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DESK SIZE ELECTRONIC COMPUTER FOR GENERAL PURPOSE USE

by

JAMES L. ROGERS

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Volume 32 December 1955 No. 2

DESK SIZE ELECTRONIC COMPUTER FOR GENERAL PURPOSE USE

James L. Rogers
Burroughs Research Center
Burroughs Corporation
Paoli, Pa.

(Presented before The Radio Club of America, February 10, 1955)

TODAY MANY PEOPLE HAVE complex computational problems which they want solved quickly, accurately and economically. Engineers have mountains of data-reduction and design formulas to calculate, scientists and statisticians want to do correlation, curve-fitting and analysis of variance, and the business man wants to turn out his performance records, cost distributions and budget forecasts. At present there are two general ways in which these problems can be solved. The first is to rely on so-called manual methods using a slide rule, or, better still, a rotary desk-top calculator.

The manual method is fine for small problems, but it starts to get expensive as soon as the problem achieves any size. What makes this method expensive is the fact that it generally ties up the higher salaried employees to do computing. With today's problems in getting enough trained personnel to help run a business, it is not economical to hire a graduate engineer or actuary and then require that he sit in front of a rotary desk-top calculator for an hour or two out of each working day. When enough people in a company are doing such calculating, the solution sometimes is to provide a calculating service by hiring a number of calculator operators. Then, of course, one has the overhead and personnel headaches associated with adding this extra help. This has caused many companies to send their computing problems to a calculating service bureau. While this solution relieves personnel problems; the service bureau must charge enough to pay their calculator operators and, in addition, make a profit for themselves. No matter how it is arranged, computation by manual methods is costly.

In addition to the manual methods, today there are available the automatic electronic computers which can carry out thousands of operations in the time that a manual operator takes to do one such calculation. Unfortunately, these larger machines are very expensive and they work most efficiently when they process enormous volumes of work. Since no single department in most companies is large enough to keep one of these giant computers busy all of the time, the computer usually ends up as part of a central service.

Now, of course, everyone with computing problems wants to get his done on the big computer, and there develops a certain amount of competition for the service available. Obviously, every computational problem in a company cannot be turned over to the large-scale computer, and some criterion must be used to decide whose problem is a good one to be done and whose isn't. Almost the only criterion that the people who run the large computer can go by is to measure the complexity of the problems involved. After all, the larger machines were designed to solve the more complex problems and it is these problems that would cost the company more money if they were done by the manual method. So complexity is the first and usually the only criterion used to decide whose problem gets done. Those who do not get their problems done on the computer are told, quite truthfully, that their problems are too "trivial" for solution on the large-scale equipment. The trouble here is that when

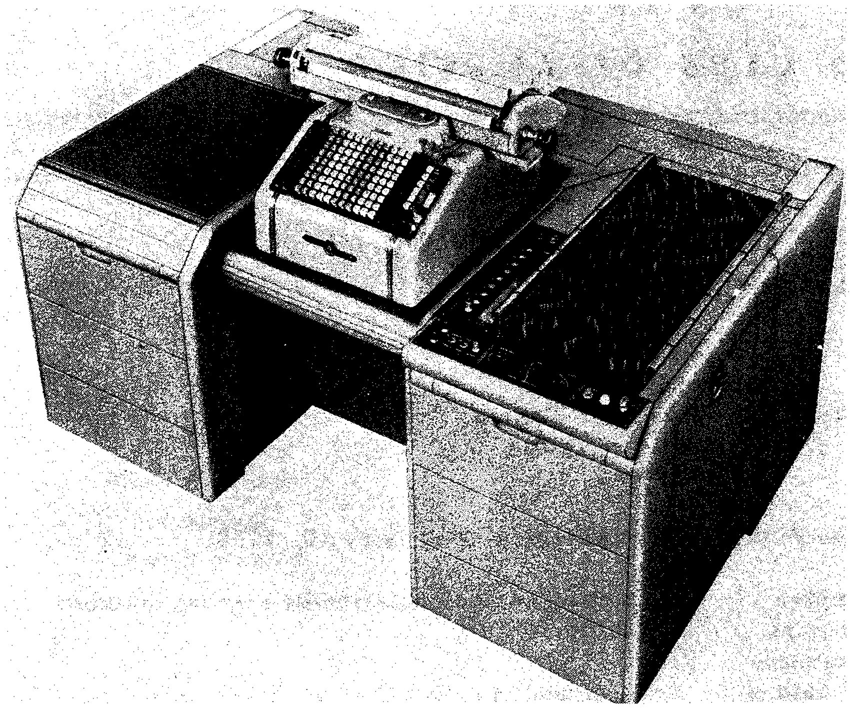


Fig. 1--Desk-size electronic computer uses modified bookkeeping machine for data input and output, and a pinboard device for programming.

a person is turned down often enough on the grounds that his problems are too "trivial", he may decide to make his problems more complex in order to get them done.

We have talked with engineers who have freely admitted that the standard way of getting trivial problems solved on the large-scale computing equipment is to make them more complex than they are. The rules are rather simple: For instance, if you require three digit accuracy, ask for eight. If you require results every two degrees, ask for them every fortieth of a degree. Now when you take your problem to the people running the large-scale equipment, they will be happy to do these problems for you. When you receive the results, the extra work required on your part to find the answers you actually need in the mass of output is more than compensated for by the fact that you did not have to go to the tedious and time-consuming manual methods to get your answers.

Even if you start with a bona fide large problem to begin with, your troubles are not always over. Take the case of the design engineer who has worked out formulas expressing the behavior of a structure. Instead of going to the trouble and expense of designing, fabricating and testing such a structure, it is far easier to find the formulas expressing this structure's behavior, and solve the formulas for enough values to give you the mathematical equivalent of testing the actual equipment. Often the design engineer finds that his formula is extremely lengthy and complex and that it would require more time and expense to find the solution of his formulas manually than it would to build the equipment. If he is fortunate enough to work for a company which has a large-scale computer, and if the problem is really large and complex enough to be out of the "trivial" category, he can talk to one of the giant computer programmers about getting the problem done. The engineer explains the problem to the programmer, and the programmer works out a list of instructions for the machine. The programmer usually asks the engineer for the results of test-point calculations to help him check the program itself when they run it on the machine. In most cases, of course, the design engineer does not have any test values, because if he had, he could have plotted them and drawn a smooth curve through them. The very reason he is asking for the computer solution of his problem is because he does not have any test points. Nevertheless, he usually knows that for certain ranges of values the results should show a trend one way, whereas for another range they should show a different trend, and so on.

When the problem finally is programmed, de-bugged, and run on the large-scale computer, the roll of printed results is sent to the engineer who then holds a hurried conference with the programmer. The engineer informs the programmer that the results don't look quite right to him, and that there is probably a mistake in the program or even perhaps in the machine itself. The programmer, of course, looks the engineer right back in the eye and says that it is very probably the engineer's formulation itself which is wrong. The only way to decide this dispute, of course, is to go back to the manual method, run off some values, and check these against the computer results for the same inputs. So we're right back where we started, having to use some sort of expensive manual system after all.

Now the fact that the manual methods are good only for the quite simple problems, whereas the highly automatic methods are better adapted to the quite complex problems, suggested to the people at Burroughs Research Center that something is missing. It would appear that there is a gap existing between the rotary desk-calculator methods on one hand and the giant computing methods on the other. Let's imagine, therefore, that we are going to design a machine to fill this gap. Let's try to figure out what features we would want this computer to have. They would include the following:

1. We would want the device to be a general-purpose computer. It should be capable of solving any problem that can be solved with arithmetic. There are enough special purpose computers available, especially of the analog type, for the special purpose applications.

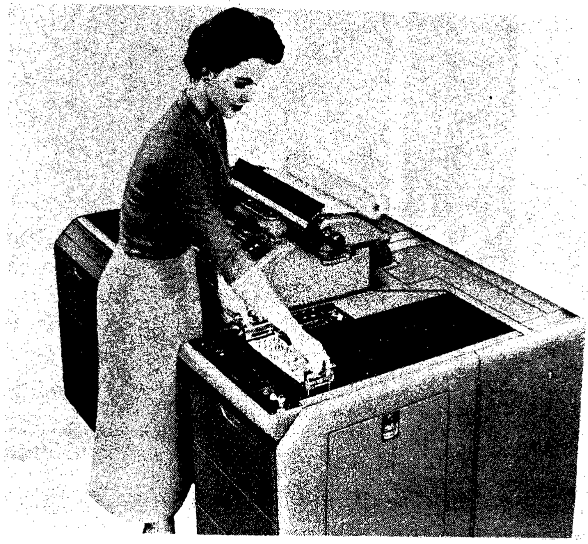
2. An intermediate computer of the type we are discussing should be simple to program. It should not require a special staff of programmers to set up problems for it. If possible, there should be no language barrier between the people who have the problems and the computer which is going to solve them. If a person has a problem complex enough to require automatic solution, he should not be required to learn the additional complexities of a large-scale electronic computer. Programmers should not have to attend lengthy school sessions and, ideally, they should be able to learn the essentials of programming from reading a programmer's manual.

3. The machine should be easy to operate. For much the same reasons that programming simplicity is required, an electronic computer should present no undue operational difficulties. Again, the people who have the problems should be able to sit down and run them on the computer without the assistance of a special staff of operators.

4. The machine should be so built that it is easy to de-bug a program. As more and more experience builds up in the computer field, it is coming to be recognized that de-bugging is a permanent and important part of the programming and problem-solving operations. The ease with which a program can be de-bugged is

Fig. 2--Paper templates, marked with the proper pin positions, are laid over the pinboard, and the operator drops in the pins.

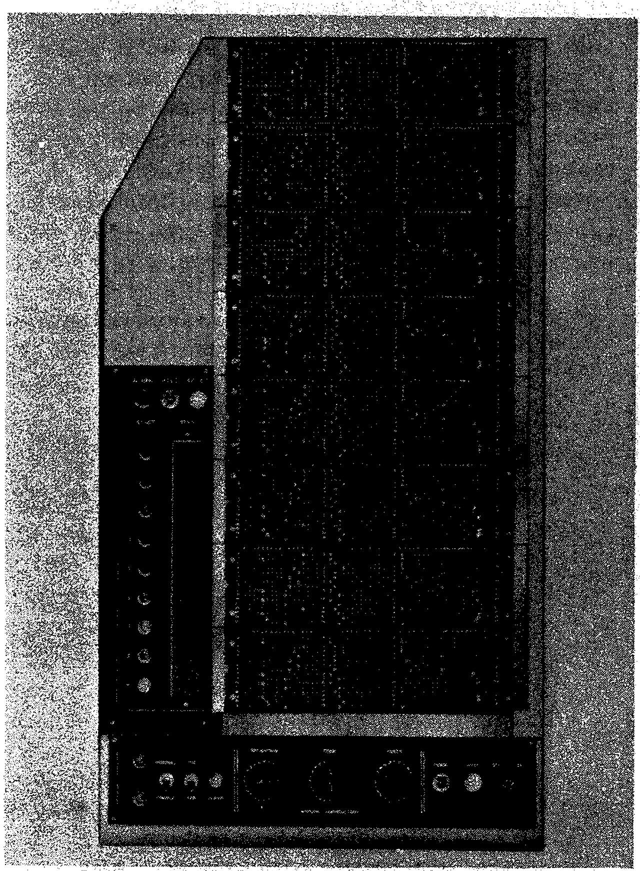
Fig. 3--Operator inserts an assembled pinboard. One problem may require as many as eight pinboards.



often a crucial factor in getting the problem done quickly.

5. An intermediate-sized machine should permit the operator to bring his judgment to bear upon a problem's solution. This would make it especially applicable to that large area of problems which use some form of trial-and-error calculation. These problems generally pose difficulties for the large-scale computers. Of course, you can stop any computer at any point in its program, look at the current results and make choices based on these results. But the large-scale machines were not designed to be used this way. The approach with large computers is to put in all the instructions and all the data at once and not allow human intervention at all. While this works splendidly with the massive data-handling problems, it makes trial-and-error solutions awkward and uneconomical.

6. Keeping in mind the concept of an intermediate computer, we could then say that a sixth characteristic is that it should be small and easy to install. Its space, power and cooling requirements should be as modest as possible.



7. And lastly, of course, such a machine should be kept as low as possible in initial cost.

What would such a machine look like? Well, here's one answer to this problem. Figure 1 shows the Burroughs E101 Desk-size Electronic Digital Computer. The modified bookkeeping machine in the center of the desk is used for data input and output. A magnetic drum is used for data storage. An electronic section does the calculating, and a novel pinboard device contains the externally-stored program. Among its operations are addition, subtraction, multiplication, division, count, compare, store, print, shift, etc. It has instructions for unconditional, and two different kinds of conditional, transfer. Thus it has the logical ability to solve any arithmetical problem, and is in every sense of the word a general-purpose computer. Furthermore, its program language has been specifically designed to avoid long lists of confusing code numbers. The symbols for all of the E101's operations are familiar to everyone. For example, the plus sign means add, the letter R means read from storage, the letter C means compare, etc.

Figure 2 shows the operator dropping pins into one of the eight removable pinboard devices, in which the pin settings tell the machine what to do. Each horizontal line of pins is a single instruction to the machine. The pin on the left tells the machine what operation to perform, and the two pins on the same line with it tell the machine where to get the number to operate upon. When the pinboard with the pins assembled in it is plugged into the machine (Fig. 3), the E101 simply scans the pin positions, doing one instruction after another until it reaches a transfer instruction, which may send it back to repeat certain of its operations, for example. Programming of the E101 can be taught in less than a day, even to people who have had no prior experience with digital computers.

The facts that data are entered directly into the keyboard and that the results print out directly in front of the operator, eliminate the need for special coding or preparation of some intermediate data-storage. The

Fig. 4--Top view of pinboards in E101 computer with indicator lights and controls.

only time the operator is involved in the problem is when the machine lights one of its two signals (see Fig. 4). One of these lights tells the operator to put the next number into the keyboard and the other one tells the operator to choose what part of the problem to go to next. Anyone who can operate a full keyboard bookkeeping or calculating machine can be taught to operate the Burroughs E101 in a matter of hours.

Figure 4 also shows the toggle switches which permit the operator to change the machine from pinboard control to control by manual switch setting. These switches can be set up to perform any one of the machine's operations, and they permit the programmer to check out the program himself, printing out the operation-by-operation check on the calculations. The switches permit examination or change of the contents of any memory location without disturbing the program itself. The visible, alterable program, and the convenience with which any or all operations can be monitored, make de-bugging simple and fast.

Problems where operator judgment can be helpful are set up with halt instructions at crucial points in the program. When the machine reaches such an instruction, it stops, lights its HALT light and, in effect, asks the operator what ought to be done next. Here, the operator need merely touch one of the nine start buttons, which send the machine automatically to predetermined points in the program. For example, in a trial-and-error calculation, the operator may enter his guess into the keyboard. The E101 takes this guess, runs it through the calculations, printing out the intermediate and final results. When the last result has been printed, the HALT light comes on, and the operator now decides whether, (1) his guess was close enough and he can go on to make a similar guess for the next member of the system or (2) his guess was not close enough and he must make a better guess, guided by the printed results. The E101 can be programmed so that in either case the operator merely touches one or another of the nine start buttons. The machine then immediately goes to the part of the problem permitting the calculation desired by the operator.

The Burroughs E101 is completely self-contained in a single 40 x 60-inch desk-like cabinet mounted on casters. It is powered from a 220-volt, single-phase, 3-wire line, and requires no extra cooling equipment beyond that found in a normally air-conditioned room. Its power consumption is a little less than 3 kilowatts.

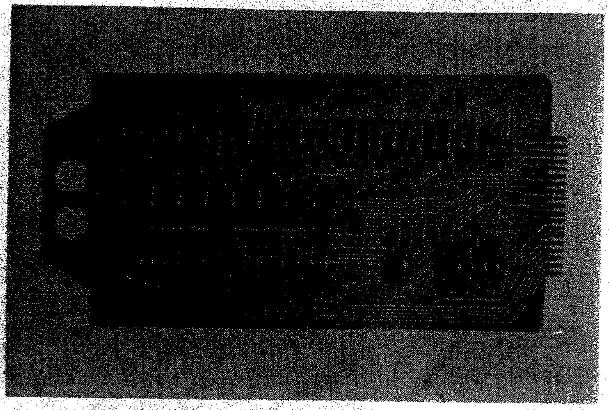


Fig. 5--One of the 50 etched-circuit plug-in cards used in electronic arithmetic section.

The cost of the E101 has been kept quite low and is the lowest priced general-purpose electronic digital computer available in this country.

The design effort for this computer was guided by the goal of low cost. For example, other digital computers used for massive data-handling problems require large storage capacities. To conserve magnetic drum storage space in these large machines, the decimal inputs are converted to a coded-binary system which allows the storage of any decimal digit in four magnetic spots on the drum. But to use this system of storage, the decimal numbers must be converted to their coded-binary equivalents and the binary numbers must be converted back to decimal before they can be printed out. The E101, on the other hand, operates in a straight decimal system with no conversion to binary. In this system of storage, nine spots on the drum are used to represent a single decimal digit, and the polarities of the magnetized spots are counted. For example, seven north pole magnets represent the number seven. The modest 1200-digit storage capacity of the E101 easily fits on the drum using this pulse-coded decimal system. At the same time it provides a substantial cost saving due to the fact that conversion equipment is not needed.

Another feature which keeps the cost of

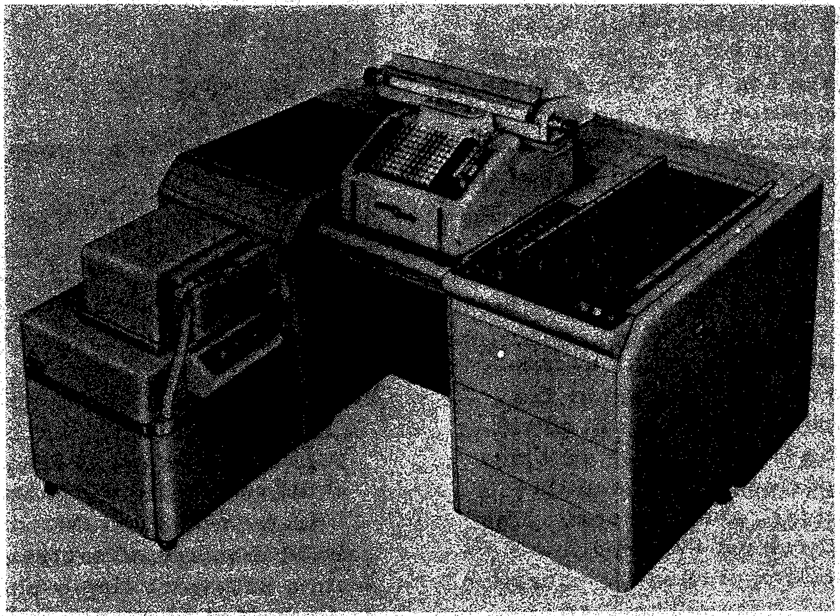


Fig. 6--The optional punched tape input unit operates with E101 computer. Both units are mounted on casters.

the machine down is the method of packaging. Almost all of the electronic components are mounted on etched circuit plug-in cards (Fig. 5). These replaceable cards are very reliable, and can be mass produced at far below the cost of wiring and hand-soldering.

One of the factors affecting price, of course, is the number of tubes. One of the earliest general-purpose computers, the ENIAC, has about 19,500 vacuum tubes. The Burroughs E101 employs 163 vacuum tubes, almost one quarter of which are thyratrons used to activate motor bar solenoids for printing. This low tube count is made possible by the use of diode logic wherever possible and by designing the system so that any one set of components serves to carry out many different functions.

Another feature which helps reduce the size and cost of the E101 is the tubeless power supply contained in the left hand bay of the machine. This assembly controls the voltages and supplies the eleven different voltage levels.

In addition to the basic machine described here, an optional punched-paper tape reader is available. This device can be used for fast entry of data into the machine, thus by-passing the keyboard (Fig. 6). It can also be used to supplement the pinboard program, thus providing a program of unlimited length.

At present, the Applications Analysts at our Paoli Research Center are examining a wide variety of scientific, engineering and statistical problems. We have found it an extremely valuable laboratory tool and many of the engineers engaged in research work have themselves used the machine to help them solve difficult computational problems.

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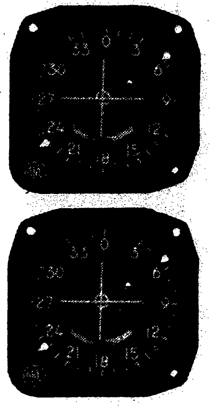

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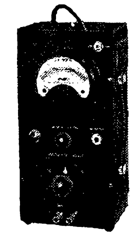
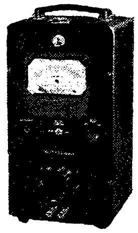


Voltage Range	**1mv—100v**
Frequency Range	**10cps—150kc**
Accuracy	**2% ENTIRE RANGE**
Input Impedance	**½ meg shunted by 30μμf**

SUB-AUDIO to 150 kc MODEL 302B

Battery Operated



Voltage Range	**100μv—100v**
Frequency Range	**2cps—150kc**
Accuracy	**3% 5cps—100kc** **5% elsewhere**
Input Impedance	**2 meg shunted by 15 μμf***

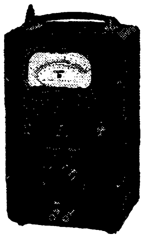
**Shunt capacitance, 8 μμf on all ranges except two most sensitive ranges*

PEAK-to-PEAK MODEL 305

Voltage Range	**1mv—1000v pk-to-pk**
Frequency Range	**10cps—100kc (sine wave)**
Pulse width	**3μsec—250μsec**
Min Rep Rate	**20 pulses per sec**
Accuracy	**5% for pulses**
Input Impedance	**2 meg shunted by 15 μμf***

**Shunt capacitance, 8 μμf on all ranges except two most sensitive ranges*

AUDIO to 2 mc MODEL 310A



Voltage Range	**100 μv—100 v** *Down to 40 μv at reduced accuracy*
Frequency Range	**10 cps—2 mc** *As null detector 5 cps.—4 mc*
Accuracy	**3% 10 cps—1 mc** **5% elsewhere**
Input Impedance	**2 meg shunted by 15 μμf***

**Shunt capacitance, 8 μμf on all ranges except two most sensitive ranges*

AUDIO to 6 mc MODEL 314

Voltage Range	**1mv—1000v** **(100μv—1mv without probe)**
Frequency Range	**15cps—6mc**
Accuracy	**3% 15cps—3mc** **5% elsewhere**
Input Impedance	**11 meg shunted by 7.5 μμf** **(1 meg shunted by 25 μμf without probe)**

INFRASONIC to 30 kc MODEL 316

Voltage Range	**20 mv—200 v pk-to-pk**
Frequency Range	**0.05 cps—30 kc** *(Down to .01 cps with corrections)*
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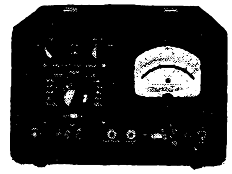

Voltage Range	**100 μv—320 v**
Frequency Range	**5 cps—500 kc**
Accuracy	**3% 15 cps—150 kc** **5% elsewhere**
Stability of Internal Calibrator	**0.5%**
Input Impedance . . .	**10 megs shunted by 25 μμf below 10 mv** **10 megs shunted by 8 μμf above 10 mv**

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Frequency (Std. Model)	**1 kc** *(other values on special order)*
Accuracy (long term)	**Better than 0.5% above 1 mv**
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Setting Resolution	**Approaches 0.01% above 10 mv**
Output Impedance (AC)	**2-20 ohms depending on range setting**

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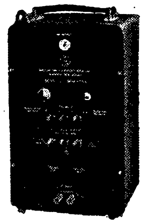

Voltage Range	**1μv—100v DC**
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Accuracy	**1% 100μv—100v**
Input Resistance	**>10 meg for 1:100** **50 meg for 10:1**

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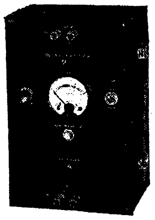

Voltage Range	**10μv—50mv**
Frequency Range	**10cps—150kc**
Accuracy	**2% ENTIRE RANGE**
Input Impedance	**5 meg shunted by 15μμf**

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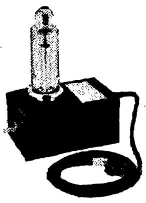

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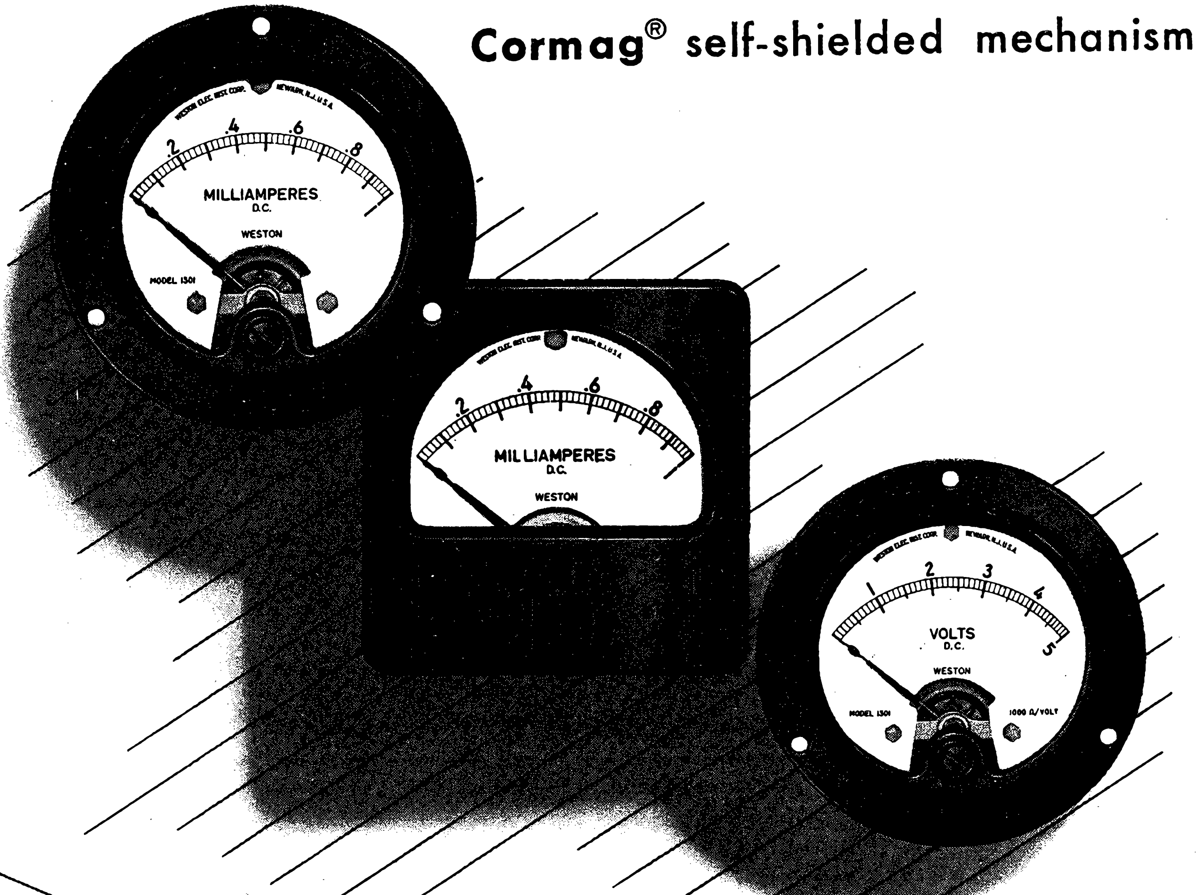

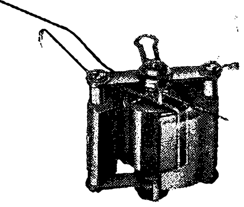

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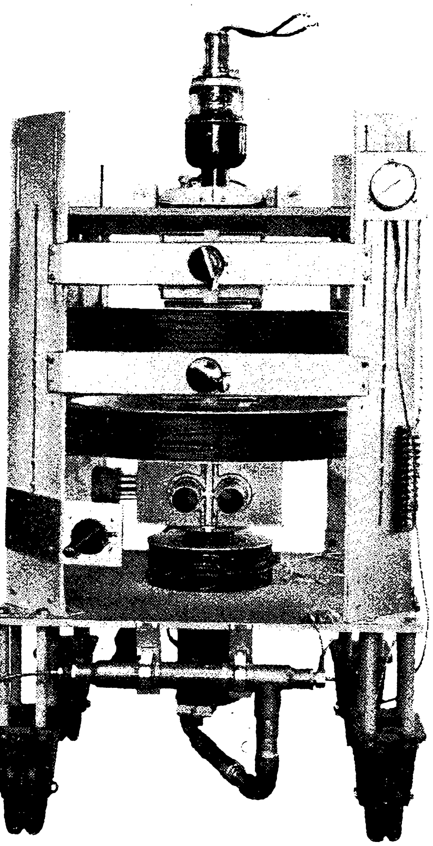

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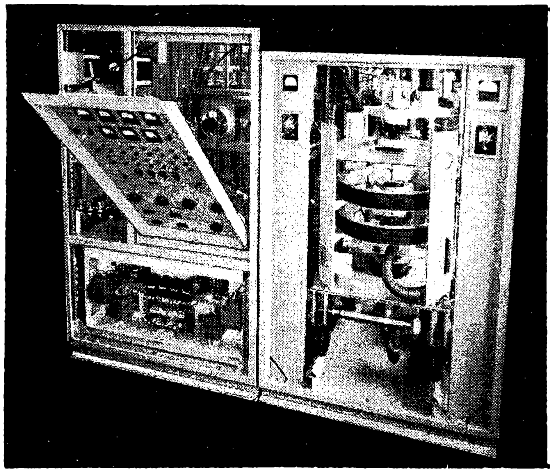
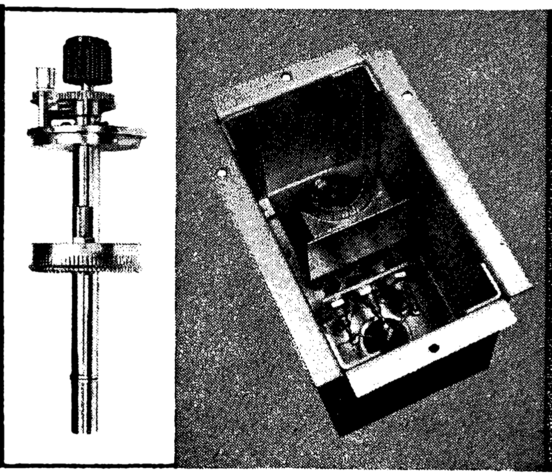
More beyond-the-horizon FM multiplex relay equipment by REL is in operation than that of all other manufacturers *combined.* No need to wait for time-consuming developmental engineering; Type 826 and 827 Terminals are standard items in the REL line of point-to-point communications gear. Each terminal includes an exciter, a dual diversity receiver with combiner or switch, as determined by application, and a Klystron power amplifier: 10 kw for the 826 and 1 kw for the 827.

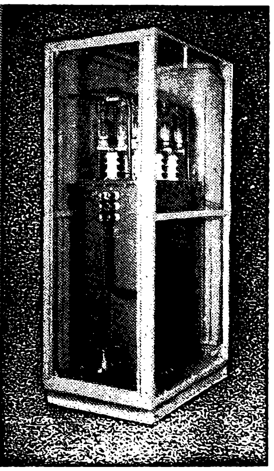
Carrier frequencies are available for both systems from 400 to 1050 mc, with base band options from 30 to 600 kc. Associated receivers have noise figures from 5.5 to 9 db, depending on frequency. Descriptive specifications may be obtained upon request.



Power amplifier and control panel (826)



Receiver tuning assemblies (826 and 827)



Beam supply (826)

Fourth in a series describing REL versatility

REL

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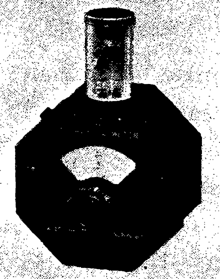
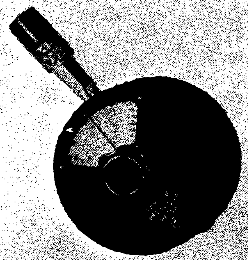
NOW! MEASUREMENTS' MEGACYCLE METER

Gives You Extended Coverage from 100 Kc to 940,000 Kc

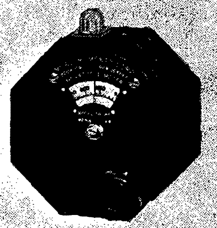
PRECISION GRID-DIP METERS



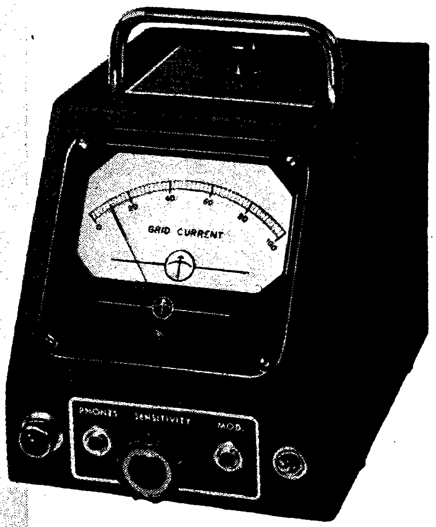
MODEL 59-LF OSCILLATOR UNIT
Frequency Range: 100 Kc to 4.5 Mc.
Price - Oscillator Unit (Head) only
$98.50



MODEL 59 OSCILLATOR UNIT
Frequency Range: 2.2 Mc to 420 Mc.
Price - Oscillator Unit (Head) only
$98.50



MODEL 59-UHF OSCILLATOR UNIT
Frequency Range: 420 Mc to 940 Mc.
Price - Oscillator Unit (Head) only
$123.00



The Power Supply is a compact, lightweight portable unit consisting of a full-wave rectifier with voltage regulator tube—designed for use with any of the oscillator heads illustrated.

PRICES:

Power Supply only $75.00
Model 59-LF Head with Power Supply $168.00
Model 59 Head with Power Supply $168.00
Model 59-UHF Head with Power Supply $198.00

Prices FOB. Boonton, N. J.

Measurements' Megacycle Meter is now available in a choice of three oscillator heads providing frequency range coverage from 100 Kc to 940,000 Kc. Thus, the utility of this versatile instrument has been extended, making it, more than ever, indispensable to anyone engaged in electronic work; engineer, serviceman, amateur or experimenter.

Laboratory Standards

MEASUREMENTS CORPORATION
BOONTON · NEW JERSEY

MEASUREMENTS CORPORATION

Laboratory Standards

Throughout the world, Measurements' reputation for accuracy and reliability is your guarantee of satisfactory service.

STANDARD SIGNAL GENERATOR MODEL 65-B

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
75 Kc.—30 Mc.	0.1 microvolt to 2.2 volts	AM. 0 to 100% 400 cycles or 1000 cycles External mod., 50-10,000 cycles

STANDARD SIGNAL GENERATOR MODEL 78

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
15-25 Mc.; 195-225 Mc. 15-25 Mc.; 90-125 Mc. Other ranges on order	1 to 100,000 microvolts	AM. 8200-400 cycles 625—400 cycles Fixed at approximately 30%

STANDARD SIGNAL GENERATOR MODEL 78-FM

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
86 Mc.—108 Mc.	1 to 100,000 microvolts	Deviation 0-300 Kc. 2 ranges FM. 400-8200 cycles External mod. to 15 Kc.

STANDARD SIGNAL GENERATOR MODEL 80

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
2 Mc.—400 Mc.	0.1 to 100,000 microvolts	AM. 0 to 30% 400 cycles or 1000 cycles External mod., 50-10,000 cycles

STANDARD SIGNAL GENERATOR MODEL 82

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
20 cycles to 200 Kc. 80 Kc. to 50 Mc.	0-50 volts 0.1 microvolt to 1 volt	Continuously variable 0-50% from 20 cycles to 20 Kc.

STANDARD SIGNAL GENERATOR MODEL 84

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
300 Mc.—1000 Mc.	0.1 to 100,000 microvolts	AM. 0 to 30%, 400, 1000, or 2500 cycles. Internal pulse modulator. External mod., 50-30,000 cycles.

STANDARD SIGNAL GENERATOR MODEL 84-TV

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
300 Mc. to 1000 Mc.	Continuously variable from 0.1 microvolt to 1.0 volt	Continuously variable 0 to 30% External modulation 20 to 20,000 cycles.

STANDARD SIGNAL GENERATOR MODEL 90

FREQUENCY RANGE	OUTPUT RANGE	MODULATION
20 Mc.—250 Mc.	0.3 microvolt to 0.1 volt	Continuously variable, 0 to 100% Sinusoidal modulation 30 cycles 5 mc. Composite TV modulation.

PULSE GENERATOR MODEL 79-B

FREQUENCY RANGE	PULSE WIDTH	OUTPUT
60 to 100,000 cycles	Continuously variable from 0.5 to 40 microseconds	Approx. 150 v. positive with respect to ground. "Sync Output" 35 v. positive with respect to ground.

SQUARE WAVE GENERATOR MODEL 71

FREQUENCY RANGE	WAVE SHAPE	OUTPUT
Continuously variable 6 to 100,000 cycles	Rise time less than 0.2 microseconds with negligible overshoot	Step attenuator: 75, 50, 25, 15, 10, 5 peak volts fixed and 0 to 2.5 volts continuously variable.

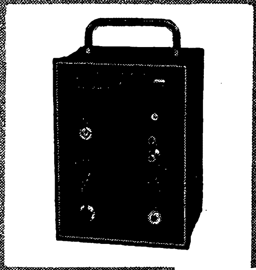
VACUUM TUBE VOLTMETERS

MODEL 62

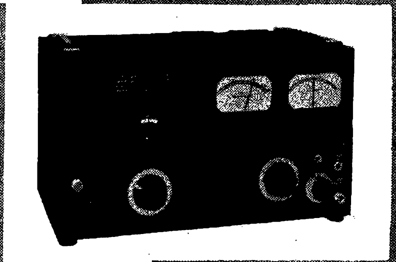
VOLTAGE RANGE	FREQUENCY RANGE	INPUT IMPEDANCE
0-1, 0-3, 0-30 and 0-100 volts AC or DC	30 cycles to over 150 Mc.	Approximately 7 mmfd.

MODEL 67

VOLTAGE RANGE	FREQUENCY RANGE	INPUT IMPEDANCE
.0005 to 300 volts peak-to-peak	5 to 100,000 sine-wave cycles per second	1 megohm shunted by 30 mmfd.



CRYSTAL CALIBRATOR MODEL 111



STANDARD SIGNAL GENERATOR MODEL 80

MEGACYCLE METER MODEL 59

V.H.F. FIELD STRENGTH METER MODEL 58

FREQUENCY RANGE	INPUT VOLTAGE RANGE
15 Mc. to 150 Mc.	1 to 100,000 microvolts in antenna. 1 to 100 microvolts on semi-logarithmic output meter, balanced resistance attenuator with ratios of 10, 100 and 1000 ahead of all tubes.

INTERMODULATION METER MODEL 31

INTERMODULATION RANGE	FREQUENCIES (CYCLES)	ANALYZER INPUT VOLTAGES
3%, 10% and 30% Full scale	LF: 60 cps HF: 3000 cps	Full scale ranges of 3, 10, 30 volts RMS

MEGACYCLE METERS MODELS 59LF—59—59UHF

FREQUENCY RANGE	FREQUENCY ACCURACY	MODULATION
0.1 Mc. to 4.5 Mc. 2.2 Mc. to 400 Mc. 430 Mc. to 940 Mc.	Within ±2%	CW or 120 cycles fixed at approximately 30%. Provision for external modulation

CRYSTAL CALIBRATORS

MODEL 111

FREQUENCY RANGE	FREQUENCY ACCURACY	HARMONIC RANGE
250 Kc.—1000 Mc.	0.002%	.25 Mc. Oscillator: .25-450 Mc. 1 Mc. Oscillator: 1-600 Mc. 10 Mc. Oscillator: 10-1000 Mc.

MODEL 111-B

FREQUENCY RANGE	FREQUENCY ACCURACY	HARMONIC RANGE
100 Kc.—1000 Mc.	0.002%	1 Mc. Oscillator: 1 — 450 Mc. 1 Mc. Oscillator: 1 — 600 Mc. 10 Mc. Oscillator: 10— 1000 Mc.

MEASUREMENTS CORPORATION

BOONTON NEW JERSEY

"With Univac time as valuable as it is, and meaning as much to us as it does, we must insure continuous satisfactory operation. If something should happen to our computer, we would want to learn about it by unmistakable indications. We use the G-R Strobotac and Impedance Bridge for measurements when a failure is indicated."

Bernard L. Stock, *Chief Engineer*
The Franklin Life Insurance Co.

Strobotac® and Impedance Bridge keep UNIVAC on the Job...

Using the Strobotac, an engineer of The Franklin Life Insurance Company checks the servo-controlled magnetic tapes which feed data to Univac's complex computing circuits. The tape speed must be 100 inches per second. Any significant variation from this speed could cause faulty recording of basic information with possible inaccurate interpretation and results.

Strobotac readily shows even the minutest change of speed. Adjustments can be made on the spot and costly "down time" is held to a minimum.

★ ★ ★

Strobotac used as a research, development or maintenance tool will "stop" cyclic motion at speeds from 400 to 100,000 rpm. Mis-alignments, slipping belts, worn or broken parts and other mechanical defects which are impossible to see with the unaided eye while they are in motion, are readily observed under stroboscopic light. Because there is no physical link between the Strobotac and the rapidly moving subject, there is no "drag" to impair the accuracy of the observation.

Compact, ready to operate (a single knob controls the flashing rate), Strobotac operates from any 115-volt, 60-cycle source. Range as electrical tachometer is 60 to 100,000 rpm.

Type 631-BL Strobotac®..............................$150

Checking one of the 252 mercury-tank memory crystals in Univac, engineer measures capacitance to ground with basic accuracy of 1%.

Under normal circumstances, each crystal has 20-30 $\mu\mu f$ of capacitance with respect to its support. Should a crystal suffer physical damage, there is invariably a corresponding change in capacitance. This change is measured conveniently and reliably with the General Radio Impedance Bridge.

★ ★ ★

Type 650-A Impedance Bridge . . . versatile Resistance — Inductance — Capacitance measuring instrument . . . is completely self-contained, including built-in standards and power sources. Accurate, direct reading and always ready for use, it measures:

Resistance: 1 milliohm to 1 megohm
Capacitance: 1 micromicrofarad to 100 microfarads
Inductance: 1 microhenry to 100 henrys
Dissipation Factor: (R/X) from .002 to 1
Storage Factor: (X/R or Q) from .02 to 1000

Four internal dry cells are the d-c power source and drive a 1000-cycle hummer for a-c measurements. A zero-center galvanometer is used for d-c balance; terminals are provided for external headset (not supplied with instrument) for a-c null detection.

Type 650-A Impedance Bridge..........................$260

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40 Years of Pioneering
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