

Standards on Electronic Computers: Definitions of Terms, 1950*

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Access Time. (1) The time interval, characteristic of a memory or storage device, between the instant at which information is requested of the memory and the instant at which this information begins to be available in useful form. (2) The time interval between the instant at which information is available for storage and the instant at which it is effectively stored.

Accumulator. A device which stores a number and, upon reception of a new number, adds it to the previous contents and stores the sum.

An accumulator may have properties such as shifting, sensing signs, clearing, complementing, and so forth.

Accuracy. The quality of correctness or freedom from error. Distinguished from *precision* as in the examples:

(a) "... this procedure measures the precision (reproducibility) of the test, not its accuracy (closeness to the true value)."

(b) A four-place table correctly computed is more accurate but less precise than a six-place table containing errors.

See also: Precision.

Adder. A device which can form the sum of two or more numbers, or quantities, impressed upon it.

Adder, Algebraic. *See Algebraic Adder.*

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Address. Information (usually a number) which designates a particular location in a memory or storage device.

Algebraic Adder. An adder which can form an algebraic sum.

Amplifier, Torque. *See* Torque Amplifier.

Analog (in computer work). A physical system on which the performance of measurements yields information concerning a class of mathematical problems.

Analog Computer. A physical system together with means of control for the performance of measurements (upon the system) which yield information concerning a class of mathematical problems. In an analog computer quantities are represented without explicit use of a language.

See also: Language.

"And" Circuit. *See* Gate.

Arithmetic Element. That part of a computer which performs arithmetic operations.

Synonyms: Arithmetic Organ and Arithmetic Unit.

Arithmetic Organ. *See* Arithmetic Element.

Arithmetic Unit. *See* Arithmetic Element.

See also: Parallel Arithmetic Unit and Serial Arithmetic Unit.

Base (or Radix). *See* Radix (or Base).

Binary Cell. An information-storing element which can have one or the other of two stable states.

Binary-coded Decimal System. A system of number representation in which the decimal digits of a number are expressed by binary numbers.

Binary Digit. A digit of a binary number.

See also: Memory Capacity or Storage Capacity.

Binary Number System. A number system which uses two symbols (usually denoted by "0" and "1") and has two as its base, just as the decimal system uses ten symbols ("0, 1, . . . , 9") and the base ten.

See also: Positional Notation and Radix.

Binary Point. The radix point in the binary system.

Block. A group of words considered as a unit.

See also: Word.

Break Point. A point in a program at which a special instruction is inserted which, if desired, will cause a digital computer to stop for visual check of progress during the initial checking of a problem.

Buffer. (1) An isolating circuit used to avoid reaction of a driven circuit upon the corresponding driving circuit. (2) A circuit having an output and a multiplicity of inputs so designed that the output is energized whenever one or more inputs are energized. Thus, a buffer performs the circuit function which is equivalent to the logical "or."

Bus (in computer work). One or more conductors which are used as a path for transmitting information from any of several sources to any of several destinations.

Carry. (1) A condition occurring in addition when the sum of two digits in the same column equals or exceeds

the base of the number system in use. (2) The digit to be forwarded to the next column. (3) The action of forwarding it.

Cascaded Carry. A system of executing the carry process in which carry information can be passed on to place $(N+1)$ only after the N th place has received carry information or has itself produced a carry.

See also: Complete Carry, Partial Carry, Self-instructed Carry, Separately Instructed Carry and Standing on Nines Carry.

Cell, Binary. *See* Binary Cell.

Character. One of a set of elementary symbols which may be arranged in ordered aggregates to express information.

Check Problem. A problem whose incorrect solution indicates an error in the operation or programming of a computer.

Circulating Memory. A memory consisting of a means for delaying information and means for regenerating and reinserting the information into the delaying means.

Clear (verb). To restore a storage or memory device to a prescribed state, usually that denoting zero.

Clock, Master. *See* Master Clock.

Code. (1) A system of symbols and rules for use in representing information. (2) Loosely, the set of characters resulting from the use of a code. (3) To express given information by means of a code.

See also: Language.

Code, Excess 3. *See* Excess 3 Code.

Code, Instruction. *See* Instruction Code.

Coded Program. A description of a procedure for solving a problem by means of a digital computer. It may vary in detail from a mere outline of the procedure to an explicit list of instructions coded in the machine's language.

See: Program.

Column. In Positional Notation a position corresponding to a given power of the radix. A digit located in any particular column is a coefficient of a corresponding power of the radix.

Synonym: Place.

Command. One of a set of several signals (or groups of signals) which occurs as the result of an instruction; the commands initiate the individual steps which form the process of executing the instruction.

See also: Instruction.

Comparator. A circuit which compares two signals and supplies an indication of agreement or disagreement.

Complement. A number whose representation is derived from the finite positional notation of another by one of the following rules:

(a) True complement—Subtract each digit from the radix less 1, then add 1 to the least significant digit, executing any carries required.

(b) (Radix-1)'s complement—Subtract each digit from the radix less 1.

Complete Carry. A system of executing the carry process in which all carries and any carries to which they give rise are allowed to propagate to completion.

See also: Cascaded Carry, Partial Carry, Self-instructed Carry, Separately Instructed Carry and Standing on Nines Carry.

Computer. A device which can accept information and supply information and in which the supplied output information is derived from the accepted input information by means of a process of logic.

Note—"Process of logic": Any systematic process of derivation which is demonstrably free from self-contradiction.

Conditional Transfer (of control). In digital computing, an instruction which will, depending upon some property of a given number (or numbers), cause the proper one of two other instructions to be executed.

Control Circuits. The circuits of a digital computer which effect the carrying out of instructions in proper sequence, the interpretation of each instruction, and the application of the proper commands to the arithmetic element and other circuits in accordance with this interpretation.

Correction. The quantity which is added to a calculated value to obtain the correct value.

Counter. (1) In mechanical analog computers, a means for measuring the angular displacement of a shaft. (2) A device capable of changing from one to the next of a sequence of distinguishable states upon each receipt of a discrete input signal.

The term **Counter** is in some cases used to mean **Accumulator**.

Cycle, Major. *See* Major Cycle.

Cycle, Minor. *See* Minor Cycle.

Cyclic Shift. An operation which produces a word whose characters are obtained by a cyclic permutation of the characters of a given word.

Decimal Number System. The method of positional notation using ten as the radix.

See also: Positional Notation and Radix.

Decimal Point. The radix point in the decimal system.

Delay-line Memory. A type of circulating memory in which a delay line is the major element in the circulation path.

See also: Circulating Memory.

Delay-Line Register. An acoustic or electric delay-line, usually one or an integral number of words long, together with input, output, and circulation circuits.

Differentiator. A device, usually of the analog type, whose output is proportional to the derivative of an input signal.

Digit. One of a definite set of characters which are used as coefficients of powers of the radix in the positional notation of numbers.

Digit, Binary. *See* Binary Digit.

Digit, Sign. *See* Sign Digit.

Digital Computer. One in which information, numerical or otherwise, is represented by means of combinations of characters in such a way that the number of distinguishable combinations is much greater than the number of distinguishable characters. Thus, a digital computer is one which makes explicit use of a language.

See also: Language.

Dispatcher (in computer work). That part of a digital computer which performs the switching determining the sources and destinations for the transfer of words.

Double-Precision Number. A number having twice as many significant digits as are ordinarily used in a particular computer.

Dynamic Sequential Control. A method of operation in which a digital computer, as the computation proceeds, can alter instructions, or the sequence in which instructions are executed, or both.

Electrical Function Switch. *See* Function Switch.

Electrostatic Memory. A memory device utilizing electrostatic charge as the means of retaining information, involving usually a special type of cathode-ray tube together with associated circuits.

Electrostatic Memory Tube. An electron tube in which information is retained by means of electric charges.

Synonym: Storage Tube.

Equation Solver. A computing device, often of the analog type, which is designed to: (a) Solve systems of linear simultaneous (nondifferential) equations, or (b) find the roots of polynomials, or both.

Error. The quantity which is subtracted from a calculated value to obtain the correct value.

Error, Round-Off. *See* Round-Off Error.

Error, Truncation. *See* Truncation Error.

Excess 3 Code. A code for numerical data in which each decimal digit d is represented by the binary number $(d+3)$.

Extract Instruction. In a digital computer, the instruction to form a new word by juxtaposing selected segments of given words.

Fixed-Point System. A system of number notation in which a number is represented by a single set of digits and in which the position of the radix point is not numerically expressed.

See also: Floating-Point System.

Flip-flop. An electronic circuit having two stable states and ordinarily two input terminals (or types of input signals) each of which corresponds with one of the two states. The circuit remains in either state until caused to change to the other state by application of the corresponding signal.

Floating-Point System. A system of number notation in which two sets of digits are used, the added set being included to denote the location of the radix point.

See also: Fixed-Point System.

Flow Diagram. A graphical representation of a sequence of operations.

Function Switch. A network or system having a number of inputs and outputs and so connected that signals representing information expressed in a certain code, when applied to the inputs, cause output signals to appear which are a representation of the input information in a different code.

Function Switch, Many-One. A function switch in which a combination of the inputs is excited at one time to produce a corresponding single output.

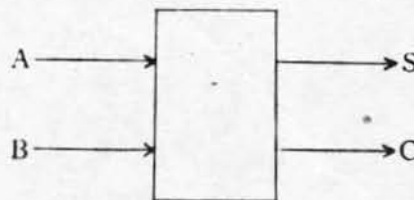
Function Switch, One-Many. A function switch in which only one input is excited at a time and each input produces a combination of outputs.

Function Unit. A device which can store a functional relationship and release it continuously or in increments.

Gate. (1) A circuit having an output and a multiplicity of inputs so designed that the output is energized when and only when a certain definite set of input conditions are met. In computer work, a *Gate* is often called an "and" circuit. (2) A signal used to enable the passage of other signals through a circuit.

Half-Adder. A circuit having two input and two output channels for binary signals (0, 1) and in which the output signals are related to the input signals according to the following table:

Input to		Output from	
A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1



(So called because two half-adders may be used to form one adder.)

Holding Beam. A diffuse beam of electrons for regenerating the charges retained on the dielectric surface of an electrostatic memory or storage tube.

Input Equipment. The equipment used for introducing information into a computer.

Inscriber. Input transcriber.

Instruction. Information which, when properly coded and introduced as a unit into a digital computer, causes it to perform one or more of its operations. An instruction commonly includes one or more addresses.

Instruction Code. A code for representing the instructions which a particular digital computer can execute.

See also: Multiple-Address (Instruction) Code and Single-Address (Instruction) Code.

Instruction, Extract. *See* Extract Instruction.

Instruction, Transfer (of control). *See* Transfer (of control) Instruction.

Integrator. A device whose output is proportional to the integral of an input signal.

Language. A set of symbols, with rules for the combination of these symbols, which may be used to express information, such that the sum of the number of sym-

bols and the number of rules is much smaller than the number of distinct expressible meanings.

See also: Code.

Major Cycle. In a memory device which provides serial access to storage positions, the time interval between successive appearances of a given storage position.

Master Clock. The primary source of timing signals.

Memory. Any device into which information can be introduced and then extracted at a later time. The mechanism or medium in which the information is retained commonly forms an integral part of a computer.

See also: Storage.

Memory Capacity. The maximum number of distinguishable stable states in which a memory device can exist is a measure of its capacity. It is customary to use the logarithm to the base two of that number as a numerical measure of the memory capacity. In this case, the unit of memory capacity is a binary digit.

Memory, Circulating. *See* Circulating Memory.

Memory, Delay-Line. *See* Delay-Line Memory.

Memory, Electrostatic. *See* Electrostatic Memory.

Memory Tube, Electrostatic. *See* Electrostatic Memory Tube.

Minor Cycle. In a digital computer using serial transmission, the time required for the transmission of one word, including the space between words.

Multiple-Address (Instruction) Code. An instruction in general consists of a coded representation of the operation to be performed and of one or more addresses of words in storage. The instructions of a multiple-address code contain more than one address.

Multiplier (in computer work). A device which has two or more inputs and whose output is a representation of the product of the signed magnitudes represented by the input signals.

Notation, Positional. *See* Positional Notation.

Number. (1) Formally: An abstract mathematical entity defined by the rules governing the relations and operations to which it is susceptible. In this sense, a number is independent of the manner of its representation. (2) Commonly: A representation of a number as defined above, such as a "binary number," or a "decimal number," or a sequence of pulses. (3) In a digital machine, a word composed only of digits and possibly a sign.

Number, Double-Precision. *See* Double-Precision Number.

Number System. Any system for the representation of numbers.

See for example: Binary Number System.

See also: Number and Positional Notation.

Operand. A word on which an operation is to be performed.

Operation. (1) The activity resulting from an instruction. (2) The execution of a set of commands.

Operation Code. That part of an instruction which designates the operation to be performed.

"Or" Circuit. See Buffer.

Order. The term **Instruction** is preferred. See **Instruction**.

Organ. A portion or subassembly of a computer which constitutes the means of accomplishing some inclusive operation or function, as: **Arithmetic Organ**.

Output Equipment. The equipment used for obtaining information from a computer.

Outscriber. Output transcriber.

Overflow. (1) The condition which arises when the result of an arithmetic operation exceeds the capacity of the number representation in a digital computer. (2) The carry digit arising from this condition.

Parallel Arithmetic Unit. One in which separate equipment is provided to operate (usually simultaneously) on the digits in each column.

See also: **Serial Arithmetic Unit**.

Parallel Transmission. The system of information transmission in which the characters of a word are transmitted (usually simultaneously) over separate lines, as contrasted to **Serial Transmission**.

Partial Carry. A system of executing the carry process in which the carries that arise as a result of a carry are not allowed to propagate.

See also: **Cascaded Carry**, **Complete Carry**, **Self-instructed Carry**, **Separately Instructed Carry**, **Standing on Nines Carry**.

Place. See **Column**.

Plotting Board. A device which plots one or more variables against one or more other variables.

Point, Binary. See **Binary Point**.

Point, Decimal. See **Decimal Point**.

Point, Radix. See **Radix Point**.

Positional Notation. One of the schemes for representing real numbers, characterized by the arrangement in sequence of *digits* (symbols for integers) with the understanding that the successive digits are to be interpreted as the coefficients of successive integral powers of a number called the *radix* or *base* of the notation.

The representation of a real number by the notation

$$A_n A_{n-1} \dots A_2 A_1 A_0 . A_{-1} A_{-2} \dots A_{-m} /$$

which is an abbreviation for the sum

$$\sum_{i=-m}^n A_i r^i,$$

where the r is called the *radix point*, the A_i are integers ($0 \leq |A_i| \leq r$) called *digits*, and r is an integer greater than one called the *radix* (or *base*). The signs of all of the A_i are the same as the sign of the number represented.

In the decimal number system, the radix is ten and the radix point is called the decimal point. In the binary number system, the radix is two and the radix point is called the binary point.

For some purposes the system of notation has been broadened to include the case in which the radix as-

sumes more than one value in a single number system. In this case the notation

$$A_n A_{n-1} \dots A_2 A_1 A_0 . A_{-1} A_{-2} \dots A_{-m}$$

is an abbreviation for the sum

$$\left(\sum_{i=1}^n A_i \prod_{j=1}^i r_j \right) + A_0 + \left(\sum_{i=-m}^{-1} A_i \prod_{j=i}^{-1} \frac{1}{r_j} \right).$$

Several such systems have been used. The biquinary system uses a radix which is alternately two and five for successive values of j . The quinary vicenary system uses a radix which is alternately five and twenty for successive values of j .

For the names of various number systems, as characterized by their radix, see **Radix**.

Precision. Quality of being exactly or sharply defined or stated. A measure of the precision of a representation is the number of the distinguishable alternatives from which it was selected.

See also: **Accuracy**.

Problem, Check. See **Check Problem**.

Problem, Trouble Location. See **Trouble Location Problem**.

Program. (1) A set of instructions arranged in proper sequence to instruct a digital computer to perform a desired operation (or operations), such as the solution of a mathematical problem or the collation of a set of data. (2) To prepare a program (contrast with "to code").

See: **Coded Program**.

Radix (or Base) (of the positional notation system of numbers). The integer of whose successive powers the digits of a number are the coefficients.

Symbolically: $\dots + a_2 r^2 + a_1 r + a_0 r^0 + a_{-1} r^{-1} + a_{-2} r^{-2} \dots$ is written $\dots a_2 a_1 a_0 . a_{-1} a_{-2} \dots$ where r is the radix and the a_i are the integers $0 \leq a_i \leq r-1$. For example, in the number π written in the common decimal system, we have: $r=10$; $\dots a_2 = a_1 = 0$; $a_0 = 3$; $a_{-1} = 1$; $a_{-2} = 4 \dots$

Synonym: **Base**.

See also: **Positional Notation**.

The adjectives used for describing various number systems, as characterized by their radices are given below:

Base or Radix	Adjective
Two	Binary
Three	Ternary
Four	Quaternary
Five	Quinary
Six	Senary
Seven	Septenary
Eight	Octonary (loosely called Octal)
Nine	Novenary
Ten	Decimal
Eleven	Undecimal
Twelve	Duodecimal
Thirteen	Terdenary
Fourteen	Quaterdenary
Fifteen	Quindenary
Sixteen	Sexadecimal
Seventeen	Septendecimal
Eighteen	Octodenary

Nineteen
Twenty
Thirty
Forty
Fifty
Sixty
Seventy
Eighty
Ninety
One Hundred

Novendenary
Vicenary
Tricenary
Quadragenary
Quinquagenary
Sexagenary
Septuagenary
Octogenary
Nonagenary
Centenary

These terms are all either derived from the Latin distributives ("ary" endings) or ordinals-cardinals ("imal" endings). The "ary" endings seem more logical and have been chosen except for ten and twelve, where the "imal" usage is prevalent. In the other cases the "imal" word can be found in standard dictionaries while the "ary" word cannot.

Radix Point. The index which separates the digits associated with negative powers from those associated with the zero and positive powers of the base of the number system in which a quantity is represented. For example, *binary point*, *decimal point*.

Read. To extract information.

Register. A device capable of retaining information which is usually a subset of the aggregate information in a digital computer.

Register, Delay-Line. See *Delay-Line Register*.

Register, Static. See *Static Register*.

Resolver. Means for resolving a vector into two mutually perpendicular components.

Roll Out (verb). To read out of a storage device by simultaneously increasing by one the value of the digit in each column and repeating this r times (where r is the radix) and, at the instant the representation changes from $(r-1)$ to zero: (a) generating a particular signal, or (b) terminating a sequence of signals, or (c) originating a sequence of signals.

Round-Off (verb). To delete less significant digits from a number and possibly apply some rule of correction to the part retained.

Round-Off Error. Error resulting from rounding off.

Routine. A sequence of operations which a digital computer may perform, or the sequence of instructions which determine these operations.

Scale Factor. (1) In analog computing, a proportionality factor which relates the magnitude of a variable to its representation within a computer. (2) In digital computing, the arbitrary factor which may be associated with numbers in a computer to adjust the position of the radix point so that the significant digits occupy specified columns.

Self-instructed Carry. A system of executing the carry process in which information is allowed to propagate to succeeding places as soon as it is generated and without receipt of a specific signal.

See also: *Cascaded Carry*, *Complete Carry*, *Partial Carry*, *Separately Instructed Carry*, *Standing on Nines Carry*.

Separately Instructed Carry. A system of executing the carry process in which carry information is allowed

to propagate to succeeding places only on receipt of a specific signal.

See also: *Cascaded Carry*, *Complete Carry*, *Partial Carry*, *Self-instructed Carry*, *Standing on Nines Carry*.

Sequential Control. The manner of operation in which instructions to a digital computer are set up in sequence and are fed consecutively to the computer during the solution of a problem.

See also: *Dynamic Sequential Control*.

Serial Arithmetic Unit. One in which the digits of a number are operated on sequentially.

See also: *Parallel Arithmetic Unit*.

Serial Transmission. A system of information transmission in which the characters of a word are transmitted in sequence over a single line, as contrasted to *Parallel Transmission*.

Shift. Displacement of an ordered set of characters one or more columns to the right or left. In the case in which the characters are the digits of a number, in a fixed-point digital computer, a shift is ordinarily equivalent to multiplication by a power of the radix.

Shift, Cyclic. See *Cyclic Shift*.

Sign Digit. A character used to designate the algebraic sign of a number.

Significant Digits. The digits of a number can be ordered according to their significance; the significance of a digit is greater when it occupies a column corresponding to a higher power of the radix. The significant digits of a number are a set of digits from consecutive columns beginning with the most significant digit different from zero and ending with the least significant digit whose value is known or assumed to be relevant.

Simulation. The representation of physical systems by computers and associated equipment.

Single-Address (Instruction) Code. An instruction in general consists of a coded representation of the operation to be performed and of one or more addresses of words in storage. The instructions of a single-address code contain only one address.

Standing on Nines Carry. A system of executing the carry process in which it is sensed whether a carry into a given place produces a carry from that place; if so, the incoming carry information is routed around that place.

See also: *Cascaded Carry*, *Complete Carry*, *Partial Carry*, *Self-instructed Carry*, *Separately Instructed Carry*.

Static Register. A register which retains information in static form.

Storage. (1) Any device into which information can be introduced and then extracted at a later time. The mechanism or medium in which the information is stored need not form an integral part of a computer. (2) The act of storing information.

See also: *Memory*.

Storage Capacity. The maximum number of distinguishable stable states in which a storage device can exist is a measure of its capacity. It is customary to use

the logarithm to the base two of that number as a numerical measure of the storage capacity. In this case, the unit of storage capacity is a binary digit.

Storage Tube. See **Electrostatic Memory Tube Subprogram.** Part of a **Program.**

Subroutine. Part of a **Routine.**

Torque Amplifier. A device possessing input and output shafts and supplying work to rotate the output shaft in positional correspondence with the input shaft without imposing any significant torque on the input shaft.

Transcriber. Equipment associated with a computing machine for the purpose of transferring input (or output) data from a record of information in a given language to the medium and the language used by a digital computing machine; or from a computing machine to a record of information.

Transfer (of control), Conditional. See **Conditional Transfer (of control).**

Transfer (of control) Instruction. An instruction which (conditionally or unconditionally) causes the next instruction word to be selected from a specified memory location.

Transfer (of control), Unconditional. See **Unconditional Transfer (of control).**

Trouble-Location Problem. A test problem whose incorrect solution supplies information on the location of faulty equipment; used after a check problem has shown that a fault exists.

Truncation Error. Error resulting from the approximation of operations in the infinitesimal calculus by operations in the calculus of finite differences.

Unconditional Transfer (of control). In a digital computer which obtains its instructions serially from an ordered sequence of addresses, an instruction which causes the following instruction to be taken from an address which becomes the first of a new sequence.

Verification. The process of automatically checking one data typing or recording process against another for the purpose of reducing the number of human errors in data transcription.

Volatile. The attribute of a memory device that information is lost in the event of a power interruption.

Word. An ordered set of characters having a meaning and considered as a unit. Digital computers commonly use a fixed word length (that is, a fixed number of characters) which is a characteristic of each computer.

Write. To introduce information, usually into some form of storage.



A Precision Decade Oscillator for 20 Cycles to 200 Kilocycles*

CHARLES M. EDWARDS†, MEMBER, IRE

DURING THE PAST few years numerous technical articles have been written on the subject of oscillator circuits utilizing resistance-capacitance tuning elements. The more common types have been designated as bridge-stabilized,¹ parallel T,² or phase shift.³ In most of these treatments, the authors have praised the results which can be obtained by resistance-

capacitance tuning, namely, high frequency stability, good wave form, and constant output over a wide frequency range, but have made little mention of the frequency accuracy which could be expected. Some writers have estimated a few per cent as being realizable and there are available commercial units which are reliable to within 2 or 3 per cent. For some applications, frequency accuracy approaching 0.1 per cent is required of oscillators operating in the audio- and carrier-frequency ranges.

An RC-type oscillator with a frequency accuracy of 0.1 per cent over a range of 100 cps to 100,000 cps has been developed for a testing application at Western Electric.⁴ For the ranges of 20 cps to 100 cps and 100 kc to 200 kc, the accuracy is 0.5 per cent. The

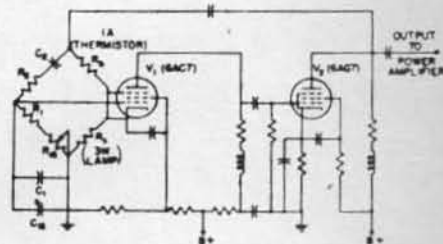


Fig. 1—Simplified version of basic circuit for decade-oscillator design.

unit is composed of three sections: an RC oscillator, a power amplifier, and a power supply.

Fig. 1 presents a simplified version of the oscillator circuit which consists of a two-stage amplifier with a resistance-capacitance bridge circuit connecting the

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¹ W. G. Shepherd and R. O. Wise, "Variable-frequency bridge-type frequency-stabilized oscillators," *Proc. I.R.E.*, vol. 31, pp. 256-268; June, 1943.

² H. H. Scott, "A new type of selective circuit and some applications," *Proc. I.R.E.*, vol. 26, pp. 226-236; February, 1938.

³ E. L. Ginston and L. M. Hollingsworth, "Phase-shift oscillators," *Proc. I.R.E.*, vol. 29, pp. 43-49; February, 1941.

⁴ The decade oscillator is similar in type to the 51A Oscillator developed at the Bell Telephone Laboratories for use in field testing of carrier systems.