The Lenkurt Demodulator

NEWS FROM LENKURT ELECTRIC

VOL. 9 NO. 6 JUNE, 1960

The Changing "Look" of Communications Equipment

Within the past few years, rather dramatic changes have been taking place in the appearance and form of carrier systems and other communications equipment. These changes result from new developments in components and from unending efforts to increase reliability and performance, while at the same time keeping costs from getting out of hand. Although there are great differences between the old and new approaches, both are conceived in the same tradition of conservative design which results in long, reliable service. This article discusses some of the important differences and how they affect the life and maintenance of communications equipment.

New communications equipment just beginning to come off the production line is different than almost any similar equipment produced more than a very few years ago. This new equipment may be compared to the early steam-powered ships which revolutionized marine transportation after centuries of sailing vessels, and raised it to unprecedented heights of performance and economy.

The basic style of electronic construction remained virtually unchanged for nearly half a century. The principal differences were in the refinement and efficiency that comes with experience. Early equipment was clumsy but reliable. Quality was obtained by "brute force" methods. If you had a one-watt job to do, you provided a fifty-watt capacity and let the equipment idle along in the hope that the extra reserve would offset the uncertainty about the component life.

Mechanical construction followed a similar pattern. Even simple components were large and heavy—a relay might weigh five pounds, a retardation coil 25 pounds. Early telegraph repeaters and associated equipment required a mahogany table taking up nearly nine

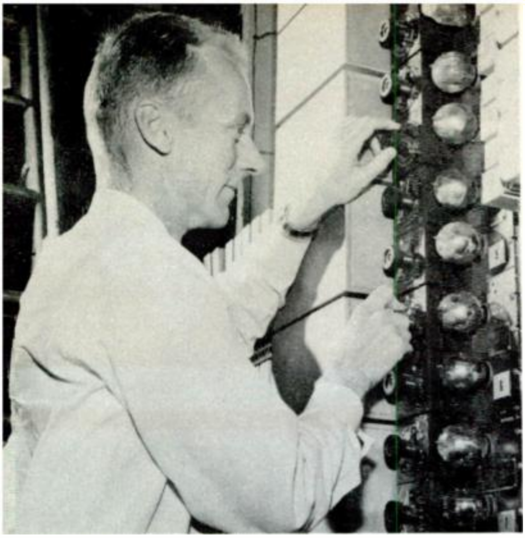


Figure 1. Antiques of communication, these 22-A-1 voice frequency repeaters were put in service 37 years ago, one year before Chief Transmission Man D. L. Hensley, shown inspecting, was born. This long service typifies telephone industry insistence on reliability and compatibility between old and new. Electron tubes shown are relatively new, having been substituted for an older version about 1929. Repeaters still worked perfectly when retired from service recently.

square feet of floor space! At the time, good design meant generosity—in size, weight, and performance de-rating.

The earliest electronic equipment introduced the basic design approach which is only now being superseded: a metal box with electron tubes and controls projecting from it, with the other components and wiring located within the box or chassis. This type of construction is quite practical, particularly for equipment which uses electron tubes or which is large and heavy. The box construction is quite strong and it provides shelter and shielding to the components within. The external location of the electron tubes permits them to transfer their heat to the surrounding air.

In the earliest designs, there was little need for compactness. Telephone and other communications channels were relatively few and could be treated rather luxuriously. Since about 1920, however, the number of telephones has grown at an explosive rate—much faster than the population. In addition, new services have been offered as fast as technical developments permitted. The result has been to increase vastly the amount of equipment used in communication systems, for a given number of telephones.

The growth in the number of telephones, and the increased services available to each telephone, have placed a premium on compactness in equipment. Electron tubes were reduced in size and increased in efficiency. Other components also became more compact and efficient, and designers learned many new ways to crowd more equipment functions into less and less space. Still, there were practical limits as to how far this compression might be carried.

The Newest Look

The "mechanics revolution" began with the discovery of solid-state amplification and the invention of the transistor in late 1948. This exciting development set the stage for entirely new approaches to the design of communications and other electronics equipment.

Despite their glowing promise, transistors did not live up to expectations for years after they were first developed. Fabrication methods were not sufficiently refined to prevent contamination, even from materials in their own cases. Furthermore, transistors had difficulty at first in matching the performance of electron tubes, particularly in noise figure, frequency range, and power-handling capability.

This has now changed. With the exception of high power capability, transistors can now match all but the fanciest special-purpose electron tubes. New circuits, such as the Vodicka converter (see the *Demodulator,* March, 1960), and new semiconductor devices like the tunnel diode have largely freed the transistor from former limitations. Recent developments indicate the possibility of the transistor taking a clear lead over electron tubes in every department, including power-handling ability.

Even though the transistor was invented in a telephone research laboratory and has been most vigorously investigated in such laboratories, telephone and carrier equipment manufacturers have been among the slowest to introduce them into their equipment. This is because telephone and related communications systems maintain the most stringent requirements for reliability found in any electronics field. Not until transistors could demonstrate that they had achieved reliability far superior to that of electron tubes did they begin to appear in carrier and other telephone-type equipment.

So-called "printed wiring" appeared about the same time as transistors, in response to a need for more uniformity in electronics equipment. This type of construction was found to be ideal for transistor circuits. All components are attached to an insulating board, and interconnections between them are made through lines of copper foil laminated to the surface, as shown in Figure 2. All but the desired connections are etched away by a photo-engraving process. Components are attached and all connections are soldered. The resulting "card" is compact, light, and usually easy to replace. Printed capacitors, inductors, and transformers have been made in this fashion, using both sides of the board. Circuits formed in this way are exceedingly uniform, thus eliminating some of the variables that are characteristic of hand wiring.

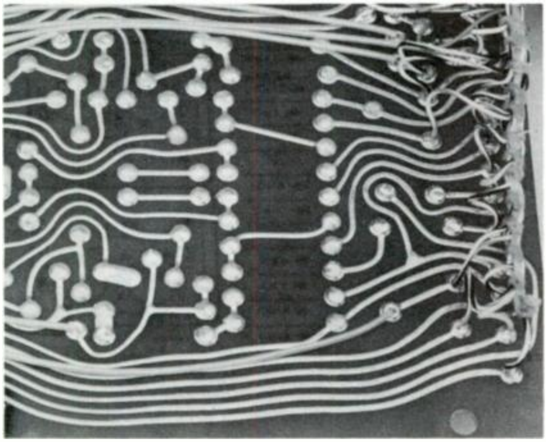


Figure 2. Typical high-quality printed circuit. Board material is Fibreglas and epoxy resin to minimize effect of moisture absorbtion on circuit performance. Printed circuits are uniform and economical, but require very tight control of many process steps to maintain high reliability.

Despite the extreme "neatness" and economy of printed wiring, it has sometimes been the cause of trouble. A minor source of trouble, particularly when the process first became popular, was delamination or separation of the copper from the board when solder connections were repaired. The electrical characteristics of some types of board change with variations in humidity, due to the moisture absorbed. There may be increased leakage between adjacent "wires," or a change in circuit constants. This will be more noticeable in circuits using electron tubes, because of the higher voltages and higher impedances associated with electron tube circuits. Many special board materials are available, however, which tend to reduce this effect.

Solder Joint Reliability

One of the most important causes of poor reliability in printed wiring is the solder joint between a printed conductor and a component lead. Most printed circuits are designed so that all such joints are soldered at one time by a dip soldering process. One recent investigation of the reliability of printed circuit solder joints compared such solder joints to a poorly designed wheel casting, and suggested that failures occurred as a result of built-in and externally-applied stresses. The investigators determined that printed wiring solder joints became much more vulnerable to failure if an optimum combination of about half a dozen factors was not rigidly maintained. Thus, if the size of the component lead, size and material of the eyelet (which goes through the board), nature of the solder, temperature of the solder, time of immersion in the solder, preparation of the laminated foil, tension of component leads, and other factors, are not all rigidly controlled, the solder joint becomes a "poor risk." In one of their conclusions, the investigators asserted

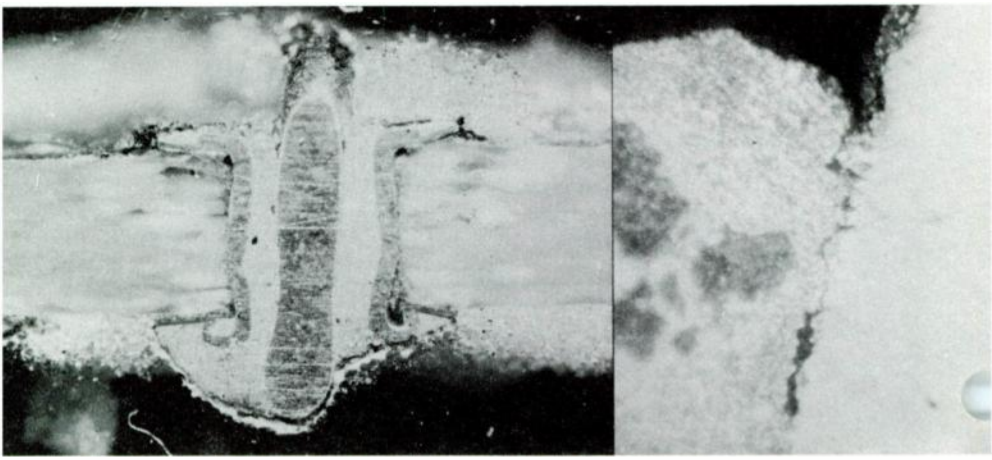


Figure 3. Magnified cross section of printed wiring solder joints, showing cracks between solder and component lead. This type of failure cannot be detected visually, but results in high resistance joint or open circuit.

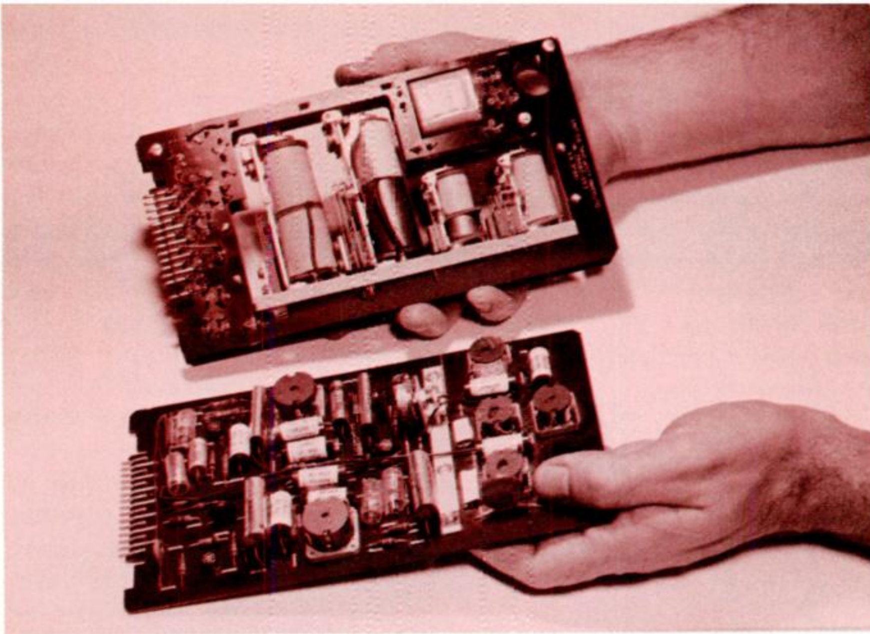


Figure 4. The new Type 81A Exchange Carrier uses "stitched wiring" to improve solder joint reliability and reduce the number of hand operations. Automatically-inserted bronze staples serve as attachment points for components and interconnecting wires. Components may be inserted by machine or hand. Units shown are a channel unit and a signaling unit. Although far smaller than old channel-signaling units, new design approach permits far more elaborate signaling functions.

that "Any mechanism which will introduce *stress relief* will insure greater fail-safe protection against failure in a poorly made solder joint" (italics ours).

"A Stitch In Time . . ."

One answer to the problem of poor reliability in printed circuit boards is a process which dispenses with the printed wiring and substitutes tin-coated bronze staples and "automatic hand wiring" at appropriate locations. Each staple becomes the termination for one or more nearby components and for bare wire connections to other such terminations. All component leads and connecting wires are wrapped firmly around the staple ends, thus providing excellent mechanical and electrical connections *before soldering*. Unlike conventional printed wiring assemblies, the solder is not used to strengthen the mechanical joint between components and connecting wire, thus eliminating a most serious cause of failure in printed circuits. Figure 4 shows examples of carrier equipment which use this new "stitched wiring" concept.

The stitched wiring process achieves the advantages of printed wiring with almost none of the disadvantages. Since all connections are firmly made before soldering, the unit may be completely tested before it is soldered. Because all component leads are attached to the staples, field repairs may be made much more easily than in the case of printed boards, and there is less chance of damaging the wiring. Humidity and moisture have less chance of affecting performance, since conductors are in much less intimate contact with the board than in the case of printed wiring. The disadvantage of this type of construction, compared to printed wiring, is that slightly more space is required because of the staple-ends which project through the board.

Space Savings

Card-mounted carrier equipment, using transistors and other miniature components, achieves savings in space that would have seemed fantastic not long ago. One approach that is becoming standard throughout the industry is to make each card a separate plug-in unit, containing its own male connector. A simple, rack-mounted tray or box provides protection, support, and interconnections between individual cards. Units which contain bulky components are usually built up on a modular basis, with two or more cards supporting the outsized components. Thus, this method is physically compatible with existing equipment-mounting facilities, yet the advantages of the card type of construction are not lost. For instance, a new carrier system using this type of construction requires only one standard rack for 96 channels, including all common equipment and power supplies. This is a space saving of as much as four racks and as little as 1½ racks, compared to older systems which are still in widespread use.

Small as the new systems are, forthcoming ones are going to be even more compact. New techniques for making

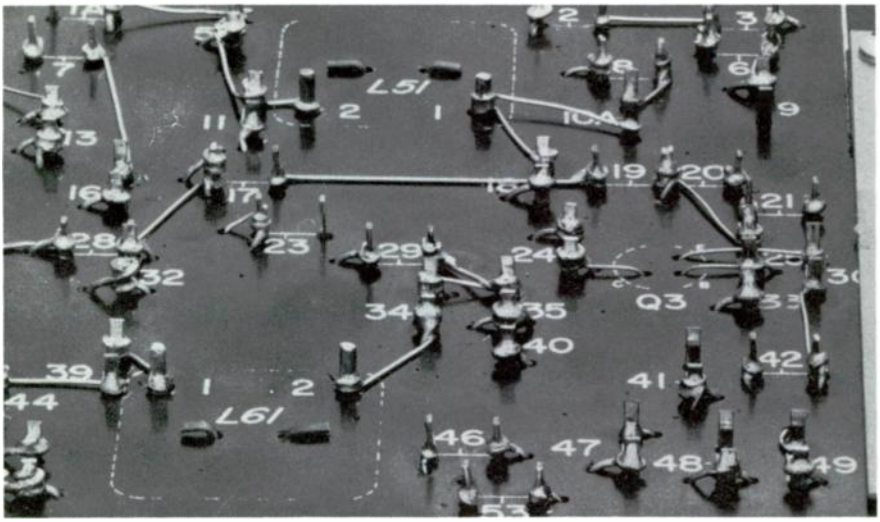


Figure 5. Back view of channel unit. Interconnections are automatically machine-wired, thus providing uniformity and economy of printed wiring. All wires and component leads are machine-wrapped around staple-ends at optimum tension for good mechanical and electrical connection. Units may be performance-tested before soldering. Unlike printed wiring, components are easily replaced without risk of damaging board or interconnections.

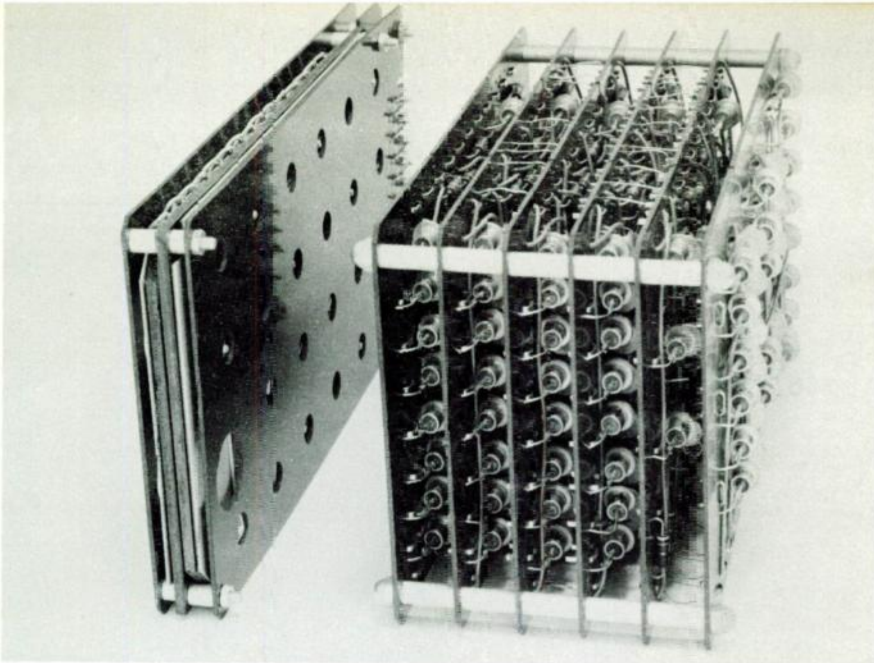


Figure 6. Modern communications systems are becoming more complex, requiring careful design to reduce space requirements. Prototype logic circuit on right employs 96 semiconductor diodes. Production version on left uses 332 diodes, yet requires only small fraction of the space of the earlier unit.

small components even smaller are announced every day. One such approach that shows particular promise in reducing the size of electronics equipment has been dubbed "microminiaturization" and "molectronics." In this approach, entire circuit functions are combined into one tiny part. Thus, a multivibrator circuit, such as might be used in a pulse code modulation system, might be reduced from two transistors and about ten other components, to a single complex part which does the same job and takes no more space than a single transistor.

Clever re-packaging of familiar components can achieve similar reductions, often with performance improvements, as shown in Figure 6. Regardless of the method used to accomplish the changes, communications equipment is becoming smaller, even while achieving greater reliability. Transistor manufacturing techniques have now developed to the point where transistors may be reasonably expected to achieve an indefinite life, as has been long predicted. New materials for capacitors and inductors, new devices and circuits will continue the new rush of progress. •

Bibliography

1. J. J. Sparkes, J. G. Bannochie, R. W. Beattie, "The Reliability of Printed Wiring," *A. T. E. Journal,* Strowger House, London, England; July, 1959.
2. R. H. Hronik, S. Levine, P. A. Thompson, and W. M. Verbeck, "Investigation of Printed Board Soldered Joints," *1959 IRE Wescon Convention Record—Part 6,* p. 77; August, 1959.
3. J. M. Coffin, "The Lenkurt Automatic Wiring Process." *1959 IRE Wescon Convention Record—Part 6,* p. 64; August, 1959.

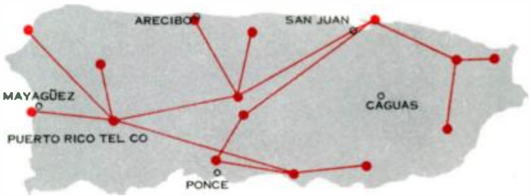
Lenkurt Electric Co.
San Carlos, Calif.

Bulk Rate
U.S. Postage
Paid
San Carlos, Calif.
Permit No. 37

MR. DONALD J. FRANCIS
1145 AMADOR
BERKELEY, CALIF.
656-259

Form 3547
Requested

Better Communications for Puerto Rico



Puerto Rico

Lenkurt has been selected to engineer, furnish, and install a major communications network for the island of Puerto Rico. The installation, which quadruples existing toll facilities, will link the Capitol at San Juan with major centers throughout the island. Initially, the complex system will use Lenkurt 74A2 microwave, 45BX carrier, and 45A carrier.

Lenkurt

SAN CARLOS, CALIFORNIA, U.S.A.

a Subsidiary of General Telephone & Electronics

GENERAL SYSTEM

Lenkurt Subsidiaries

Lenkurt Electric of Canada, Ltd.,
Vancouver, B. C. — CY 8-2464
Lenkurt de Mexico
Mexico City, D. F. — 24-46-50

Field Offices

Washington, D. C., U.S.A. • Panama City, Panama
Caracas, Venezuela • San Salvador, El Salvador

Automatic Electric Company and Automatic Electric International Inc., Northlake, Ill., and their affiliates are distributors of Lenkurt products.

The Lenkurt Demodulator is a monthly publication circulated to individuals interested in multichannel carrier, microwave radio communication systems and allied electronic products. Permission to reproduce material will be granted upon request. Please address all correspondence to the Editor.

Litho in