-PRECISION- *Electronamic** TUBE TESTER

*Reg. U.S. Patent Office

PRINCIPLES OF ELECTRONAMIC TUBE TESTING

The All-Inclusive, Single-Operation, Positive Vacuum-Tube Performance Test!

More than just Mutual Conductance

☆ A most perplexing issue confronting the radio service engineer is the choice of tube testing equipment that will solve his tube test problems with **greatest possible accuracy and reliability.** With this thought foremost in mind, "PRECISION" engineers have devoted unlimited time in extensive vacuum tube testing research and development.

All varieties of tests were conducted upon thousands of tubes, at our own fully equipped laboratories **and** at the plants of leading tube manufacturers. From this, a vital point stood out above all others which dictated that **"the resultant tube tester design cannot be based upon just one selected characteristic, such as just mutual conductance alone."**

☆ A tube test based upon **just any one characteristic** does **not** fully vouchsafe the **overall** performance capabilities of an amplifying tube.

When a vacuum tube is "receiver tested", the electronic circuits DEMAND **PERFORMANCE** predicated upon the simultaneous presence and interaction of a multiplicity of tube characteristics including the following:

Electron Emission
Amplification Factor
Plate Resistance
Mutual Conductance (Transconductance)
Plate Current
Power Output, etc.

☆ To perform a whole series of such **individual** tests, in order to evaluate the overall merit of a tube, involves a collection of laboratory equipment hardly available to the general user of vacuum tubes. In addition, these characteristics are very closely knit to operating parameters. To the electronically trained mind, this means that the predictable characteristic values are dependent upon the great variety of voltage, current and load conditions to which the tube, under consideration, may be subjected. This further means that for ANY GIVEN TUBE TYPE, **there is not** just one value of mutual conductance or power output, etc. characteristic of that tube.

For this very reason tube characteristic manuals list CURVES (graphs) of operation to assist the design engineer in selecting tubes and circuit parameters which he **desires** to employ in the particular receiver or other electronic apparatus being developed.

The printed tabular data listed in tube manufacturers' manuals is not to be considered as fixed and inflexible ratings. Rather, such examples of operating conditions are given merely as guiding information. The tubes can be and are used under **any** suitable conditions within their maximum ratings. The **curves** provide the information to determine the proper operating points which will yield a required characteristic.

☆ One other aspect of the tube engineering problem is the question of rejection limits for **any** particular characteristic. This actually is a double-barrelled topic. New tube production is concerned with "Production Tolerance Limits." The electronic design engineer, and of course the apparatus which uses the tubes, are further interested in "Life Test End Limits."

Electronic apparatus, using vacuum tubes, must not only perform well with tubes which are within "Production Tolerance Limits," but should be able to perform until the tube has reached its "Life Test End Limit."

Detailed specifications of such "limits" are not generally available to the field and of course, specific **numerical** characteristics tests (such as micromhos) are inconclusive unless compared to a detailed table of limits parallelling actual test parameters or actual testing conditions.

Moreover, numerical characteristics readings (as micromhos) are not fully meaningful unless the tester **duplicates** the exact voltages and loads under which the particular tube in question is actually operating in the specific circuit from which it has been removed. It would furthermore require reference to the tube's plate family and transfer characteristic curves in order to determine what the numerical characteristic SHOULD be under the particular conditions in which the receiver is using this tube.

☆ Therefore, since the numerical value (such as micromhos) of a tube characteristic varies so widely with the applied element potentials, it is necessary to provide in TRUE vacuum tube characteristics **measuring** instruments:

1. Appropriate means for **metering** and reading each and every applied element potential.
2. Appropriate means for **metering** and reading each tube element current.
3. Suitable devices for **adjustment** and **control** of every element potential to duplicate operating conditions or to set up the specific operating point being investigated.

☆ It is obviously entirely impractical to construct such a device, for general tube testing, as would permit the operator to do this; not only from the viewpoint of simplicity of operation, but also in consideration of the extremely high cost and physical size.

Accordingly, such equipment (for actual **numerical** characteristics investigations) is only found in research and production laboratories, which are the only places wherein such elaborate equipment might ever be required.

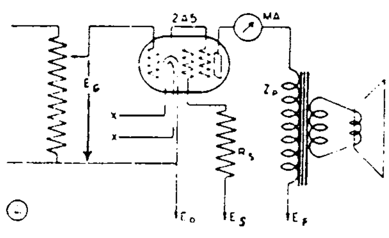
Needless to say, it would also not be practical for a tube tester's chart data to offer a multiplicity of alternative test settings for each and every tube.

☆ It has therefore been the constant purpose of Precision engineers to develop a tube tester circuit which would best meet the **realistic** needs of the electronic maintenance and radio service professions; to develop a basic test circuit affording the ultimate in correlation between test results and actual "in application" performance.

In the course of such investigations, it becomes conclusively apparent, that regardless of amplifier tube type number or variety of circuit applications, one phenomenon constantly manifests itself: **the tube output (voltage or power) is the result of a plate current caused by an applied control grid voltage, which current must be adequate even at full peak operating conditions.** This being a basic concept of amplifier tube operation (involving all operating characteristics), it led to the now famous, time-proven and tried, Precision "***Electronamic***" (Reg'd U. S. Patent Office) tube tester.

☆ In offering the "***Electronamic***" tube tester, to the discriminating purchaser, Precision does so with a **"performance checked"** background. Such "performance" tests, particularly emphasized during World War II, were based upon the primary purpose of the instrument—**TO FIND BAD TUBES!**

☆ To familiarize ourselves with the principles of this "PRECISION" innovation, let us briefly observe the operation of a simple pentode such as the 2A5, in a standard power amplifier stage, shown in diagram A, with the addition of a current indicating meter in the plate circuit.



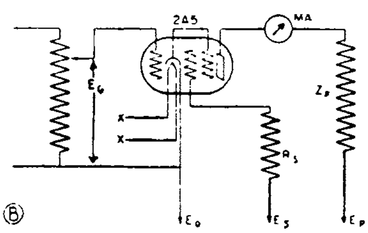
The primary purpose of this tube is to deliver electrical output to the speaker through plate load Zp, in the following manner: with filament and plate supply operating and with zero signal applied to the input circuit, the plate milliammeter "MA" will indicate a steady current flow dependent upon cathode emissive power and the potentials of the interspaced elements. This zero signal meter reading is an indication of the tube's plate conductance. By applying an audio signal, Eg, to the input grid, THE PLATE CURRENT THROUGH Zp MUST VARY IN ACCORD WITH THE CHANGES IN GRID VOLTAGE. This is dependent upon the mutual conductance, plate resistance, amplification factor, load resistance, etc. The greater the grid voltage swing, the greater should be the plate current excursions, and accordingly, the louder the sound from the speaker.

Let us now assume that a high order of peak grid signal voltage is applied, that is in keeping with the tube operating conditions, but severe distortion is nevertheless produced at the speaker, even though all circuit components, aside from the tube, are normal. This condition coincides with low peak plate current readings, and is usually caused by poor cathode structure and/or high plate resistance. In other words, an insufficient quantity of electrons is available to the plate circuit to handle peak power requirements.

Now let us suppose that with a normal signal applied to the input circuit, insufficient or no volume is obtained from the speaker, again assuming all circuit components, aside from the tube, are normal. This condition would indicate that the magnitude of plate current variations versus applied grid signal are not in keeping with the tube specifications and circuit requirements. This can be caused by a multiplicity of internal tube conditions, including reduced amplification factor, low mutual conductance, open, misplaced or shorted screen, control grid, suppressor, or plate, even though the tube's cathode structure may be absolutely normal.

In the case of resistance-coupled amplifiers, the change in plate current produces a change in voltage drop across the plate load resistor. This is then passed on through suitable coupling means to the succeeding stage.

☆ It can therefore again be readily seen that the overall PERFORMANCE Merit of a tube is absolutely dependent on the ability of **output plate current to respond to the applied grid voltage, over the full range of possible operating conditions, which involves More than just Mutual Conductance.**



(B)

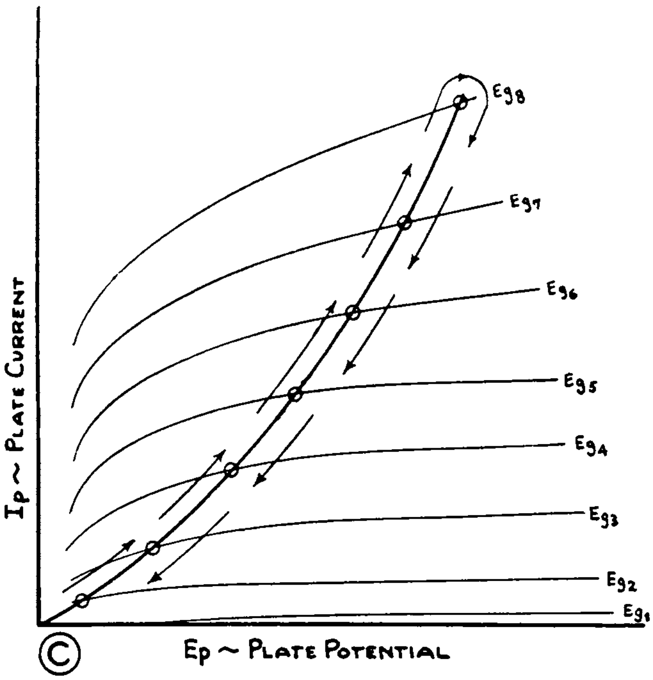
In Diagram B is shown the PRECISION "*Electronamic*" circuit set up to check the same type 2A5. Note that individual plate, screen and grid voltages and loads are applied to the respective elements of the tube under test and it is thereby being "*Electronamic*ally" tested as a pentode. PLATE SUPPLY VOLTAGES FROM 50 TO AS HIGH AS 300 VOLTS ARE APPLIED TO THE TUBES UNDER TEST DEPENDING ON THE INDIVIDUAL TUBE'S REQUIREMENTS.

Appropriate treatment is accorded all amplifier tubes depending whether they are triodes, tetrodes, etc. Multi-purpose tubes are treated and tested as two or more completely independent tubes, WITHOUT REMOVING THE TUBE FROM THE TEST SOCKET. All plate, screen, grid and filament test voltages and respective loads are factory calibrated (per the roller chart) to assure the high tube performance correlation for which the "*Electronamic*" tube testers are known to the field, both civilian and the military — a performance check based upon the **peak service** for which the tube was designed rather than just an arbitrarily chosen low or midpoint.

☆ As previously outlined, the overall quality or performance merit of a tube is dependent on how well control grid voltage "controls" plate current over a complete **range** of tube application.

For this reason, the PRECISION "*Electronamic*" circuit places the TUBE MERIT METER in the plate or output section only of the tubes under test. Accordingly, the resultant quality or performance figure of merit involves a whole **series** of meaningful operational factors, not just one inconclusive characteristic, and will reject all tubes which do not come up to the same standards from which the tube chart data is prepared.

☆ Much of the success of the "*Electronamic*" **tube tester is** attributable to the ELECTRO-DYNAMIC SWEEP nature of its circuit operation. Through application of appropriately phased individual element potentials, the tube under test is dynamically swept over a **Path of Operation,** on a sinusoidal time base, encompassing a wide range of plate family characteristics curves. In brief, the tube under test is made to **perform** on a basis which involves its ability to operate at a multiplicity of



(C)

potential peak conditions rather than at just one arbitrarily chosen point.

Reference to diagram C graphically and directly illustrates this "*Electronamic*" picture. It is this encompassing **Path of Operation, involving More than just Mutual Conductance,** which is automatically integrated by the meter as the resultant figure of merit in the direct and non-confusing terms of REPLACE-WEAK-GOOD.

☆ The very nature of the "*Electronamic*" circuit necessitates and assures utmost instrument flexibility, to permit positive location and selection of all tube elements. In the "900" Series, this was accomplished via appropriate combination of a multi-purpose PUSH-BUTTON master element selector system plus simplified load-potential rotary switch design. In the "10-00" MASTER series, the "*Electronamic*" facilities are further magnified via design and use of a new LEVER TYPE master element selector system in combination with a multiple push-button short check unit, plus specially engineered rotary, load and element potential selectors.

☆ Aside from the development of the complete "*Electronamic*" circuit, full consideration was given to the design of a Hot Cathode Leakage test, inter-element Short Check, instantaneous Filament Continuity Test and Audible Noise Test, affording maximum reliability and accurate neon lamp indications to show up physical and mechanical tube defects such as cathode to filament leakage, shorted, loose or open elements, open filaments, etc. THE CATHODE LEAKAGE CIRCUIT SENSITIVITY IS ADJUSTED TO COMPLY WITH THE APPROVED LEAKAGE SPECIFICATIONS OF LEADING TUBE MANUFACTURERS. Additional independent circuit facilities appropriately accommodate all diodes, rectifiers, tuning eyes, gas rectifiers, thyratrons, etc.

☆ Modern methods of construction, telephone cabled wiring, Precision resistors and wire-wound impregnated shunts, and highest quality of materials combined with INDIVIDUAL DUAL CALIBRATION against laboratory standards, insures maximum accuracy and ruggedness for lasting satisfaction. NEW TUBE TEST DATA CHARTS ARE FURNISHED UPON REQUEST FROM TIME TO TIME AT ABSOLUTELY NO CHARGE — FOR THE LIFE OF YOUR "PRECISION" TUBE CHECKER.