TEKTRONIX CRT HISTORY
Part 6. CRTs for Solid-State Instruments: 1964-1967

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Part 1 described the situation leading to the decision in 1951-52 for Tektronix to begin design of cathode-ray tubes for its own use. Part 2 discussed the development of the first Tektronix CRT, the T51, in two different versions. Part 3 covered the classic Tektronix vacuum tube oscilloscope CRTs during the period of about 1955 to 1959. Part 4 covered the innovative period from 1959 to 1961. Part 5 discussed more innovative CRTs for the first Tektronix storage oscilloscope and several other instruments using hybrid technology, which combined solid-state circuitry with the tail-end of vacuum tube technology. This concluding article covers the beginnings of the solid-state era as well as one last unique hybrid model worthy of mention.

SCAN-EXPANSION MESH

Scan-expansion systems came into being in the early- to mid-1960s. At this time, transistors were taking over many circuit functions previously performed by vacuum tubes. One of the most difficult functions was the amplifier used to drive the deflection plates of the CRT. Large voltage swings, combined with the need for ever-increasing bandwidths, dictated the continuing use of tube in these stages. Tubes operated comfortably at plate voltages up to several hundred volts, while the emerging transistors might tolerate only 60 volts or less without permanent damage. Scan expansion provided magnification of the beam and deflection by shaping the electrostatic fields between the deflection plates and final acceleration region. Either a frame-grid which gave magnification for only the vertical axis or a domed-mesh (Figure 1), which magnified both axes, was used. The trade-offs included scattered secondary electrons from the grid mesh, which gave a dim ghost image, magnification of spot-size, contamination by loose foreign particles in the tube,

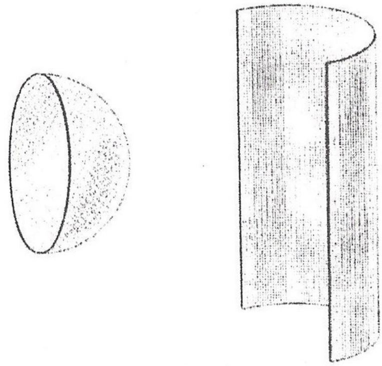

Fig. 1. Domed and frame-grid scan-expansion mesh

greater assembly complexity, lower production yields and higher cost. Still, scan expansion was a "must" in order to complete transistorization of the product line.

T6470

The T6470 (Figure 2) was used only in the 647 and RM647 oscilloscopes introduced in 1964. These were designed for the Royal Air Force and used a pair of special plug-ins: the 10A- series vertical amplifier and 11B- series horizontal time-base. The 647 was all solid-state and only about 2/3 the size of the ubiquitous 500-series oscilloscopes. The instrument was ruggedized for the severe operating environments of the military.

The T6470 CRT was rectangular, with the 3" by 5" screen dimension closely approximating the 6-by-10-cm useful scan area. The earliest instruments up to approximately serial number 560 used a ceramic CRT. This was changed to a glass version in December 1964, presumably because of manufacturing problems, possibly high voltage punch-through caused by contamination of the frit seal. The T6470 also featured an illuminated internal graticule, 14 kV accelerating potential, frame-grid mesh for greater vertical deflection sensitivity and a spiral accelerator. The latter presented some challenges, since painting the resistive helix on a rectangular envelope would be difficult. The problem was solved by having a flared, round transition section of the envelope between the neck and the larger rectangular portion. This resulted in a much shorter helix compared to previous tubes, where the helix extended almost the full length of the bulb. P31 phosphor was standard, with P11 available as an option for those customers requiring high photographic writing speed.

T4220

The Model 422 15 MHz dual-trace general-purpose portable oscilloscope of 1965 began the series of solid-state oscilloscopes that thrived until the end of CRT production at Tektronix in 1994. True, the Model 321 of 1960 was the first solid-state Tektronix scope, but it was more of a test bed for the concept and never became a best-seller. The 422 used a new horizontal form-factor with an adjustable carrying handle that also served as a tilt bail. This configuration evolved through the 453 and 454 to the 465 of the 1970s, probably the best-selling Tektronix oscilloscope family of all time.

The T4220 (Figure 3) was a compact, rectangular, all-glass CRT employing a scan expansion mesh for good deflection sensitivity despite the short length. Also contributing to the shortened length was the first use of the "hard-pin" stem or base. Instead of the conventional bakelite base, the T4220 used a glass header with heavier, short feed-through leads that were used as the connecting pins, as had been in use for over 20 years for miniature receiving tubes. A plastic base guide provided indexing and protection of the exhaust tip-off seal in the center of the pin circle. An accelerating voltage of 6 kV, combined with P31 as standard phosphor, resulted in a bright display even in adverse ambient environments. A short spiral accelerator was located in the circular transition area from the neck to the rectangular funnel. The screen had an illuminated internal graticule with 8 by 10 divisions of 0.8 cm each. A two-watt heater, instead of the customary four-watt heater, was used to reduce power consumption for battery operation. By this time, phosphor choices had been reduced to P1, P2, P7, P11, and P31, which helped the proliferation of part numbers to some degree.

T4530

The 453, introduced in 1966, brought lab instrument performance to the portable oscilloscope. It had 50 MHz vertical bandwidth with dual trace and delayed sweep capability in a rugged and compact design. It was useful for most things that a 547 would do with well under half the weight and volume. Power consumption was only 100 watts compared to 510 watts for the 547. The useful screen area was still 6 by 10 divisions but the divisions were only 0.8 cm instead of the traditional 1 cm.

The T4530 CRT (see Figure 5 below for the similar-appearing T4540) looked somewhat like a stretched T4220. Like the T4220, it also used a scan expansion mesh, hard-pin base, spiral accelerator, and illuminated internal graticule. All of these defined state-of-the-art CRTs for some time to come. An acceleration voltage of 10 kV was used for high photographic writing speed. P31 phosphor was standard with P1, P2, P7, and P11 available as options.

T5490

In 1966, the final instrument in the revered 530 / 540 series of instruments was introduced. It was the Model 549 storage oscilloscope and used the T5490 CRT. The 549 was something of an ugly brute. It combined an improved storage CRT for the 30-MHz bandwidth and plug-in compatibility of the older 540-series instruments. The physical size and layout were pretty much in the tradition of the 530 / 540-series, although the screen was lowered, with the storage controls located just above it. A rectangular bezel was used to mask the unusable portions of the screen. Because of the performance trade-offs required to add storage capability, the 549 never achieved the popularity of its predecessors.

The T5490 CRT used a round screen and ceramic envelope (Figure 4). The basic operating principle was the same as in the T5640 DVST discussed in Part 5 of this series. To obtain higher stored writ-

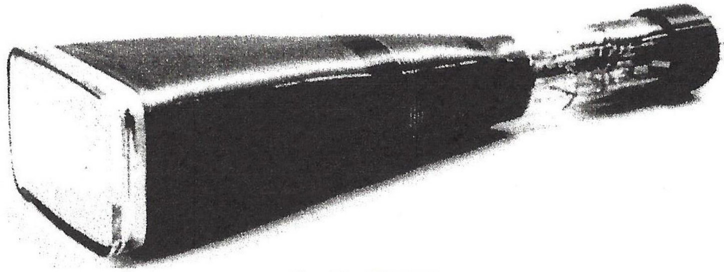

Fig. 2. T6470

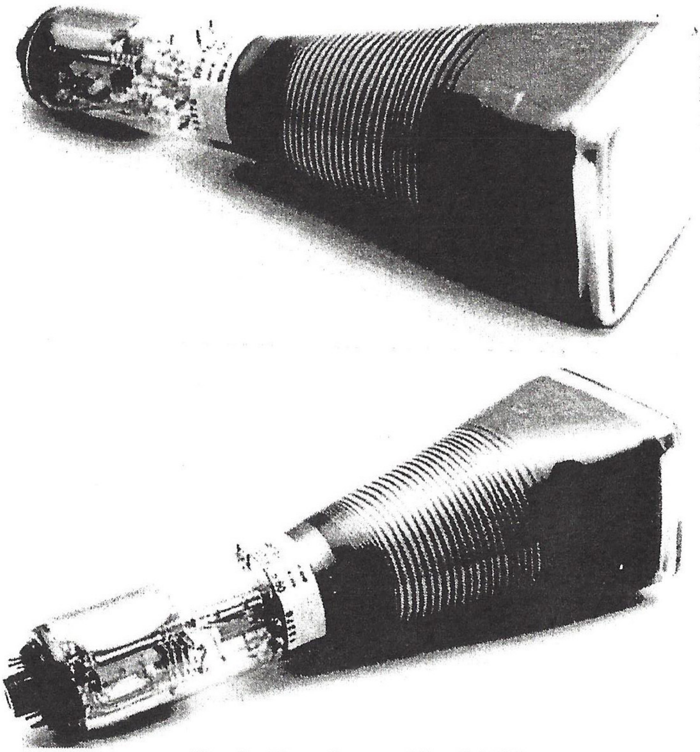

Fig. 3. Two views of the T4220

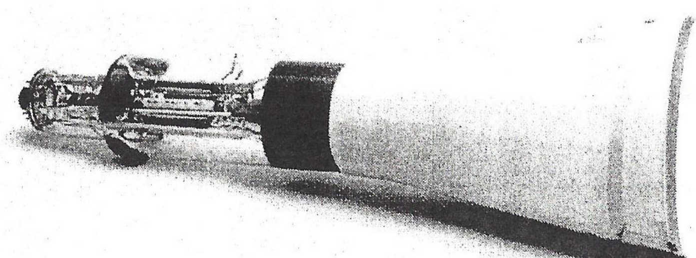

Fig. 4. T5490 storage CRT

ing speed suitable for the instrument's wider bandwidth, a more complex screen (or "target") structure designated Type 202, and consisting of closely-spaced hexagonal dots of P1 phosphor, was used. This left exposed conductive areas surrounding the dots, which aided collection of secondary electrons and resulted in about ten times the stored writing speed of the T5640-201. Unfortunately, the T5490-202 lacked the high brightness of the original 540 series in the conventional operating mode. This was due to several factors. The accelerating voltage was only 4 kV, compared to 10 kV; the screen could not be aluminized; the P1 phosphor was not as bright as P31; the exposed collector area decreased the screen area covered by phosphor and contributed no light; and MgO added to the phosphor for improved writing speed further decreased light produced by the phosphor. The phosphor layer may also have been thinner than used for conventional screens that had thicknesses optimized for brightness. An external illuminated graticule was used, since it would have been very difficult to add it to the already complex screen structure. No optional phosphor types were ever available as options since it was the unique secondary-emission properties of P1 that made the simplified storage CRT work in the first place.

T4540

The 454 was merely a 453 with the vertical bandwidth extended to 150 MHz in keeping with the trend towards ever-increasing needs for higher frequency design work. The 453 debuted in 1967.

The T4540 CRT (Figure 5) differed from the previous T4530 primarily in its use of a distributed vertical deflection-plate system in order to achieve 150 MHz bandwidth with good deflection sensitivity. The same phosphors were available as in the T4530.

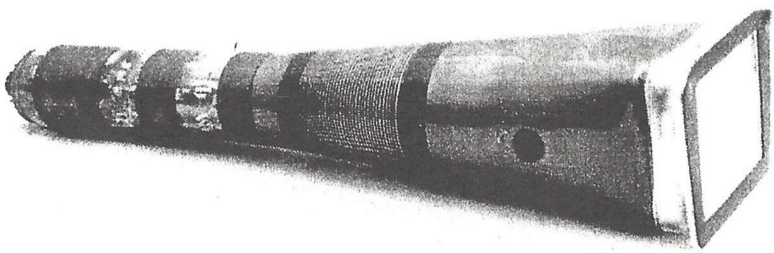

Fig. 5. T4530

TYPE	P1	P2	P7	P11	P31
T4220 Early	154-0466-01	154-0466-02	154-0466-03	154-0466-04	154-0466-00
T4220 Later	154-0466-06	154-0466-07	154-0466-08	154-0466-09	154-0466-05
T4530	154-0492-00	154-0492-01	154-0492-00	154-0492-00	154-0492-00
T4540	154-0505-01	154-0505-02	154-0505-03	154-0505-04	154-0505-00
T6470 Early					154-0424-00
T6470 Late				154-0434-00	154-0448-00

Table 1. CRT Part Numbers

CREDITS

I would like to acknowledge the many CRT design engineers, scientists and others at Tektronix who made possible the significant advances discussed in these articles. The author worked with many of them from 1963 on. Any omissions are due to faulty memory caused by forty to fifty years of elapsed time. These "Tekies" include:

Continued from p. 16

Robert Anderson
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This concludes the series of articles about CRT innovations developed and used by Tektronix in many of the "classic" oscilloscopes. Many more milestone CRTs were developed in subsequent years. These are covered in my book, The Cathode-Ray Tube, and are outside the scope of this series.

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