FET

Another experimenter of this era who deserves far greater credit is Dr Julius Lilienfeld of Germany, who in 1926 patented the concept of a field effect transistor (FET). He believed that applying a voltage to a poorly conducting material would change its conductivity and thereby achieve amplification. Lilienfeld is rightly noted for his work on the electrolytic capacitor fame but according to Stockman should be recognised also for his pioneering work on semiconductors.

Says Stockman, himself a distinguished author of many books and papers on semiconductor physics, "He created his non-tube device around 1923, with one foot in Canada and the other in the USA, and the date of his Canadian patent application was October 1925. Later American patents followed, which should have been well known to the Bell Labs patent office. Lilienfeld demonstrated his remarkable tubeless radio receiver on many occasions, but God help a fellow who at that time threatened the reign of the tube."

David Topham GM3WKB adds that Lilienfeld followed his 1925 (Canadian) and 1926 (American) patent applications for a 'Method and Apparatus for controlling Electric Currents' with another granted in 1933. Says David: "US patent 1,900,018 clearly describes the field effect transistor, constructing it using thin film deposition techniques and using dimensions that became normal when the metal oxide FET was indeed manufactured in quantity well over 30 years later. The patent (and subsequent ones) describes the advantages of the device over 'cumbersome vacuum tubes'."

More prior art

The web site of Dr Robert G. Adams states that he designed a crystal amplifier at the age of thirteen years, when he lived at Hastings, New Zealand. A photograph of his set-up is shown on his web site along with the diagram reproduced here with acknowledgment.

Connections to the two crystals made use of the then-available vertical cantilever type cat's whisker holders, providing stable connections to the central junction and input and output points. Two different methods of interconnection between the two crystals gave no apparent difference in performance. Adams stresses that it never occurred to him to pursue any patent action simply because the invention was already in the public domain. In his view it was obviously unpatentable by anybody (Bell Labs notwithstanding).

Someone who built a similar amplifier of this kind is Canadian radio amateur Larry Kayser (VA3LK/WA3ZIA), who spotted a circuit for a 'novel' crystal radio circuit that exhibited 'amplification' published in Gernsback's magazine *Radio* during the 1932-1934 period. This, he recalls, used two cat's whisker probes on a lead-mounted galena (PbS) detector. He says he was able to duplicate this action in the early 1950s as a young hobbyist and whilst the degree of amplification was nothing like that of the first commercial transistors, it was at least in the order of 3dB or a bit more.

History repeated

That was then but this is now. American radio amateur Nyle Steiner K7NS was determined to prove or disprove these claims for himself—and has succeeded in spectacular fashion. On his website he posts technical results, photographs and curve traces of several experiments in which he has demonstrably achieved oscillation with iron pyrites and even transmitted his voice over the air (a circuit for a broadcast band iron pyrites negative resistance oscillator is given there).

> *"Success with this experiment has been a very exciting experience for me as it represents the ability to build a simple homemade active semiconductor device. It is almost like making your own homemade transistor," he states. "This is an actual realisation of some very old, and esoteric 1920s experiments by Eccles, Pickard and Lossev, that were so vaguely reported in a few articles that I have often wondered if in fact it had actually been done. Even so, I have always had an extreme fascination with those reports of being able to produce a continuous wave RF signal from a crude semiconductor material back in the very early days of radio."*

Other experiments of his show an oscillator based on zinc ferrite and an N-type negative resistance device, similar to a tunnel diode, created by touching a piece of galvanized steel wire against a piece of aluminium. As Nyle says, "This project may not be very practical but I find it to be a very exciting experience.

Historic conclusion

The more you study the history of invention, the fewer examples you find of entirely new devices conceived and perfected by one individual in isolation. History loves heroes and people prefer simple stories, regardless of inconvenient facts.

It's perfectly clear that Bell Labs didn't invent the transistor, they re-invented it. The fact that they totally failed to acknowledge the pioneer work done by others can be explained by human nature—pride, arrogance, ignorance or plain self-interest. It's perfectly true that the world wasn't ready for previous incarnations of the transistor but that was no reason for denying that Lilienfeld patented the original solid-state triode oscillator/amplifier well before others claimed all the credit. But that's life; it was not the first time and doubtless not the last.■

Further reading

Michael Riordan and Lillian Hoddeson, Crystal Fire (1998)

William Brinkman, Douglas Haggan and William Troutman, A History of the Invention of the Transistor and Where It Will Lead Us, IEEE Journal of Solid-State Circuits, vol. 32, no. 12, December 1997 (and on the WWW at www.sscs.org/AdCom/transistorhistory.pdf)

Julius Nesper, Wie baue ich einen einfachen Detektorempfänger? (1925)

Ronald Ives, Transistors in 1923, CQ magazine (USA), January 1959

Be sure to check out this month's bonus pages for more material related to the anniversary of the transistor...

2007 TCI Fall Show
Financial Report and Awards

Income

Registrations	$1,056.00
Tables	550.00
Donations (Auction/Coffee etc)	337.85
Auction Income	514.65
Auction Tags	10.00
Reimbursed Auctioneer Expenses	196.93
Total	**$2,665.43**

Expenses

Hotel/Room	$1,400.00
Auction Payout	514.65
Auctioneer Expenses	293.66
Shipping	43.12
Total	**$2,251.43**
Surplus over expenses	**$414.00**

Thanks to Jonathan Finder and Gary Goff for hosting this very fine event.

The TCI Board of Directors is please to announce the following awards for their outstanding displays at the Cincinnati Labor Day 2007 Fall Telephone Exhibition held at the Airport Holiday Inn in Erlanger, KY.

Most Educational: Paul Wills
Best Display: Jim Aita
Best Desk Set: Barry Erlandson
Best Wall Set: Steve Howell
Must Unusual: Ray Streuker
Honorable Mention: Jim Hurtle
Honorable Mention: Bob Bartlett

The TCI Honorable Mention Ribbon

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$47.00 each. Price includes shipping and handling in the U.S. Special pricing for orders of 3 or more.

Larry Kolb
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FOR SALE

1)Western Electric embossed telephone battery jars, complete $75
2)W.E. electronic ringers #s1A $20 each
3)S.C. oval bottom plates for dial or non-dial bakelite desk phones,complete with snap rings, #1197 or 1191, 5 for $30
4)WE 3 bar 2 bolt magneto ringer boxes $30/ea or just the mags $20
5)WE 5 bar 4 bolt magneto ringer boxes $35/ea or just the mags $25
6)WE oak type 300F magneto ringer box with a red 5 bar 2 bolt mag, embossing on the door and the left side of the box, works, with a key latch $50, another w/o embossing and key latch, $40
7)WE black metal rectangular switches #6017AP or C, $6/ea
8)A.E. #4055D paperback catalog 60 ppg $50
9)Two different cast brass or bronze rectangular signs for above the door from old wooden phone booths, Telephone 13 1/2" x 2 1/4" or Bell Telephone 2 1/4" x 16 3/4" $75/ea both with extended threaded bolts on the rear.

David Martin
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"If it keeps up, man will atrophy all his limbs but the push-button finger."
- Frank Lloyd Wright, 1953