Sept. 27, 1960 R. S. DUGOT 2,954,518

RESISTANCE-CAPACITANCE COMBINATION SUBSTITUTION INSTRUMENT

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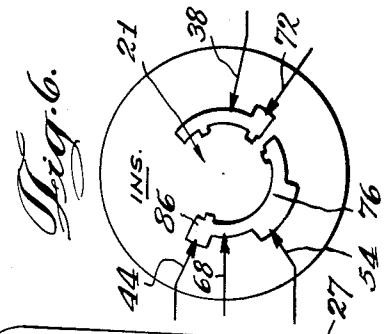


Fig. 6.

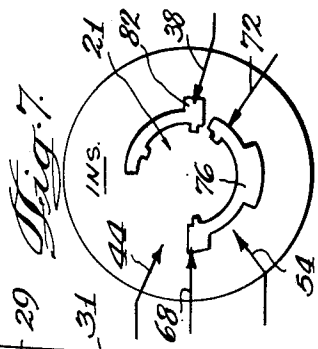


Fig. 7.

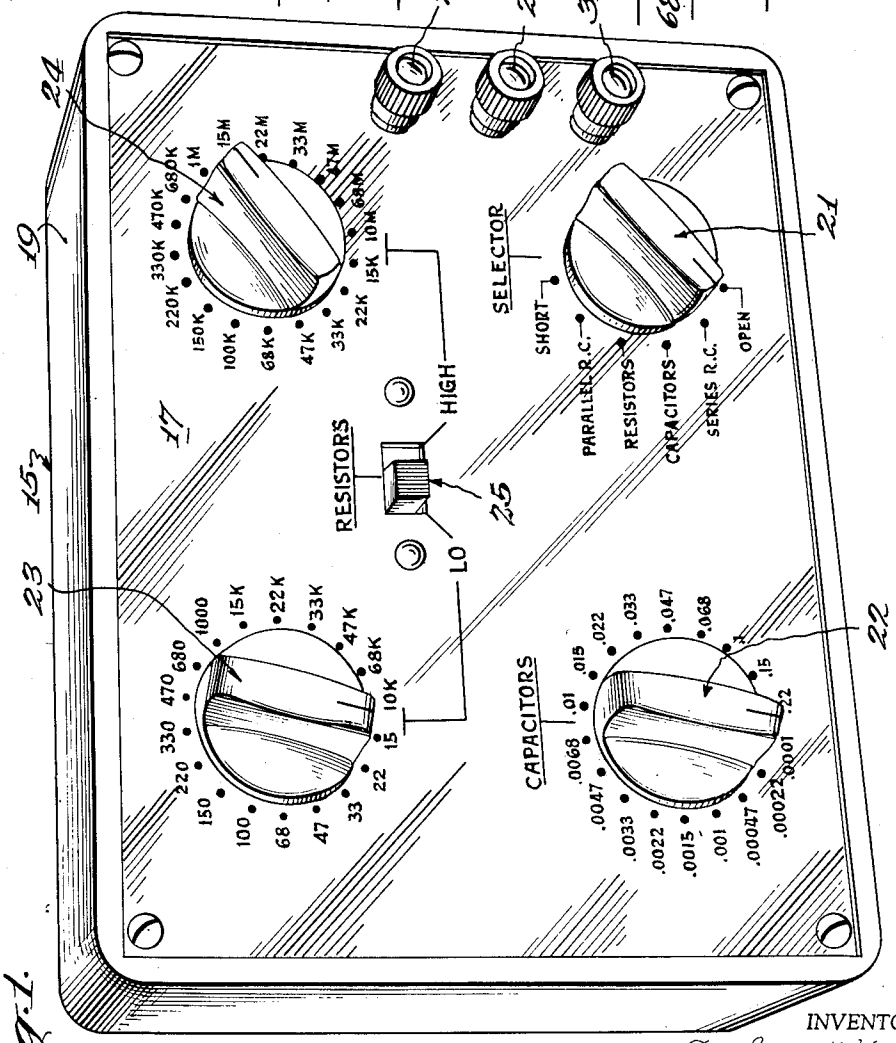


Fig. 1.

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Fig. 2.

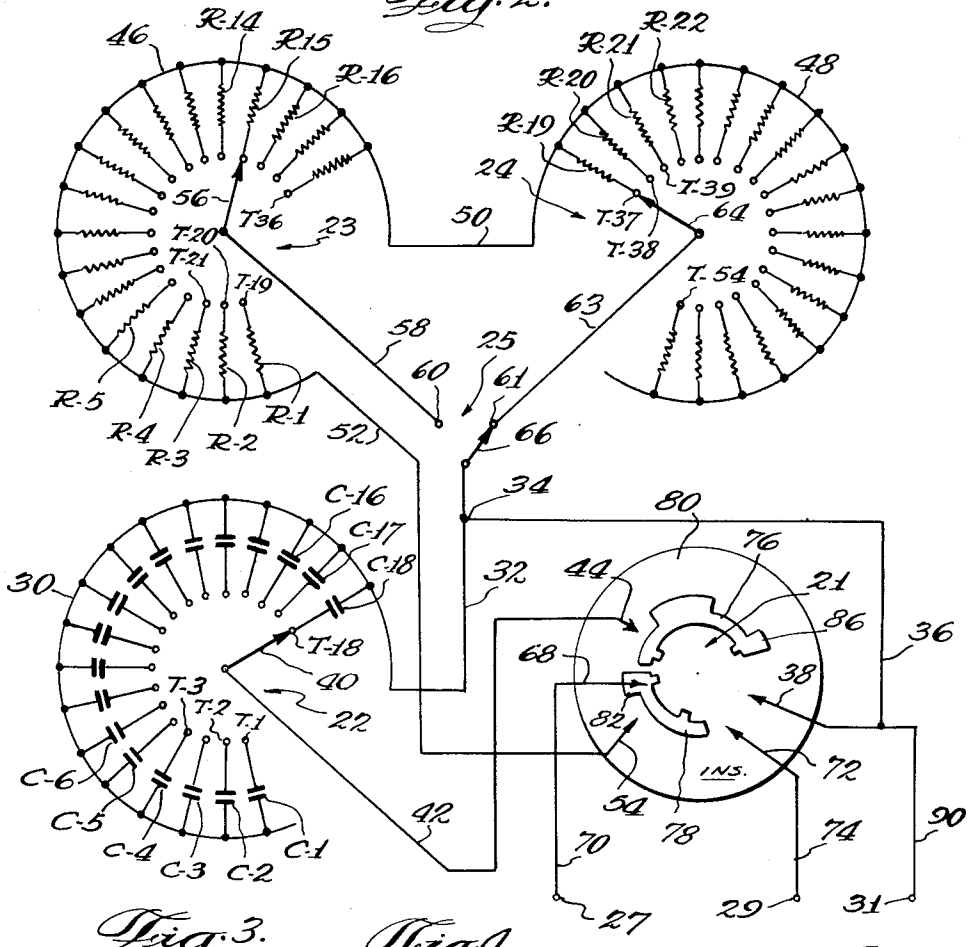


Fig. 3.

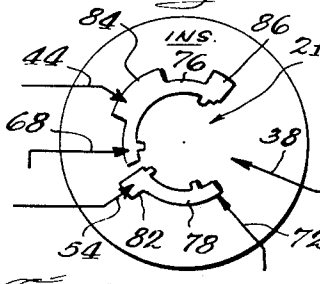


Fig. 4.

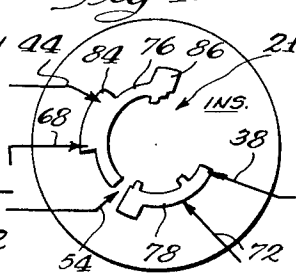


Fig. 5.

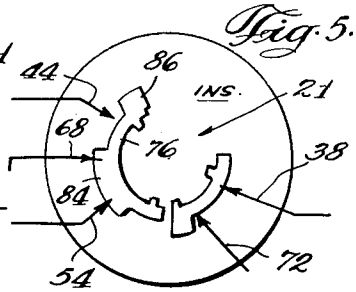


Fig. 8.

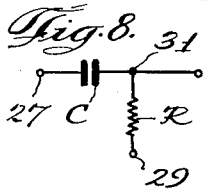
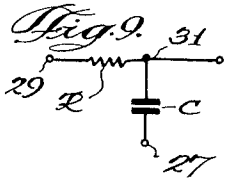


Fig. 9.



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RESISTANCE-CAPACITANCE COMBINATION SUBSTITUTION INSTRUMENT

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Filed Aug. 11, 1958, Ser. No. 754,283

11 Claims. (Cl. 323—74)

This invention relates generally to apparatus of the broadly classified category, electronic instruments, and more particularly is concerned with a novel arrangement of resistance and capacitance elements with switching means suitably connected therewith, and the whole being assembled in a portable housing for use as a so-called substitution box.

There are many substitution boxes on the market, in which there is an arrangement of different values of resistors or condensers connected so that the user may connect the box into a circuit where it is desired to ascertain the effect of substituting different values. Such instruments are valuable in servicing television and radio receivers, in laboratory and experimental work, and comprise an aid in engineering circuitry of different kinds. Primarily, the availability of a large number of capacitors or resistors saves considerable time in computing such values as required for different purposes, and in addition enables computed values to be assayed or varied as to their values in circuitry.

The primary object of the invention is to provide a novel substitution instrument in which a large number of different combinations of resistance and capacitance, both in series and in parallel may be achieved through the use of an extremely simple circuit and switching means associated therewith.

A further object of the invention is the provision of a novel substitution instrument of the character described in which a single selector switch effects the connection of the chosen elements in a variety of different arrangements for different positions of the switch.

Other objects of the invention are concerned with the construction of the instrument which has extreme versatility but which is simple in operation and compact so that it is readily portable and hence highly useful for servicemen.

Many other objects will occur to those skilled in the art to which this invention appertains, as a detailed description of a preferred embodiment is set forth hereinafter, in connection with which the details of construction have been illustrated in suitable drawings.

In said drawings:

Fig. 1 is a perspective view of an instrument constructed in accordance with the invention, to show the housing, the selector switches and the terminals thereof;

Fig. 2 is a circuit diagram of the instrument which is illustrated in Fig. 1, the circuit selector switch being shown in "Open" position;

Figs. 3, 4, 5, 6 and 7 are diagrammatic views showing the connections provided by the circuit selector switch when it is in the following consecutive positions: "Series R.C.," "Capacitors," "Resistors," "Parallel R.C." and "Short."

Fig. 8 is a circuit diagram of a basic integration network which can be achieved with varying values of the elements thereof by means of the invention; and

Fig. 9 is a circuit diagram of a basic differentiating network which can be achieved with varying values of the elements thereof by means of the invention.

The invention generally comprises a circuit which has means for connecting capacitors and resistors thereinto, and which has a circuit-selecting switch which effects the connection of the components into various combinations so that the user can achieve different effects by connecting the terminals of the instrument into a circuit upon which he is operating.

As illustrated in Fig. 1, there are only five controls on the instrument, designated generally by the reference character **15**, and these five are all mounted on the face of the panel **17** which is mounted to a suitable housing **19**, preferably of insulating material. There are four rotary selector switches **21**, **22**, **23** and **24** and a slide switch **25**. The functions of these switches will be disclosed as the description proceeds. The panel **17** also has mounted thereon two or three terminals or binding posts, three being provided in the embodiment described herein and being designated **27**, **29** and **31**.

The rotary switch **21** is the circuit selector switch, the rotary switch **22** is the capacitor selector switch, the rotary switch **23** is a low range resistor selector switch, and the rotary switch **24** is a high range resistor selector switch. The slide switch **25** has only two positions and it connects either the high or low resistor group into the operating circuit.

As noted from Fig. 1, each of the switches **22**, **23** and **24** have a great many positions, compared with the switch **21** which has but six. The number of positions of the rotary switches **22**, **23** and **24** depends upon the ranges of values desired to be covered, the value of the steps desired between consecutive values, the economy desired, and other factors. The instrument illustrated was constructed to sell in the medium price range and each of the rotary switches **22**, **23** and **24** had eighteen positions providing eighteen different values of capacitance and **36** different values of resistance.

The exact values and ranges used will depend upon the uses to which the instrument **15** is intended to be put, but in the commercial version of the instrument described herein, which was intended especially for general television, radio and audio servicing, the ranges were as follows:

Capacitors: .0001 to .22 microfarad with about 25% to 50% increase between values.

Resistors: One range from 15 to 10,000 ohms with about 25% to 50% increase between values; a second range from 15,000 ohms to 10 megohms with about the same increase between steps as the first range.

In Fig. 2 the internal circuit of the instrument **15** is illustrated. The capacitors are designated **C–1**, **C–2**, **C–3**, etc., to **C–18**; the resistors of the low range are designated **R–1**, **R–2**, **R–3**, etc., to **R–18**; and the resistors of the high range are designated **R–19**, **R–20**, **R–21**, etc., to **R–36**. The components are shown arranged radially, and as a practical matter they may be physically mounted and connected in this manner. The outer electrodes of the capacitors **C–1**, **C–2**, **C–3**, etc., are all connected to a common circular conductor or bus **30** which connects by the lead **32** with a common junction terminal **34** and extends thence by way of the lead **36** to the wiper contact **38** of the rotary switch **21**. The inner electrodes of the condensers are connected respectively to contact terminals **T–1**, **T–2**, **T–3**, etc., to **T–18**, which are arranged circularly to be engaged by the wiper **40** of the rotary switch **22**. The wiper **40** is suitably mounted in conjunction with detent means so that the contact terminals **T–1**, **T–2**, etc., to **T–18** are engaged consecutively in steps, and this is also true of all of the contact terminals of the switches **23**, **24** and **21**.

The wiper 40 connects by the lead 42 to the wiper contact 44 of the rotary switch 21.

The switches 23 and 24 both have circular conductors or bus rings 46 and 48 respectively which are similar to the bus ring 30 and which also are used in the physical embodiment to support the resistors connected therewith. Bus rings 46 and 48 are connected as at 50, the opposite end of the ring 46 being connected by the lead 52 to the wiper contact 54 of the rotary switch 21. The opposite end of the ring 48 is free.

The resistors R–1, R–2, etc., to R–18 are arranged radially as shown, and each has one terminal connected to the ring 46 and the opposite terminal connected to a contact terminal T–19, T–20, etc., to T–36 respectively, the contact terminals adapted to be wiped by the wiper 56. The wiper 56 connects by lead 58 to one contact 60 of the switch 25, the other contact 61 being connected by the lead 63 to the wiper 64 of the rotary switch 24. The resistors R–19, R–20, etc., to R–36 are connected and mounted on the ring 48 similarly to the manner in which the resistors of the switch 23 are mounted and connected. The inner contact terminals are T–37, T–38, etc., to T–54.

The arm 66 of the switch 25 is connected to the common junction terminal 34. The switch 25 therefore connects one or the other of the groups of resistors of the switches 23 and 24 to the wiper contact 38. The wiper contact 68 connects by the lead 70 to the terminal or binding post 27, and the wiper contact 72 connects by the lead 74 with the binding post 29.

The switch 21 has six positions, as described above, and is called the circuit selector switch because its position will determine the connections which are established between the groupings of components and the binding posts 27 and 29. The switch 21 has two arcuate contact members 76 and 78 which are insulated from one another and mounted upon a rotatable wafer such as indicated schematically at 80. Rotation of the wafer 80 will change the positions of the arcuate contact members 76 and 78 circumferentially, not with respect to one another, but with respect to the fixed wiped contacts 44, 38, 72, 54 and 68 which are radially arranged about the wafer.

In Fig. 2, the rotary circuit selector switch 21 is in a position wherein the circuit of the instrument is open, and hence this is designated "Open" position. It will be noted that the radially outwardly extending ear 82 is the only portion of either of the arcuate contact members 76 and 78 which engages any wiper contact, the wiper contact 68 in this case being the one which makes electrical contact with the arcuate member 78. Note that the wiper contact 72 is clear of either of the arcuate contact members and hence the terminals or binding posts 27 and 29 look into an open circuit. This condition is useful in circuit work since it defines infinite impedance. It is easily achieved in the instrument 15 by merely turning the switch 21 to said "Open" position, regardless of the positions of any of the other switches.

In Fig. 3 the switch 21 has been turned to its next circumferential position which is designated "Series R.C." The wiper contact 54 now electrically contacts the ear 82 and the wiper contact 72 also engages the arcuate member 78 so that the terminal or binding post 29 is connected by the lead 52 to the rings 46 and 48 in series. The wiper contact 44 is now in electrical engagement with the large segment or extension 84 of the arcuate contact member 76 which also engages the wiper 68. Since 68 connects with the terminal or binding post 27, and the wiper contact 44 connects with the capacitor grouping, an electrical path is established from the binding post 27 to the wiper 40. The circuit between the binding posts 27 and 29 is completed by virtue of the junction terminal 34, from the rings 46 and 48 through a resistor in one or the other groupings, depending upon the position of the switch arm 66. As illustrated specifically, if the switch positions of switches 22, 23, 24 and 25 were as in Fig. 2, and the position of the switch 21 as in Fig. 3, the binding posts 27 and 29 would be connected to a circuit which included C–18 and R–19 in series.

In the event that the user wishes to change the values of the resulting series circuit, this can be done without disconnecting the test circuit from the binding posts. All that the operator need do is change the positions of the switches 22 and 24. This is done in the well-known manner of merely manually rotating a knob such as shown in Fig. 1. If the low resistor range is desired instead of the high, the operator merely slides the slider of the switch 25 to its opposite position. Furthermore, the user has infinite impedance condition available by rotation of the switch 21, and the other positions which will be described hereinafter give other conditions which may be needed at a mere twist of the knob of switch 21.

In Fig. 4 the switch 21 has been rotated to its next circumferential position from that of Fig. 3, said position being designated "Capacitors." In this position, note that the wiper contacts 38 and 72 both engage the arcuate contact member 78 and hence the junction terminal 34 is connected to the binding post 29. The wiper contact 54 is between the arcuate contact members 76 and 78 and hence, since this provides the only electrical path to one side of the resistor groups, there are no resistors connected into the resulting circuit. The wiper contacts 44 and 68 are both in electrical engagement with the extension 84 thereby establishing electrical continuity between the binding post 27 and the wiper 40 of the switch 22. Since the ring 30 also connects with the junction terminal 34, it will be seen that in this position of the switch 21, only capacitors are connected in the circuit. Any value of available capacitance can be chosen, even after the instrument 15 is connected into the test circuit, by merely changing the position of the wiper 40 through manipulation of the knob 22.

In Fig. 5, the switch 21 has been changed to its next position by rotation of the knob which, of course, carries the wafer 80 with it, as in all switch movements. In this condition, the two wiper contacts 38 and 72 are still connected together, but now the wiper contact 44 is no longer in the circuit, and in its stead the contact wiper 54 is connected with the contact wiper 68 and hence to binding post 27. Since the wiper 54 connects to the resistor groupings, it will be obvious that this position of the switch 21 provides a circuit in which there is only a path to the resistor groupings, and in the manner which has been described, any one of the thirty-six resistors can be chosen and inserted into the circuit. This position is designated "Resistors."

The next position, designated "Parallel R.C." is achieved by rotating the switch wafer 80 to the next circumferential position. This is shown in Fig. 6. In this position, wipers 38 and 72 are still connected together which establishes a path from the binding post 29 to the junction terminal 34. Now, all three of the wiper contacts 44, 68 and 54 are engaged with the arcuate contact member 76. The ear 86 provides for the contact with the wiper 44. The binding post 27 is now connected to both the capacitor grouping and the resistor groupings because the wiper contact 44 extends to the wiper 40 of the switch 22 and the wiper contact 54 connects with the rings 46 and 48. The particular capacitor and resistor which are in the circuit are now in parallel with one another and together connected between the binding posts 27 and 29.

The next position of the switch 21 is illustrated in Fig. 7, and it will be obvious that this position, designated "Short" is a short circuit between the binding posts 27 and 29 by way of the wiper contacts 68 and 72 through the arcuate contact member. This is a useful condition in circuit work also.

As thus far described the instrument 15 provides a highly efficient substitution box in which the user has at his finger tips resistance alone, capacitance alone, resistance and capacitance in series, and resistance and capaci-

tance in parallel. Furthermore, the values of the resistance and capacitance may be quickly changed without disconnecting the instrument from the circuit, or short circuit or infinite impedance conditions can be achieved by a twist of the knob of the circuit selector switch **21**. The versatility and flexibility of the instrument is readily understood from the above description, and such versatility and utility is multiplied when using more than one instrument. The low cost possible because of the simplicity of the instrument enables the user to purchase more than one without hardship.

The instrument can be rendered additionally useful and versatile by the simple connection of a conductor **90** from the junction terminal **34** to the third binding post **31**, previously described herein, but not discussed.

This connection, it will be seen, provides an externally available terminal between the capacitor and resistor groups in addition to the terminals defined by the binding posts **27** and **29** for the various positions of the switch **21**. The only position of the switch **21** which is affected by the addition of this connection is the "Series R.C." position, which connects a resistor and condenser in series. The additional connection therefore provides, at the binding post **31**, an electrical path which leads to the junction between the condenser and the resistor.

Thus, the user may connect the resistor and condenser into two completely different parts of a circuit, providing that there is a common point for one side of each of the components. Such circuitry is not unusual, since it occurs in many circuits, the common point usually being ground. Likewise, the individual effect of the respective components may be ascertained while the pair are connected into a circuit, since the junction between them is available.

A particularly interesting use of the junction between the resistor and capacitor of a series arrangement is in pulse shaping, forming and computing. The basic passive networks of many circuits are integrating circuits, differentiating circuits, and variations thereof. Such circuits also use T and pi sections, the latter also found in filter networks, and delay lines. In Fig. 8 there is illustrated a simple integrating circuit made up of a series capacitor C and a shunting resistor R. The input is across the binding posts **27** and **29** and the output is across the binding posts **29** and **31**. These are the binding posts of the instrument **15**. In Fig. 9 there is illustrated a simple differentiating circuit made up of a series resistor R and a shunting capacitor C. The input is across the binding posts **27** and **29** again, but in this case the output is across the binding posts **31** and **27**.

The two simple networks of Figs. 8 and 9 are formed with the instrument **15** without in any way changing the construction or connections of the instrument, except for the additional conductor **90** and the binding post **31**. The numbers of the resistor R and the capacitor C are omitted, since these merely represent the capacitors C–**1**, C–**2** etc., to C–**18** and the resistors R–**1**, R–**2** etc., to R–**36**.

Through the use of two or more instruments **15** modified with the addition of the connection between R and C an extremely valuable tool for circuit work can be formed since T and pi sections are readily formed for insertion into test circuits. The ease with which the values of the components can be varied enables considerable computation time to be saved.

Many additional uses and applications of the invention are easily within its capabilities. Obviously, variations in the details and specific arrangements of the parts are possible without in any way departing from the spirit or scope of the invention as defined in the appended claims.

What is desired to claim by Letters Patent of the United States is:

I claim:

1. An electrical component substitution instrument comprising, a first grouping of components of a first type and means for selecting a desired one of said components for connection into an external test circuit, a second grouping of components of a second type and means for selecting a desired one of said latter components for connection into an external test circuit, a pair of terminals adapted for connection to said external test circuit, a single circuit selector switch, a common electrical junction between the groupings, a plurality of contacts connected respectively to said groupings, said terminals, and said common junction, and said switch having contact-engaging means for electrical engagement with said contacts, said means movable to any one of a plurality of different pre-selectable positions in which said one grouping is connected across said terminals, said second grouping is connected across said terminals, the groupings are both connected in parallel across said terminals, or the groupings are connected in series across said terminals.

2. An instrument as claimed in claim 1 in which there is a third terminal and said third terminal is connected with said common junction.

3. An instrument as claimed in claim 1 in which one of said groupings is formed of two sub-groupings and said selecting means of said one grouping includes means for selecting between sub-groupings.

4. An instrument as claimed in claim 1 in which said circuit selector switch includes a pair of arcuate contact members insulated from each other and mounted on a rotatable wafer, said contact engaging means comprising a plurality of ears projecting from the outer circumference of said contact members.

5. An electrical component substitution instrument comprising, a first sub-circuit having a plurality of electrical components adapted to be connected therein and first switch means for connecting any one of said components in said sub-circuit, a second sub-circuit having a plurality of electrical components adapted to be connected therein and second switch means for connecting any one of said last-mentioned components in said sub-circuit, a pair of output terminals, a single switch means for establishing a plurality of different conditions of circuit connection of said components across said output terminals, including one condition in which the selected component of the first sub-circuit and the selected component of the second sub-circuit are in parallel across said output terminals and a second condition in which said selected components are in series across said terminals.

6. An instrument according to claim 5 in which there are two additional conditions, in which the respective selected components are individually across said terminals.

7. An instrument according to claim 5 in which there is a third terminal and a common connection between said sub-circuits, and the third terminal being connected to the common connection.

8. An electrical component substitution instrument comprising, a first grouping of capacitors and a switch for selecting a desired one of said capacitors for connection into an external test circuit, a second grouping of resistors and a switch for selecting a desired one of said resistors for connection into an external test circuit, a single circuit selector switch including a pair of arcuate contact members insulated from each other and mounted on a rotatable wafer, a common electrical junction between the groupings, a pair of terminals adapted for connection to said external test circuit, a plurality of contacts connected respectively to said groupings, said common junction, and said terminals, and a plurality of contact engaging ears projecting from the outer circumference of said arcuate contact members, said ears electrically engageable with said contacts and movable to any one of six different pre-selectable positions whereby an infinite impedance is provided across said terminals, said first grouping is connected across said terminals, said second grouping is connected across said terminals, the groupings are both connected in parallel across said terminals, the groupings are connected in series across

said terminals, or a short circuit is provided across said terminals.

9. An instrument as claimed in claim 8 in which said second grouping is formed of two sub-groupings of resistors and includes a second switch for selecting between said sub-groupings.

10. An instrument as claimed in claim 9 in which the capacitors and resistors in each of said groupings are circularly arranged and connected by a circular bus which is coaxial with its respective selecting switch.

11. An instrument as claimed in claim 10 in which there is a third terminal, said third terminal being connected with said common junction whereby said groupings may be connected into different parts of said test circuit.

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