in the value of the resistance R_1, the voltage E_1 decreases as $E_1=E_0-i_1R_1$ when the induced voltage

$$L_1\frac{di_1}{dt}$$

has faded out and the current i_1 has been increased sufficiently under a new equilibrium state. (In the theoretical economics, it is so understood that price becomes equal to production cost under an equilibrium state.)

Such lower value of the voltage E_1 or such higher price level is the result of driving up production without any additional investment in production facilities, while it is necessary to make such an investment in order to carry out an economical production. Such an additional investment results in an increase in production facilities such as labour, machine, etc. which enables the production to meet the increment in demand, and, therefore, such an investment is nothing other than a process of decreasing resistance against the production.

Thus, the investment can be construed as bringing about a decrease in the resistance R_1 in the analogous illustration. In a case where value of the resistance R_1 is decreased, it is easy to increase the current i_1 without considerable rise in the value of i_1R_1 viz. in a case where a suitable investment is made, the production of capital goods can be increased without a considerable rise in the production cost and in the price level thereof.

Controls of the resistance R_1, or investment functions on the capital goods production, are made through the circuit consisting of the vacuum tube V_{I_1}, which stands for the investment channel directed to the capital goods production group PGP, by varying the grid voltage being applied to the vacuum tube V_1. In the case where the load on the $R_1—L_1—C_1$ circuit presented by the $R_2—L_2—C_2$ circuit suddenly becomes light, there takes place in general a phenomenon contrary to as indicated above. In this case, value of

$$L_1\frac{di_1}{dt}$$

becomes negative, viz. this stands for a negative profit or loss; the charge in the capacitor C_1 increases and the voltage E_1 increases, viz. the stock of capital goods increases and the price level goes down; the current i_1 decreases and thus the voltage drop i_1R_1 in the resistance R_1 decreases, viz. the rate of change in the flow of capital goods decreases and income from the capital goods production group as well as the production cost falls down.

The dynamic changes as in the above, appear in various different forms and phases according to values of the resistance R_1, inductance L_1 and capacitance C_1, and this means that various different dynamic phenomena take place in their forms and phases as values of the resistance against labours, accompanying inertia and scope of stock differ respectively.

(B) *Functions of the $R_2—L_2—C_2$ and $R_3—L_3—C_3$ circuits standing for the consumer goods production group CGP and the trading group COM respectively*

The two stages, consisting of the $R_2—L_2—C_2$ and $R_3—L_3—C_3$ circuits respectively, which follow the first stage consisting of the $R_1—L_1—C_1$ circuit representing the capital goods production group PGP, stand for the consumer goods production group CGP and the trading group COM respectively, and their circuit connections and functionse are the same as in the $R_1—L_1—C_1$ circuit. As for the relationship of the values of the goods which are produced or handled in these three successive stages, there is an additional relationship, viz. the price level of consumer goods (the reciprocal of the voltage across terminals of the capacitance C_2) is indicated by the sum of the price level of capital goods and the level of unit income from the consumer goods production (the sum of unit production cost for consumer goods and unit profit or loss therein) and this can be formulated as follows in an electro-analog equation.

$$E_1-\left(i_2R_2+L_2\frac{di_2}{dt}\right)=\frac{1}{C_2}\int_0^t i_{C_2}dt=E_2$$

The price level of the consumer goods being supplied through the trading group is counted in the same way as in the above, viz.

$$E_2-\left(i_3R_3+L_3\frac{di_3}{dt}\right)=\frac{1}{C_3}\int_0^t i_{C_3}dt=E_3$$

These relationship are to be construed as representing the inter-relationships of values appearing in F. V. Hyake's explanation with respect to the stepwise production structure.

In addition, the values of current i_1, i_2 and i_3 stand for the rates of changes in the flows of the consumer goods and those being handled through the trading group respectively, and the values all become equal along with the current i_4, of which illustration will be made later, when the whole system is in an equilibrium state.

(C) *Functions of the circuits for aggregating incomes and for diverting national income into consumption expenditure and saving*

$$iR+L\frac{di}{dt}$$

in each of the productive stages stands for unit income from each productive group, and

$$i\left(iR+L\frac{di}{dt}\right)$$

in each stage represents total income therefrom, and the aggregation of every

$$i\left(iR+L\frac{di}{dt}\right)$$

is regarded as forming the national income Y, viz.

$$i_1\left(i_1R_1+L_1\frac{di_1}{dt}\right)+i_2\left(i_2R_2+L_2\frac{di_2}{dt}\right)+i_3\left(i_3R_3+L_3\frac{di_3}{dt}\right)=Y$$

As for the divergency of the national income Y into the consumption expenditure and saving, based on J. M. Keynes' theory, it is so regarded that one part of the national income Y is to be spent for buying the end products, which are the consumer goods being handled through the trading group after having been produced in the preceding productive stages and of which rate of change in the flow is represented by i_4, and the other part is to be saved; and the ratio of the part for the consumption C to the national income Y, or C/Y is referred to as "propensity to consume" represented by α, and the ratio of the part for the saving S to the national income Y, or S/Y is referred to as "propensity to save," represented by $(1-\alpha)$.

(It should be noted, however, that the term "unit income," "total income" and "national income," which were used in the above and will be used hereinafter, should be construed as to represent "rate of change" in unit, total and national incomes respectively in the proper expression.)

The function of representing such divergency of the national income is carried out by the potentiometer Rsc, of which the variable characteristic is linear so that the propensity to consume or to save can be read directly on a dial with a linear calibration.

The multiplication

$$i\times\left(iR+L\frac{di}{dt}\right)$$

in each productive stage is performed by an insulated coupler AT, of which circuit is shown in Fig. 5 (a description thereof will be made later) description will be made later, and the aggregation

$$i_1\left(i_1R_1+L_1\frac{di_1}{dt}\right)+i_2\left(i_2R_2+L_2\frac{di_2}{dt}\right)+i_3\left(i_3R_3+L_3\frac{di_3}{dt}\right)$$

is made through such insulated couplers which are provided in the R_1—L_1—C_1, R_2—L_2—C_2 and R_3—L_3—C_3 circuits individually. The main function of the insulated coupler AT is to perform the multiplication

$$i\times\left(iR+L\frac{di}{dt}\right)$$

and it is designed so that application of a voltage which is proportional to the current i and a voltage which is proportional to

$$\left(iR+L\frac{di}{dt}\right)$$

to the primary circuit thereof produces at the secondary circuit thereof a voltage which is proportional, in a certain range, to the product of the two voltages being applied to the primary circuit.

In aggregating incomes from each productive stage through the insulating couplers, it is necessary to have direct current insulation between the primary and secondary circuits of each insulating coupler, because the main circuit of the system consists of a direct current circuit and without such insulation, shorts can occur in essential parts of the system, viz. it is necessary to arrange circuit so as to perform the aggregation of

$$i_1\left(i_1R_1+L_1\frac{di_1}{dt}\right)+i_2\left(i_2R_2+L_2\frac{di_2}{dt}\right)+i_3\left(i_3R_3+L_3\frac{di_3}{dt}\right)$$

and to divert the sum thereof by the potentiometer R_{sc} into the two directions, one being to the grid circuit of the vacuum tube V_4 in the consumer group, the other being to the circuit BK representing the banking organ, without the occurrence of shorts among the R_1—L_1—C_1, R_2—L_2—C_2, R_3—L_3—C_3 and R_4—L_4 circuits, and such a performance is made by providing a direct current insulation between the primary and secondary circuits of the insulated coupler AT. Such requirements in the insulated coupler AT are fulfilled by employing a high frequency circuit as shown in Fig. 5 and a high frequency current is rectified so as to obtain a direct current output voltage at the secondary circuit thereof which is completely insulated from the primary circuit against direct current flow therefrom. Detailed explanation concerning the connections and components thereof will be given later.

(D) *Functions of the L_4—R_4 circuit standing for consumer group CSM*

The rate of consumption in a national economy can be expressed by the product of the national income Y by the propensity to consume α, or αY, and this can be formulated in the following electro-analog equation:

$$\alpha Y=\alpha\left\{i_1\left(i_1R_1+L_1\frac{di_1}{dt}\right)+i_2\left(i_2R_2+L_2\frac{di_2}{dt}\right)+i_3\left(i_3R_3+L_3\frac{di_3}{dt}\right)\right\}$$

and the design of the circuit is made so that the power consumption in the resistance R_4, which stand for the consumption function in the economic term, or $i_4^2R_4$, is kept always equal to αY being derived from the above equation but in the reciprocal order with respect to α or

$$Y\frac{1}{\alpha}=i_4^2R_4$$

This represents that the consumption expenditure in the national economy is equal in amount to the purchase of consumer's goods in a macro-economic view point.

The functional relation

$$\frac{1}{\alpha}Y=i_4^2R_4$$

is maintained in such a way that the grid potential of the vacuum tube V_4 is controlled by the voltage proportional to αY, which is diverted by the potentiometer R_{sc}, and in an equilibrium condition where i_1, i_2, i_3 and i_4 become equal to each other, such functional relation is to be in such a condition as follows:

$$\frac{1}{\alpha}i^2(R_1+R_2+R_3)=i^2R_4$$

or

$$\frac{1}{\alpha}i(R_1+R_2+R_3)=iR_4$$

or

$$\frac{1}{\alpha}(R_1+R_2+R_3)=R_4$$

and this is the most essential condition for establishing the fundamental set-up for operating this electro-analog model equipment.

(E) *Functions of the C_b circuit standing for the banking organ BK*

The voltage proportional to $(1-\alpha)Y$, which is diverted by the potentiometer R_{sc}, is applied to the capacitance C_b through another type of the insulated coupler, CT. A function of the insulated coupler CT is to isolate the secondary circuit from the primary circuit against the direct current flow therefrom, but CT has no multiplying function such as in the insulated coupler AT and it functions to produce at the secondary circuit a voltage which is proportional to the voltage being applied to the primary circuit, and the output capacity of CT is designed to be somewhat larger than that of the insulated coupler AT in order to provide enough voltage for operating the vacuum tubes V_{I_1}, V_{I_2} and V_{I_3} which represent the investment channels, for which explanation will appear later. The direct current insulation between the primary and secondary circuits in the insulated coupler CT is not a matter indispensably required, but such a design associated therein is preferable in consideration of possible further extentions or modifications of the circuit for investigating various problems in economic dynamics in further steps. Illustration on an example design of such as insulated coupler will be made later referring to Fig. 6.

The capacitance C_b stands for the function or scope of monetary stock, and the build-up of electrical charge therein stands for the monetary deposit in the banking organ BK, the supply for such charge being made by the voltage proportional to $(1-\alpha)Y$ through the insulated coupler CT, viz. the source for such deposit being the saved part in the national income. On the other hand, in the case where the current from the capacitance C_b to the circuits consisting of the vacuum tubes V_{I_1}, V_{I_2} and V_{I_3} increases relative to the value of the capacitance C_b as well as the supply thereto, the charge decreases and the potential across terminals of the capacitance C_b consequently decreases. This represents that the amount of investments increases relative to the scope of the banking organ as well as saving, the deposit therein decreases and the rate of interest goes up. The voltage across terminals of the capacitance C_b stands for the rate of interest in reciprocal order, viz. a rise in voltage stands for a fall in the rate of interest and vice versa.

A higher potential in the capacitance C_b drives the more current into the circuits consisting of the vacuum tubes V_{I_1}, V_{I_2} and V_{I_3}, and a lower potential decreases this current. The relationship represents that, in principle, the investment becomes active when the rate of interest is kept low and it becomes inactive under the higher rate of interest. Furthermore, more supply current is received by the capacitance C_b when the voltage across terminals of the capacitance C_b becomes lower than the supply voltage. This means that the higher rate of interest invites greater savings.

(F) Functions of the V_{I1}, V_{I2} and V_{I3} circuits standing for the investment channels

The investments can be classified into two categories, from the macro-economic point of view, viz. "Induced" and "Autonomous."

The induced investment is the kind of investment that is induced by a change in demand during business cycles. The autonomous investment is the kind of investment that is made constantly according to the scale of economy itself. Both the autonomous investment and the induced investment are dependent on the savings or the part of national income which are not spent for buying consumer goods from the macro-economic view point, and at a stabilized condition of the national economy, current savings become equal to current investment or $S=G_1+I_1+G_2+I_2+G_3+I_3$. However, we can observe that a case may exist where a portion of current savings is hoarded so that current investment is less than current savings or, on the contrary, current investment exceeds current savings, and, in the case where the unbalance between current savings and current investment is taken into consideration, the above equation must be rewritten as $S=\pm\Delta S+G_1+I_1+G_2+I_2+G_3+I_3$, where $+\Delta S$ indicates a portion being hoarded of current savings and $-\Delta S$ indicates investment depended on previously hoarded cash balance or money creation by banks.

However, it is generally true that an existence of $+\Delta S$ will tend to decrease national income and also rate of interest, and an existence of $-\Delta S$ will tend to increase national income and raise the rate of interest at the same time, so that the national economic system itself acts automatically so as to minimize the ΔS or to keep it zero with a minimum of time delay in any way.

In the present economic model as mathematically represented in Fig. 2, the existence of ΔS is disregarded in order to simplify the function of the model for the above reason, and in order to comply with the relevant equation shown on Fig. 4 in electrical terms, the type of the vacuum tubes V_{I_1}, V_{I_2}, V_{I_3} as well as value of the resistances $Raut_1$, $Raut_2$, $Raut_3$ shown in Fig. 3 are chosen and pre-adjusted so that the voltage representing $G_1+I_1+G_2+I_2+G_3+I_3$ will become equal to S at a stabilized condition or when a disequilibrium therebetween has faded away. However, in the case where it is desired to take the existence of ΔS into consideration, the relevant equation in Fig. 4 in electrical terms as well as in Fig. 2 in economic terms is to be read as $S=\pm\Delta S+G_1+I_1+G_2+I_2+G_3+I_3$, and measurement of dynamic variations in ΔS can be made by comparing variations in voltage developed through the terminal 28 with that through the terminal 29 indicated on Fig. 3.

As for the induced investment, it can be so understood that the incentive providing the inducement is an increase in profit due to an increase in demand relative to supply or production, viz. the inducement of

$$U\frac{dq}{dt}, \text{ or } L\frac{di}{dt}$$

in electrical terms.

The positive

$$U\frac{dq}{dt}$$

represents a profit and the negative one is to be understood as a loss, and the positive one induces an investment whereas the negative one discourages investment. Explanation of the functions of the circuit consisting of the vacuum tubes V_{I_1}, V_{I_2} and V_{I_3} which represent the channels for the induced and/or discouraged investment, is as follows.

The main function of the circuit is to apply such individual voltages to the grids of the vacuum tubes V_1, V_2 and V_3 as are proportional to

$$L_2\frac{di_2}{dt},\ L_3\frac{di_3}{dt} \text{ and } L_4\frac{di_4}{dt}$$

respectively, the charge in capacitance C_b being the source of power for the execution of this function. This represents an economic function whereby savings are turned into investments in accordance with the magnitude of the disequilibrium between supply and demand, and such a disequilibrium in the consumer group CSM induces an investment directed to the trading group COM, such a disequilibrium in the trading group induces an investment directed to the consumer goods production group CGP and such a disequilibrium in the consumer's goods production group CGP induces an investment directed to the capital goods producing group PGP.

The grid circuit of the vacuum tubes V_1, V_2 and V_3 are connected to the cathode circuits of the vacuum tubes V_{I_1}, V_{I_2} and V_{I_3} respectively through the individual insulated couplers BT, and the grid circuits of the vacuum tubes V_{I_1}, V_{I_2} and V_{I_3} are connected to the secondary windings of the inductances L_2, L_3 and L_4 respectively through the individual volume controls $Racc_1$, $Racc_2$ and $Racc_3$, the anode power to these vacuum tubes being supplied from the capacitance C_b in common.

The insulated coupler BT has a similar design to that of AT and CT in isolating the secondary circuit from the primary circuit against the direct current flow therefrom, and it functions to produce such a voltage at the secondary circuit as is proportional to the voltage being applied to the primary circuit, but it does not have a multiplying function as in the insulated coupler AT and does not have a large output capacity as in the insulating coupler CT.

The fundamental design of the insulating coupler BT is similar to that of the insulated coupler CT and it produces a voltage which is just enough to control the grid voltage for the vacuum tubes V_1, V_2 and V_3.

The function of the circuit consisting of V_{I_1}, V_{I_2} and V_{I_3} is explained in the following reference to an example of the operation in the V_{I_1} circuit.

As

$$L_2\frac{di_2}{dt}$$

is induced, it is applied to the grid of the vacuum tube V_{I_1} through the volume control $Racc_1$, and this results in such a change in the voltage drop in the resistance $Raut_1$ that is proportional to

$$L_2\frac{di_2}{dt}$$

and such a change in voltage is applied further to the grid of the vacuum tube V_1 through the insulated coupler BT in the same phase as of

$$L_2\frac{di_2}{dt}$$

Therefore, the change in the voltage which is applied to the grid of the vacuum tube V_1 is a function of

$$L_2\frac{di_2}{dt}$$

and also of the setting of the volume control $Racc_1$ and the potential in the capacitance C_b.

The same function as is executed in the V_{I_1} circuit is also executed in the V_{I_2} and V_{I_3} circuits, and this function represents that the investment directed to any of the productive stages are a function of the changes in the respective demands and also of the amount of saving, rate of interest and respective accelerations in inducing investments. The acceleration hereunder is to be understood as the magnification ratio of a change in the rate of change in demand to the change in the rate of change in investment induced thereby, and the accelerations directed to any of the productive stages can be adjusted by the individual volume controls $Racc_1$, $Racc_2$ and $Racc_3$ respectively.

As for the autonomous investment, it is so understood that the autonomous investments are also directed to the respective productive stages in addition to the induced investment, but without being influenced by the change in demands or

$$U\frac{dq}{dt} \text{ or } L\frac{di}{dt}$$

The levels of the voltage G_1, G_2 and G_3, which stand for the levels of the autonomous investments respectively directed to the three productive groups, can be adjusted by the potentiometer $Raut_1$, $Raut_2$ and $Raut_3$, individually.

The biasing devices BS_1, BS_2, BS_3 and BS_4, which are provided in the grid circuits of the vacuum tubes V_1, V_2, V_3 and V_4 respectively, supply grid bias voltages to these vacuum tubes individually, and the potentiometers Rcr_1, Rcr_2, Rcr_3 and Rcr_4 are used for adjusting the bias suitably. Another reason for providing such potentiometers is as follows. Often we use such an assumption in processing theoretical analyses of economic phenomena, that "should the economic quantum vary for a certain reason, or for an exogenetic reason," we can describe its results on the other economic quanta. The potentiometers Rcr_1, Rcr_2, Rcr_3 and Rcr_4 enable us to provide such an assumption in investigating economic problems employing the present electroanalog model equipment, viz. the variations of voltage by such potentiometers can be used to represent variations into a disequilibrium state of such economic quanta as demand and supply, which are caused by an exogenetic ground independent from the self-governed functions of the economic system itself, because these biasing devices are independent and the adjustments are made independent from the self-governed inter-relationships of the whole circuits.

(G) *Examples of measurement operations*

The numerals 1 to 32, inclusive, noted in Fig. 3 indicate the positions of terminals, to any of which such a reading device as a meter, recorder, oscilloscope, etc. can be connected for measuring variations in voltage or current which stands for the economic quantum in problem. The economic items measurable by this equipment are as shown in Table 3.

The process of investigating problems in a national economy employing this equipment is as follows:

In describing the national economic phenomena on a certain theoretical basis, the proper features of the economic system and the autonomous functions thereof are considered as the premise for processing such theoretical descriptions. However, it should be also noted that there are several economic factors or elements which can be controlled artificially and economic policies are therefore possible.

Therefore, in designing the present electro-analog model equipment, it is necessary to have selected electro-analog components which stand for such economic items which are controllable artificially under the national economic system in consideration. As for the properties of economic phenomena which reveal themselves necessarily under a national economic system, it might be so understood that they are derived substantially from the properties of the economic system itself as well as those of human actions in the economic lives, and as for the artificially controllable items, it might be so understood that they are "effectuating quantum" in the inter-relationships of economic elements.

Such artificially controllable items being considered in the design of this equipment are shown in Table 2, and it is so designed that any of values of the components in Table 2 are adjustable manually.

TABLE 2

	Capital Goods Production Group (PGP)	Consumer Goods Production Group (CGP)	Trading Group (OOM)	Consuming Group (CSM)
Inertia	L_1	L_2	L_3	L_4.
Inflexibility of stock	C_1	C_2	C_3	
Acceleration in inducing investment	$Racc_1$	$Racc_2$	$Racc_3$	
Autonomous investment.	$Raut_1$	$Raut_2$	$Raut_3$	
Assumption	Rcr_1	Rcr_2	Rcr_3	Rcr_4.

Capacity Organ (BK)		National Income (Y)	
Scope of capacity	C_b	Propensity to consume, propensity to save.	Rsc.

The main items which can be measured by this equipment are as shown in Table 3 and any of such items can be observed or recorded by connecting such a reading device as meter, recorder, oscilloscope, etc. to the corresponding terminals, of which indications are also given in Table 3, as a dynamic variation in the electro-analog quantum.

TABLE 3

Capital Goods Production Group (PGP)		Consumer Goods Production Group (CGP)		Trading Group (COM)		Consumer Group (OSM)	
Item	Terminal	Item	Terminal	Item	Terminal	Item	Terminal
Level of unit production cost (i_1R_1)	(1)	Level of unit production cost (i_2R_2)	(9)	Level of unit production cost (i_3R_3)	(17)		
Rate of change in flow of goods (i_1)	(2)	Rate of change in flow of goods (i_2)	(10)	Rate of change in flow of goods (i_3)	(18)	Rate of change in flow of goods (i_4)	(25)
Level of unit profit $\left(L_1\frac{di_1}{dt}\right)$	(3)	Level of unit profit $\left(L_2\frac{di_2}{dt}\right)$	(11)	Level of unit profit $\left(L_3\frac{di_3}{dt}\right)$	(19)		
Level of income $i_1\left(i_1R_1+L_1\frac{di_1}{dt}\right)$	(4)	Level of income $i_2\left(i_2R_2+L_2\frac{di_2}{dt}\right)$	(12)	Level of income $i_3\left(i_3R_3+L_3\frac{di_3}{dt}\right)$	(20)		
Price level $-(E_1)$	(5)	Price level $-(E_2)$	(13)	Price level $-(E_3)$	(21)	Price level $-(E_4)$	(26)
Rate of change in stock flow (ic_1)	(6)	Rate of change in stock flow (ic_2)	(14)	Rate of change in stock flow (ic_3)	(22)		
Induced Investment (I_1)	(7)	Induced Investment (I_2)	(15)	Induced Investment (I_3)	(23)		
Autonomous Investment (G_1)	(8)	Autonomous Investment (G_2)	(16)	Autonomous Investment (G_3)	(24)		

Banking Organ (BK)		National Income (Y)	
Item	Terminal	Item	Terminal
Rate of interest $-(E_{C_b})$	(27)	Rate of change in national income (Y)	(30)
Rate of change in monetary flow to save (i_{e_b})	(28	Rate of change in consumption (C)	(31)
Rate of change in monetary flow to invest ($i_P V i_1 - 3$)	(29)	Rate of change in saving (S)	(32)

NOTE.—The items carrying (—) are to be measured in reciprocal order.

For example, an analogous illustration of such a national economic phenomena that a sudden change in the rate of change in the demand for consumer goods due to a certain exogenetic incentive tends to bring about a variation in the price level in various forms according to existing conditions, can be obtained by connecting an oscilloscope or automatic recorder to the terminal **26** and performing controls on the potentiometer Rcr_4 in such magnitude and velocity as assumed as to the variation in the rate of change in the demand; viz. then a curve showing the variation in the voltage E_4 will be shown on the oscilloscope or recorder and various forms of curves will be shown as the condition in consideration differs.

Furthermore, measurements on various effects which are brought on the other parts of the national economic system by such a variation can also be made by using any of the terminals **1** to **32**, inclusive.

Thus, the experimental measurements on effects which are brought by one or more economic quanta on the others can be made by the equipment, and it is also possible to make experimental measurements under various different conditions by operating the adjustors which are mentioned in Table 2, viz. for instance, in the measurements as for the sudden variation in the rate of change in demand as explained above, various forms of variation in the voltage E_4 might be observed as any of values of the capacitances C_1, C_2, C_3, inductances L_1, L_2, L_3, L_4, resistances in the potentiometers $Racc_1$, $Racc_2$, $Racc_3$, Rsc, etc. differs or differ respectively. This proves, on the other hand, that experimental researches on national economic policies can be carried out by the equipment, as such operations can be regarded as the experiments on functional relations in the national economy, being made from a political point of view by setting the artificially controllable economic elements on various possible positions.

(H) *Examples of designs on the insulated couplers AT, BT and CT*

Fig. 5 shows an example of design on the insulating coupler AT. Referring to Fig. 5, V_5 is a pentagrid vacuum tube, of which No. 1 grid serves for oscillating a certain high frequency current and of which No. 3 grid serves for controlling amplitude of such oscillation in a certain range in proportion to the grid potential thereon which is kept positive with respect to the point E; VR_1 is a variable resistor for setting the variation range of voltage to be applied to the No. 3 grid; C_5 is a by-pass condenser; R_5 is a grid resistor for the No. 1 grid; C_7 is a coupling capacitor for the No. 1 grid; R_6 is a resistor for keeping the No. 3 grid negatively biased and C_9 is a by-pass condenser; R_7 is a resistor for keeping Nos. 2 and 4 grids at an appropriate positive potential and C_{10} is a by-pass condenser used therewith; R_8 indicates a resistor for developing high frequency output at the anode circuit; L_5 and C_8 designate inductance and capacitance respectively for the high frequency oscillation tuning.

V_6 is also a pentagrid vacuum tube, of which No. 3 grid is excited with high frequency voltage being supplied from the vacuum tube V_5 through a coupling capacitor C_{11} and of which No. 1 grid is kept at the same potential as at the anode of the vacuum tube V_7, of which potential is kept positive with respect to the point E and varies proportional to the voltage being applied to the grid thereof in a certain range. High frequency output current in the anode circuit of the vacuum tube V_6 varies proportional to the voltage being applied to the No. 1 grid thereof in a certain range, and therefore, the high frequency output current in the anode circuit of the vacuum tube V_6 varies proportional to the voltage being applied to the grid of the vacuum tube V_7 in a certain range. As the anode voltage of the vacuum tube V_7 is supplied through a resistor R_{13}, the lower grid voltage of the vacuum tube V_7 brings the higher No. 1 grid voltage to the vacuum tube V_6, accordingly the more high frequency output current in the anode circuit of the vacuum tube V_6. R_{10} is a resistor for keeping the No. 1 grid of the vacuum tube V_6 negatively biased and R_{11} is a resistor for keeping the No. 3 grid thereof also negatively biased; C_{12} is a by-pass condenser and R_9 is a grid resistor for the No. 3 grid of the vacuum tube V_6; R_{12} and C_{13} are resistor and condenser respectively for applying a certain positive voltage to the Nos. 2 and 4 grids of the vacuum tube V_6; L_6 and C_{14} are inductance and capacitance respectively for the anode tuning circuit having the same resonance frequency as by the inductance and capacitance L_5 and C_8; VR_2 is a variable resistor for setting variation range of the voltage being applied to the grid of the vacuum tube V_7; C_6 is a by-pass capacitor.

Thus, variation in voltage being applied to the No. 3 grid of the vacuum tube V_5 varies proportionally amplitude of the high frequency voltage being applied to the No. 3 grid of the vacuum tube V_6 and the high frequency current being produced in the anode circuit thereof accordingly. Furthermore, the variation in voltage being applied to the No. 1 grid of the vacuum tube V_6 varies the amplitude of the high frequency current being produced in the said anode circuit of tube V_6. Therefore, application of two independent voltages to the terminals A, B and C, where a voltage is applied to the terminals A and B in such a connection as the terminal A being positive and the terminal B negative, and the other voltage is applied to the terminals B and C in such a connection as the terminal B being positive and the terminal C negative, controls the amplitude of the high frequency current being developed in the anode circuit of the vacuum tube V_6 in proportion to the product of such two independent voltages in a certain range, viz. the high frequency voltage being developed in the said anode circuit varies in proportion to the product of these two independent voltages in a certain range.

Therefore, supervision or measurement of variations in such powers as being dissipated in a resistor X carrying a direct current *i*, of which value may vary due to a change in value of the resistance of the resistor X or to other reasons, can be made in such a way that the voltage being developed through the resistor X is applied to the terminals A and B of the insulated coupler AT, voltage being developed through another resistor X', which is connected in series with the resistor X and of which resistance value is selected negligibly low as compared with that of the resistor X, is applied to the terminals B and C, and the measurement is made on the high frequency output voltage from the vacuum tube V_6.

This insulated coupler is required to have such a design that the secondary circuit is insulated from the primary circuit against the flow of direct current therefrom and at the same time the output voltage is obtained in direct current at the output terminals F and D in order to be used in the circuit as shown in Fig. 3. Therefore, the high frequency output from the vacuum tube V_6 is delivered to the diode rectifier V_8 through the coupling capacitors C_{15} and C_{16}, and the rectified output is delivered, through the resistors R_{14} and R_{15} and the filter condenser C_{17}, to the output terminals F and D, which are insulated from the input terminals A, B and C against direct current flow therefrom. In each of the stages PGP,