Weston ENGINEERING NOTES

VOLUME 10 DECEMBER 1955 NUMBER 2

THE WESTON INDUCTION MODULATOR

General

THE success of the Weston Inductronic Amplifier in applications that require the measurement or amplification of small direct currents has led to the development of other new devices using the same principle of operation. One such new device is the Model 1408 Induction Modulator, which has been designed for those applications requiring the conversion of direct current to alternating voltage. The principle of operation of the Induction Modulator is entirely different from that used in previous transducers, such as vibrators or choppers.

The details of construction of the Induction Modulator are shown in Figure 1.

Operation

The mechanism assembly consists basically of pole pieces, a frameless movable coil supported on a pivot and jewel structure, and the control springs. This assembly, together with the permanent magnets, which are oriented axially, and the iron case form the essential elements of a conventional D'Arsonval type d-c mechanism. Positioning of the movable coil is obtained in the usual manner by application of a direct current to its terminals. The field coils are mounted directly on the magnets and are connected electrically in series to produce additive fluxes with application of a-c excitation. The alternating flux set up by the field coils is axial in direction and will induce into the movable coil a proportionate voltage whose magnitude is a function of coil position and the electromagnetic characteristics of the system. Since the direct flux produced by the permanent magnets and the alternating flux produced by the field coils follow the same path, it was necessary in the design of the unit to limit the a-c ampere turns to a sufficiently small value so as not to noticeably demagnetize the magnet.

When the movable coil is positioned so that the plane of its turns is parallel to the alternating flux lines, there is no flux linkage and thus no induced voltage. This orientation of the movable coil is termed its zero center position, and the mechanical construction of the pole piece assembly will allow a rotation of as much as 50 degrees

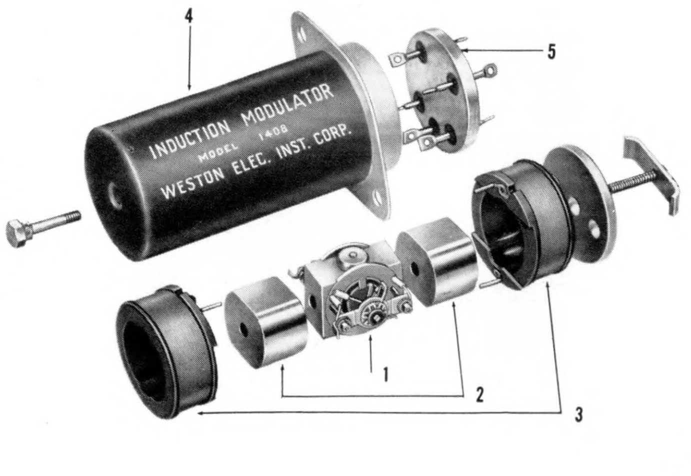

Figure 1—Exploded view showing component parts of Model 1408.

1. Mechanism assembly,
2. Permanent magnets,
3. Field coil,
4. Iron case,
5. Header.

In This Issue

John Parker, Editor

T. A. Connors, Technical Editor

WESTON ELECTRICAL INSTRUMENT CORP.,
A Subsidiary of Daystrom, Incorporated,
614 Frelinghuysen Avenue,
Newark 5, N. J., U. S. A.

both clockwise and counterclockwise. The direction of the deflection is determined by the polarity of the applied direct current. For a fixed a-c excitation, the magnitude of the voltage induced in the movable coil will be substantially linear over the deflection range with respect to the applied d-c signal. Since opposite excursion of the movable coil from its zero center position reverses the coupling of its turns to the alternating flux, a corresponding 180° phase reversal occurs in the phase angle of the induced voltage with respect to the excitation. With a sinusoidal alternating voltage applied across the field coils, the wave shape of the output voltage induced in the movable coil will also be sinusoidal with a very low distortion content. The design has been directed toward operation at a frequency of 400 cps, although the unit will function satisfactorily over the frequency range of 60 to 1,000 cps.

When the unit is operated as explained above, it may be termed a modulator, and, in contrast to other conversion devices, it has conversion gain. When this gain is expressed as the DB ratio of the maximum a-c power output to the d-c power supplied, its value will be in the order of 28 DB. The unit may also be operated as a function multiplier, as it will resolve an a-c excitation applied to the field coils and the d-c signal applied to the movable coil into a voltage product.

Design Considerations

The magnitude of the a-c output voltage obtained from the Induction Modulator is naturally dependent on the turns ratio of the field coil to the movable coil. Variations in either or both of these elements make possible a relatively wide selection of values which may be chosen to most advantageously match the signal requirements of the external circuitry.

In the initial development of the device, field coils were selected which would receive their excitation directly from the 115-volt 400-cps source so prevalent in aircraft applications. In order to obtain as large an output voltage as possible without overtaxing the heat-dissipating capabilities of the construction, winding characteristics were designed to limit the excitation to a value of 1.25 watts. This results in a temperature rise within the unit of approximately 15° C when operated under standard temperature conditions.

It is interesting to note that where it is necessary to make use of excitation voltages lower than 115 volts, i.e., ranging down to 26 volts, coil windings may be chosen so that the magnitude of the output voltage will be unaffected as long as the input is limited to 1.25 watts excitation and the amount of copper in the field coils is kept constant. The impedance of the 115-volt design is 6,150 + j 5,850 ohms and that of the 26-volt design is 314 + j 300 ohms.

The number of turns on the movable coil has a dual significance in the operation of the Induction Modulator. As the number of turns is increased, the amount of current required for a fixed angular deflection is decreased proportionately, and at the same time the output voltage is increased proportionately. Naturally, there are definite design limits as to the maximum and minimum number of turns that can be wound, and this will establish a resultant range for the level of the d-c signal and the magnitude of the output voltage. Since it is thought that this device would be used in circuit applications where the level of the d-c signal is relatively low, the springs employed in the movable coil system are kept to a practical minimum, resulting in designs of maximum d-c sensitivity. The most sensitive d-c design would be 30-0-30 microamperes, resulting in a maximum open circuit output of 1.9 volts 400 cps with a field coil excitation of 115 volts 400 cps.

Linearity

Of particular importance in the Induction Modulator is the relationship between the d-c signal and the output alternating voltage. The deflection of the movable coil is determined by the strength and distribution of the magnetic field in addition to the other factors previously mentioned. The pole piece and core structure has been designed so that the permanent field will be essentially uniform in the air gap throughout the range of deflection of the movable coil. For that reason, the deflection angle will be directly proportional to the d-c signal applied to the movable coil. This relationship will be linear to within 1 per cent of the full-scale deflection of 100 degrees employed in the device. Since the alternating flux produced by the field coils acts to modulate the direct flux, it will follow the same path as the latter and its distribution over the deflection range will also be linear to within 1 per cent of full scale deflection. The input current to output voltage relationship will be the sum of the separate effects, resulting in a linearity within 2 per cent of full-scale deflection. In addition, skin effect on the alternating flux and pickup from leakage flux will result in a slight decrease in linearity of operation so that the composite value of linearity will be within 2½ per cent of full-scale deflection. Where applications require better linearity of operation, the deflection angle may be restricted to 40-0-40 degrees, resulting in the linearity within 1½ per cent of full-scale deflection.

Damping

The movable coil in the Induction Modulator is frameless in construction, as a frame would present a shorted turn to the alternating field. Therefore, the device has no inherent damping other than the relatively negligible amount produced by the air media itself. When a fixed response time for a certain percentage of deflection of the movable coil is required for a specific application, the necessary damping to accomplish this must be supplied by external circuitry connected to the movable coil; e.g., a shunt resistor. However, this element would act as a direct load to the induced voltage, thus reducing the terminal voltage available to the output circuit. Therefore, the external circuit design must take into account not only the response requirements for operation of the d-c mechanism but also the power output requirements. To maintain better flexibility in design for both requirements, it would naturally be best to isolate the output from the d-c signal circuit.

Basically, then, because of this lack of any inherent damping, the Induction Modulator is a highly underdamped device, having an undamped natural period of about 0.37 sec. for the most sensitive d-c design. However, proper selection of the external circuit resistance will enable the designer to obtain a wide range of selectivity for the response requirements, with a consequent sacrifice in the d-c power level of operation. For example, a shunt resistance of about five times the value of the movable coil will produce critical damping of the d-c mechanism. This will result in a response time of about 0.12 sec. for 62.8 per cent of full-scale deflection. A decrease in the shunt resistance to about one-fourth that of the movable coil will produce an over-damped condition having a specific dampening coefficient of about 3.9 and an associated response time of 0.50 sec. for 62.8 per cent of full-scale deflection. Where much slower response than this is required, it would be best to utilize time delay circuits for impressing the d-c signal.

Phase Shift

In certain applications of the Induction Modulator, it is desirable to have a known phase relationship between the input voltage applied to the field coils and the output voltage induced in the movable coil. The phase angle of the current flowing through the field coils with respect to the applied voltage is approximately 45° lag and is determined by the impedance characteristic of the circuit. Theoretically, the voltage induced in the movable coil should lead the field current by 90 degrees and consequently lead the input voltage by 45 degrees. In practice, however, this ideal quadrature condition is not obtained due to hysteresis and eddy current effects throughout the iron path, causing the output voltage to lead the input voltage by approximately 22 degrees.

Should an application require a phase relationship to exist other than that mentioned above, this may be accomplished by means of external circuitry. One such circuit that has been tried successfully consists of a shunt capacitor connected across the field coils, the combination being excited through a series resistor. This circuit serves to shift the phase relationship of the field current with respect to the input voltage in such a manner that the output voltage and input voltage are brought into phase, providing the proper values of resistance and capacitance are employed. It should be noted that, since this method requires a relatively large amount of shunting of the field coils by the capacitor, a considerable amount of power will be lost in the external resistor. Where power consumption is an important consideration, this phase correction can, if desired, be made at some other point in the circuit following the output of the modulator.

A correction can also be made to provide for the output voltage to be in quadrature with the input voltage. This may be accomplished by using a series capacitor to shift the power factor angle of the field circuit from its normal value of 45° lag to 23° lead. This method will result in no power loss external to modulator. Both this circuit and that mentioned above for in-phase operation will require a modulator with field coils designed for operation lower than 115 volts in order to provide for 1.25 watts input to the modulator.

As previously mentioned, the relative phase shift of input voltage to output voltage is affected by eddy current losses within the modulator. Experiments have been conducted using parts made from special high resistivity alloys and a marked reduction in eddy current loss has been effected. This resulted in the output voltage leading the field current by 80 degrees instead of the 67 degrees obtained with iron. An increase in output voltage of approximately 10 per cent also resulted. However, since fabrication of parts using high resistivity alloys is extremely difficult from a machinability viewpoint, this type of construction should only be used for the rare applications where it is absolutely necessary.

Balance

Since the mass distribution of the movable system is not symmetrical about the pivot axis, it is necessary to provide a means for statically balancing the system; otherwise, the position in which the modulator is operated would affect the output voltage. This has been accomplished by means of the balance cross and movable weight system common to instrument design. Since it is impossible to obtain an absolutely perfect balance and also because some looseness between the pivots and jewels is necessary to prevent friction, there will be a slight change in output voltage as the modulator is rotated into various positions. This position error is held within ± 1 per cent of the end scale output voltage. Where it is desired to minimize this error, the modulator, if possible, should be mounted with the pivots in a vertical position.

Performance

As can be seen from viewing Figure 1, the entire construction of the Induction Modulator is quite compact, being approximately 2.4 inches long, 1.1 inches in diameter, and weighing 5 ounces. The mechanical construction is designed to be rugged enough to assure adequate performance under the usual environmental conditions imposed on airborne devices. The unit, in addition, is hermetically sealed in construction, thus making it impervious to such exposures as salt spray, humidity, and sand and dust. In contrast to a conventional d-c instrument, the movable coil system is relatively light because the movable coil, itself, is frameless in construction and the pointer is only made large enough to provide contact against the pointer stops to prevent travel beyond end scale deflection. This results in reduced wear of pivots and jewels.

In closing, it is worth noting that

conversion devices, such as vibrators and choppers, in use prior to the introduction of the Induction Modulator, operate on a principle of making and breaking of contacts. It is a recognized fact that there is some deterioration in contact surfaces with operation, resulting in an unpredictable life expectancy for such devices. The principle of operation of the Induction Modulator naturally eliminates this disadvantage. Furthermore, in contrast to other types of conversion devices, the Induction Modulator will present a constant resistance to the d-c signal input and will also be unaffected by pickup from stray fields.

This article also appeared in the September 1955 issue of *Jet Propulsion* and was written by A. B. Muller and Gerald Stolar of Weston Electrical Instrument Corporation.

E. N.—No. 110 —*A. B. Muller* and *Gerald Stolar*.

HEAVY CURRENT SHUNTS IN MULTIPLE

WITH the increasing use of high direct currents having values of 30,000 to 100,000 amperes, the shunts normally required become very large assemblies weighing several thousand pounds, awkward to handle and expensive to build. To be sure, transductors of various types are used on occasion, but they also turn out to be quite heavy and unwieldy.

In August 1920 an article was published in the *Journal of the Institution of Electrical Engineers*, the British electrical engineering society, discussing the possibility of using several shunts in parallel where heavy currents were to be measured. The author, M. B. Field, went into great mathematical detail to prove his point and report on numerous experiments which confirmed his findings. The engineers in the Weston organization have been aware of this possibility and of the methods by which accuracy has been obtained, and they have applied this arrangement

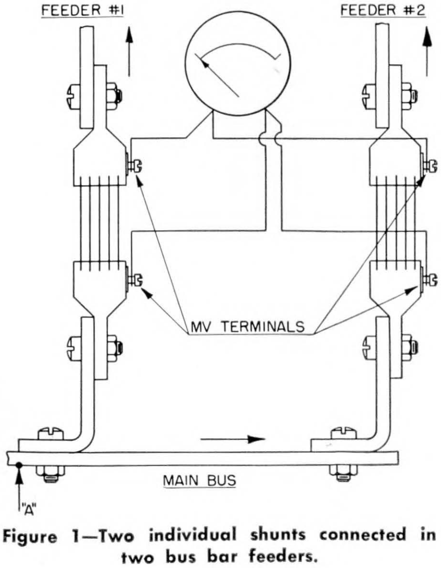

Figure 1—Two individual shunts connected in two bus bar feeders.

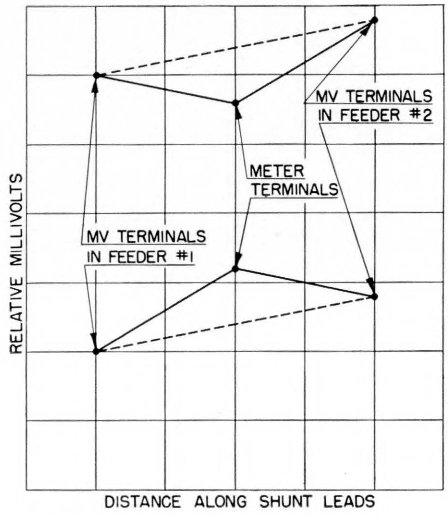

Figure 2—Equal currents in both feeders.

on occasion. It is apparently finding favor in some applications. Of particular importance is the fact that it is practically impossible to stock shunts having a range of 50,000 amperes, but 10,000- and 15,000-ampere shunts are frequently available from stock.

To understand this use of multiple shunts, let us take the simple case of two individual shunts connected in two bus bar feeders as in Figure 1. Feeder number 2 is beyond feeder number 1, and there is more conductor length up to its shunt than there is in feeder number 1. Figure 2 shows a plot of millivolts—relative to point "A" for example—of each shunt potential terminal and of a millivoltmeter connected by leads of the same resistance to *each* shunt, assuming equal current in each feeder. There will be some current in the shunt leads because of the voltage difference between them, and this current will cause a drop in the leads. If no meter is connected, the drop between them is the difference between the dotted lines and is constant along them; when the meter is connected, it draws current and the millivolt value along the shunt leads follows the solid lines.

Suppose the current in one feeder drops to half its previous value; the drops would be as in Figure 3. The total at the instrument can be seen to be three-fourths of the original amount. And if the current completely ceases in one feeder, the millivolt values are as in Figure 4, with the value at the meter terminals again proportional to the total current.

The actual millivolts available at the instrument can be calculated by assuming full-scale current for the instrument equally divided among the shunts. The millivolts from one shunt can then be figured on the basis that the instrument current comes equally from each shunt. For example, if we are measuring a total of 50,000 amperes with a group of five separate shunts, each with a 50-millivolt,

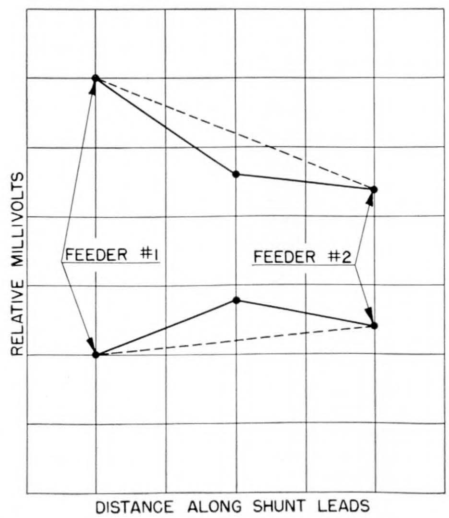

Figure 3—Current in feeder No. 2 reduced by half; original current in feeder No. 1.

10,000-ampere rating, and operating an instrument taking ten milliamperes full scale, the instrument will effectively take two milliamperes from each shunt. Thus, if each shunt lead is one ohm (two ohms for the loop resistance of the pair of leads), we will have a drop

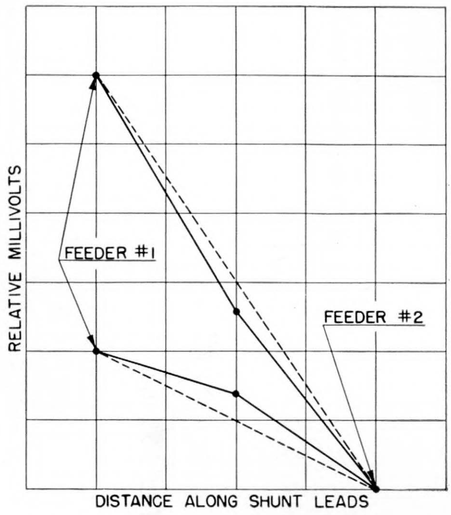

Figure 4—No current in feeder No. 2; original current in feeder No. 1.

of two millivolts in each wire, or four millivolts in the positive and negative wires, and the instrument should be adjusted to forty-six millivolts full scale.

In this same example, if there is one volt difference between two of the shunts, since the shunt lead resistance from one shunt to the next is two ohms on each pair in series, we will have one-half ampere circulated due to this difference in each pair of leads. But if the resistances are properly proportioned, two milliamperes from each shunt still finds its proper course to the instrument and it reads correctly.

Still more generally, we can operate any number of shunts of any rating, the same or mixed, in parallel, provided that the several shunt lead pairs brought from the shunts to the common terminals of the instrument have a resistance strictly in proportion to the resistance of the shunt.

Figures 5 and 6 are copied from the Field paper, and were redrawn to facilitate reproduction; they show two different methods which can be used for connecting shunts in parallel. Quoting directly from Field: "The scheme involves a number of sub-shunts, similar in respect that, with the same current traversing each, the volt-drop measured between the potential terminals is the same in each. The like potential terminals are connected to star points by leads of equal resistance, termed equalizers, and the milliammeter is connected between the star points."

It will be observed that there may be a circulating current in the shunt leads, and if the voltage between the several left-hand terminals of Figure 5 is such as to circulate several amperes through the shunt leads, then that current will circulate and will produce voltage drops in the shunt leads. Nevertheless, the instrument will continue to read correctly. But it will be correct *only* if the shunt leads are in proportion to the shunt resistances as stated above, and if the values of resistance are high, it may be necessary to make the shunt leads of manganin to avoid *changes* in this proportionality due to temperature. If the shunts are at different distances from the meter, the requirement for proportional resistances in the leads still holds, and they may be made of the same length of wire, with the extra length coiled up, or they may be made of different sizes of wire, just so the proportionality is maintained.

Additional gear, relays, regulators, etc., may be paralleled with the millivolt meter provided the *total* current of all items is used in the calculations. But it is frequently better to run individual sets of leads from each shunt to each end device, since the leads to the instruments, for example, can be adjusted to a high degree of accuracy and the leads to the other items can be adjusted to whatever accuracy is appropriate. It is to be noted also that individual millivolt meters for reading the individual currents passing through each shunt may be connected directly to those shunts by separate sets of leads without interfering in any way with the summation.

It should be recognized that the entire problem here is to make the shunt leads of an appropriate resistance and, by the same token, they must be large enough to carry whatever current will flow in them under most extreme set of conditions. It is usually necessary, therefore, to analyze each application individually and to consider what will happen if the current in each shunt rises to its maximum or falls to zero. Such an analysis is

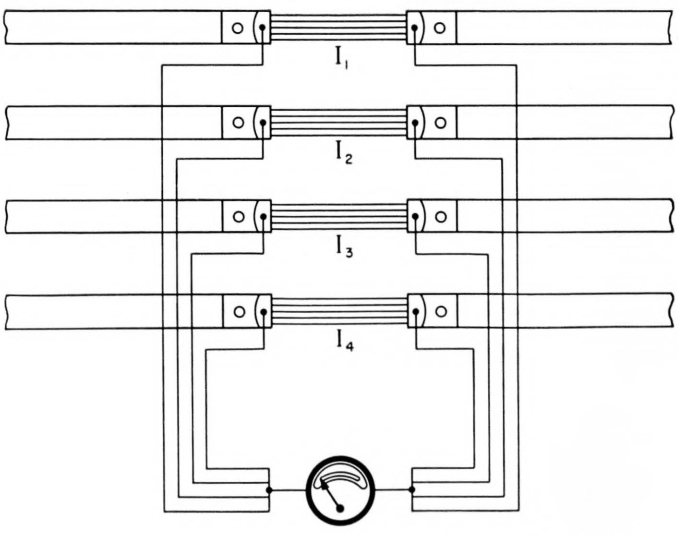

Figure 5—One method for connecting shunts in parallel.

not very difficult, and a selection of appropriate shunt leads can often be made by mere inspection without the necessity of detailed mathematical analysis.

For those interested in more details, we recommend a study of the original paper which runs from page 661 to 669 of the August 1920 *Journal of the Institution of Electrical Engineers,* this being a part of Volume 58.

E. N.—No. 111 —*J. H. Miller.*

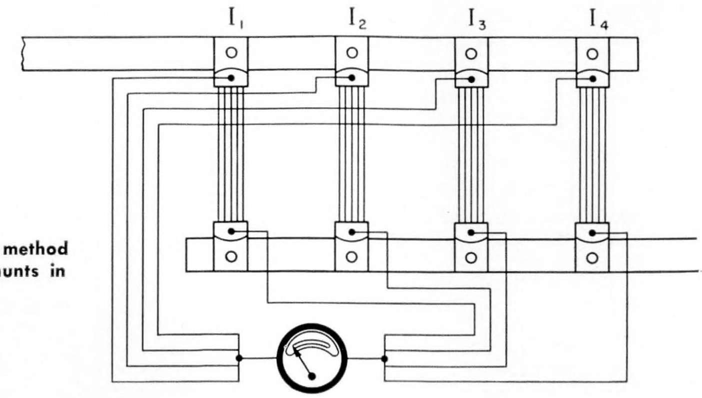

Figure 6—Another method for connecting shunts in parallel.

THE WESTON MODEL 1473 PRECISION INTEGRATOR

THE Weston Model 808 Industrial Integrator[1] has been in use for several years for time integration of sensitive levels of d-c voltage or current. In this case, as in all basic measurement techniques, a demand for improved accuracy, range and sensitivity has developed, and in response thereto the present Model 1473 Integrator was designed. The new instrument is not intended to supersede the older Model 808, being somewhat more complex, but it is complementary for more precise classes of service. Also, it differs from the Model 808 in an ability to accept reversed input and integrate subtractively.

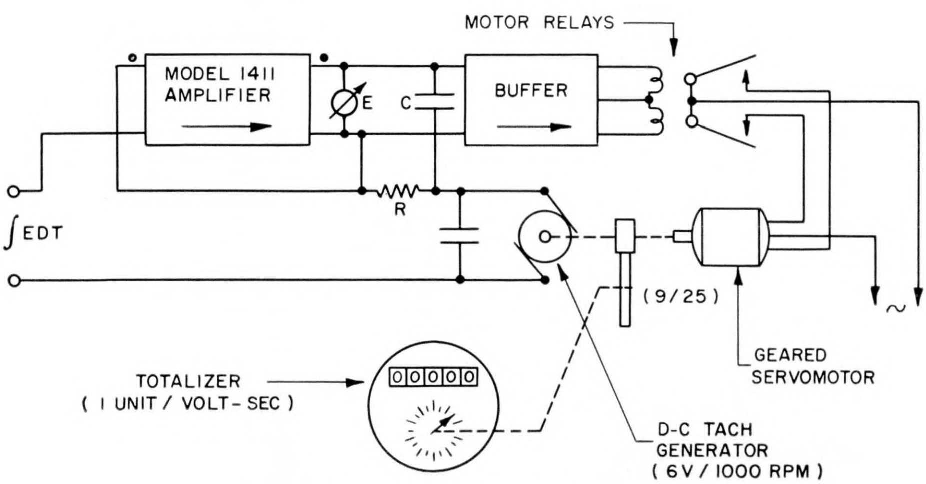

Figure 1—Block diagram of Model 1473 Precision Integrator.

Operation

The Model 1473 is a feedback integrator arranged as shown in the explanatory diagram of Figure 1. A primary amplifier section (a Model 1411 D-C Amplifier[2]) is connected through an integrating capacitor (C) and a mutual resistor (R) to time integrate applied potential (e) in terms of an output voltage (E). The feedback relationship is

$$\int_{t_1}^{t_2} e\,dt = RC \times (E_{t_2} - E_{t_1}),$$

wherein the constant of integration is the time constant of feedback (RC). Additionally, the amplifier output voltage (E) is applied through a buffer amplifier to actuate a reversible motor through forward and reverse relays. The motor, in turn, drives a modified d-c tachometer generator which is included within the input balance circuit. The generator shaft also drives a totalizer, providing the time integral indication.

In operation, a connected input potential (e) will be integrated by a rising voltage (E) on the capacitor (C) to the point of relay operation. The generator will then drive to carry the input balance, plus a sufficient potential, to lower the capacitor potential with time to cut off the motor drive relay. The generator then stops, the capacitor voltage again builds up, and the cycle of operation repeats. For reversed input potential, the reverse relay operates in the same cyclic manner to drive the generator in a reverse direction, and subtracts on the totalizing counter.

Note, however, that the capacitor (C) cannot pass d-c, and so, in time, the transient integral stored by the capacitor will become negligible with respect to the integrated feedback through the generator. The capacitor type is selected to have a leakage current that is negligible with respect to the resolving power of the amplifier. So, for integrating over longer time periods (10 minutes and more), or more particularly for high indicated integrals, the transient capacity of the RC feedback system may be neglected. For shorter integrations, where the RC stored integral cannot be neglected, it is indicated by the voltmeter (E) and may be applied by algebraic addition to the totalizer reading to include the transient integral. Or alternatively, at the start and the finish of a run, the generator shaft may be rotated to zero the voltmeter (E), thereby transferring the transient integral to the totalizer before reading.

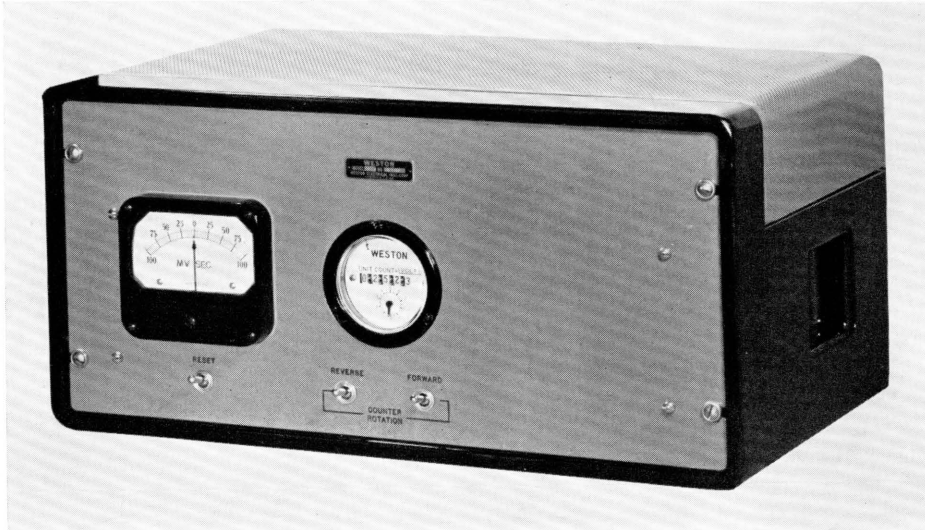

Figure 3—Weston Model 1473, Type 2, Precision Integrator with interpolating indicator and control buttons.

Types

For this reason, the Model 1473 is available in two types: a Type 1 without the indicating voltmeter for long-run integrations, and a Type 2 including the voltmeter for applications where short runs are, or may be, required. The Type 2 version is likewise equipped with a pair of motor control push-buttons for manual setting of the generator position to zero the voltmeter, and a reset push-button to independently reset the voltmeter by discharging the capacitor. The voltmeter is calibrated in terms of the integral units indicated by the totalizer for direct addition.

Feedback Generator

The tachometer generator is specially temperature compensated to hold within 0.1 per cent over a range of 40-100° F. Compensation applies to the permanent field magnet only and not to the resistance of the copper windings, because the output is in a null current circuit which is not sensitive to resistance. The full drive speed is only about 10 rpm, so commutation is no problem; but for immunity against brush jumping, a large capacitor is included across the generator output to hold the feedback loop during transient opening of the commutator circuit. The generator is wound and adjusted to deliver the usual standard 6 volts/1,000 rpm, which corresponds to an integral of 1 millivolt-second/degree of shaft rotation, or 1 volt-second per 1,000 degrees of shaft rotation. The generator shaft is geared down to the totalizer with a speed ratio of 1,000/360, or a tooth ratio of 9/25, so that each revolution of the totalizer is an integral of 1 volt-second.

Totalizer

The indicating totalizer comprises a small pointer and scale calibrated 1 volt-second per revolution in 50 millivolt-second divisions. The pointer shaft rotation is totalized on a 5-digit counter, giving an over-all range of 100,000 volt-seconds before repeating. At the maximum input level of 50 millivolts, the pointer will rotate once each 20 seconds, and the total over-all time range will be 2 million seconds, or about 23 days.

Performance

The basic maximum steady input level is ±50 millivolts, but the input may exceed 50 millivolts transiently, provided that the crest level does not exceed ±100 millivolts, and that the integral over any single period of input overload does not exceed 200 millivolt-seconds. The input resolution is 5 microvolts maximum, which is 1 part in 10,000 at the maximum operating level of 50 millivolts. Thus the resolving power may become more limiting than the basic accuracy of the system at input levels lower than 10 per cent of the maximum steady input level, or at 5 millivolts. The input circuit is balanced, and performance figures include source resistances from 0 to 50 ohms, without qualification.

Current input types are supplied by including internal 50-millivolt shunts from maximum input levels of 1 milliampere to 1 ampere. For higher current inputs, a 50-milli-

Figure 2—Weston Model 1473, Type 1, Precision Integrator.

volt type and an external 50-millivolt shunt are used.

The Model 1411 Amplifier has the ability to average error components of unbalance upon a linear basis despite rates-of-change faster than it can follow in balance. Therefore, the system will respond accurately to ripple components and step changes without filtering or smoothing, regardless of the frequency or instantaneous time rate. For example, the input may be chopped or include a-c strays without loss of accuracy. The over-all accuracy is 0.1 per cent, plus the resolution figure of 5 microvolts, as a percentage of the average input level.

Mechanical Design

The Model 1473, Type 1, is shown in Figure 2, and the Type 2 in Figure 3. Both types are similar, except for the interpolating indicator and the control buttons in the Type 2. The panel is a 10-unit ($17\frac{1}{2}$-inch high) standard 19-inch rack panel, and is supplied in a standard rack cabinet.

Specifications

Input:

Potential: ±50 millivolts maximum continuous level, and ±100 millivolt crests not exceeding 200 millivolt-seconds while above 50 millivolts.

Current: Corresponding maximum continuous levels from 1 milliampere to 1 ampere; higher currents require external shunts.

Range:

100,000 volt-seconds before repeating (50-millivolt basis).

Input Circuit:

Potential inputs balanced; tolerable source resistance 0-50 ohms. Current inputs, 50-millivolt shunt. Input circuit ungrounded; 50 volts maximum to ground. No input shielding required.

Types:

Type 1—For integrating periods at least longer than 100 volt-seconds.

Type 2—Includes interpolation meter for short period as well as long period integrations, and manual drive push-buttons. Reading resolution 2 millivolt-seconds.

Power Supply:

115±10 volts, 50-70 cps, 40 watts demand.

Mounting:

Standard 19-inch relay rack, 10 units ($17\frac{1}{2}$ inches) high; depth behind panel 11 inches maximum. Supplied in rack cabinet.

Accuracy:

±0.1 per cent, plus 5 microvolts related to the average input level, in per cent.

References:

[1] *"The Weston Model 808 Industrial Integrator,"* WESTON ENGINEERING NOTES, Vol. 3, No. 5, October 1948.

[2] *"The Weston Model 1411 Inductronic D-C Amplifier,"* WESTON ENGINEERING NOTES, Vol. 6, No. 1, April 1951.

E. N.—No. 112 —*R. W. Gilbert.*

EDITOR'S NOTE: *The Precision Integrators described in the above article are experimental models and any inquiries regarding their use for special applications should be directed to the Home Office, Newark 5, New Jersey.*

New Booklet Available

The booklet illustrated here incorporates all previous articles printed in Engineering Notes on the subject of Weston INDUCTRONIC® Instruments. Any reader interested in receiving a copy of this booklet is requested to write to Weston Electrical Instrument Corporation, Newark 5, New Jersey, attention Editor, WESTON ENGINEERING NOTES. Just ask for a copy of Bulletin Z-14.

"Westonia"

"A FEW days ago we were discussing carbon resistors and the way in which the Doctor flashed carbon filaments in a hydrocarbon atmosphere at red heat. But did you ever hear about the lacquer business that he worked on as another side issue of making lamp filaments?"

E. F. Weston was again chatting at the lunch table and it sounded too interesting to miss.

"You will remember the Doctor was in the plating business quite early and was well acquainted with Hanson and Van Winkle, who formed the plating supply business bearing their name. They were getting along fine in the plating field but were having difficulty getting a good lacquer to cover silver and copper plating jobs. So they came to the Doctor, as they usually did when they were in trouble, to see if he could suggest a lacquer formulation that would stand up better than what they had been using. Well, the lamp filament, die cut from a cellulose sheet, had just been finished up, and, of course, before it was cut and carbonized it was essentially a lacquer film, so that using the same base material, with some variation in the procedure and in the solvents, he was able, after a relatively few weeks of experimentation, to produce a new pyroxylin lacquer which was quite an advance for its time. The formula was patented and a deal was made with Hanson and Van Winkle for its manufacture and use.

"But the real payoff, in satisfaction but not in money, came when General Motors and du Pont developed a lacquer for automobile bodies. The story goes that in digging around in the prior patent art they located this patent of the Doctor's of some thirty years' standing; it was so broad and so basic that it effectively prevented any breadth of patent coverage on the new quick-drying automobile lacquers!"

Reference:

"A Measure for Greatness," pages 161-162.