A   DESIGN AND CONSTRUCTION OF A MICROWAVE ACCELERATOR

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The last Progress Report gives an account of the reasons   building a microwave accelerator and of the plans which had been developed for building a full-scale test model   This model is to be 20 ft long and is expected to give electron energies of the order of 30 Mev   It is expected that all of the problems of building a much longer tube will be met in this test model, and that work on it will provide most of the necessary information for building any desired size of machine in the future   It is the purpose of this report to state the progress which has been made on the various problems connected with the design and construction of the 20-foot model

The Accelerator Tube   A series of measurements have been made on the effects of small changes in the dimensions of the iris-type accelerator tube   From these tolerance measurements it is possible to predict the exact dimensions which will give a satisfactory resonant frequency and an arbitrary degree of coupling between sections   A method of fabrication has been developed and a one-foot length (containing 6 sections) has been built in the same fashion as will be the final tube The method of construction consists of soldering together lengths of copper tube (of 4" inner diameter and 3/8' thickness) with the irises placed between each junction of the copper tubes   The soldering operation is very critical in that any defects in the joints may seriously affect the electrical characteristics of the tube   It has been found that very good joints can be obtained by placing 2-mil BT (silver-copper) foil in the joints to be soldered, and then heating in a hydrogen oven   Since the entire 20-foot tube cannot be soldered all at once, it is planned to build up the tube in suitable sections and to join them at the iris Irises at the ends of sections will be made of half the normal thickness so that upon being joined to the adjacent section, a normal iris will be formed   This method avoids the need for soldering sections together since no current will flow across the split iris

The first one-foot length has already been tested in preliminary fashion It is found to have an unloaded Q of about 14 000, and the frequencies of the various modes are found to occur as predicted by theory   This section will be used to determine final dimensions of the coupling hole through which the magnetron power is coupled and to make various other preliminary measurements before longer sections

are constructed

Mode and Field Testing   In connection with the problems of identifying the nature
of various modes which are obtained and of measuring the fields set up by the micro-
wave power in the cavities a number of conventional methods (e g   various types
of probes) have been used   In addition a very useful new method has been developed
which not only shows the type of mode but will in fact measure the magnitude of
the field at any required point in the cavity   Upon suitable calibration this
field measurement can be made absolute

This new test method makes use of the fact that if the volume of a resonant
cavity is changed by a small amount the frequency of resonance is shifted and this
frequency change depends on the percentage volume change and on the field strength
in the volume removed   Thus a very small metal ball (of the order of 1 mm diameter)
is introduced into a resonating cavity and the shift of resonant frequency is
measured   As the ball moves through regions of various field strengths, the fre-
quency shift is proportional to the square of the field in each region   This method
will be particularly useful in testing sections of the iris tube since a great deal
can be learned about the field without making undesired extra holes for probes
(The ball can be introduced through the iris openings by mounting it on a fine
thread)

Also under consideration is the possibility of extending this method by
using materials which perturb either the electric or magnetic field alone and thus
permit separate measurement of each field   This will lead to measurements of the
dielectric properties of small amounts of material at microwave frequencies

The Electronics of the Beam   Experimentally the study of the electron beam problem
has been advanced by the building of an analyzer for measuring the energy spectrum
of an electron beam   This analyzer is attached to a 250,000-volt Van de Graff gen-
erator in a manner which will allow the electron beam to pass through an accelerating
field in a microwave cavity   Thus measurements of the acceleration in the cavity can
be made under various conditions and compared with theory

On the theoretical side most of the problems of the behavior of electrons
which are injected into the accelerator tube have been solved   The effects of injec-
tion energy on the energy and intensity of the emergent beam and on the energy
spectrum have been worked out   Optimum injection energy can be computed for a given
maximum r-f field in the cavity   These computations have been based on the assumption
of a wave traveling down the tube with the velocity of light, as will be the case
for the tube being constructed   It will also be possible to calculate the way in
which the wave velocity should be varied if low injection energies are used

Physical Design of the Tube Mounting and Associated Equipment   Preliminary design
work has been finished on the tube mounting and the auxiliary apparatus (magnetrons
vacuum system, modulators, etc)   Actual construction awaits the availability of
space for the apparatus   In the meantime, orders have been placed for all of the
main items needed   Construction will begin as soon as the space is available

The largest piece of auxiliary apparatus is the Van de Graff generator which will be used to provide electron injection energies up to 2 Mev   The design of this generator is completed and it is now on order

Miscellaneous Items. There are a number of additional studies proceeding which should be mentioned   Work is continuing on the characteristics of reentrant type cavities   This type of cavity will not be used in the first accelerator, but it is felt that the information will be of considerable interest   Some work has been done on the problem of mode suppression in iris cavities   Dimension-determining measurements have been made on iris cavities designed for a wave velocity less than the velocity of light.   This latter information will be of great value if it is decided at any later date to use lower electron injection energies

III. B   ULTRASONICS RESEARCH PROGRAM

Staff   Dr C Kittel
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Description of Project   Radar pulse technique and microwave power sources are employed to study ultrasonic properties of solids, liquids, and gases   Some of the techniques applied are discussed in the Final Report of June 1946.   The principal projects of the group are

1   Measurements of velocity and absorption of sound in liquefied gases including liquid helium at 15 Mc/sec and 45 Mc/sec

2. Absorption measurements at 200 Mc/sec

3   Absorption in solids at 1 to 100 Mc/sec

4   Paramagnetic relaxation experiments using ultrasonic waves at 15 Mc/sec

5. Attenuation in single crystals

Several reports by members of the group have been, or are about to be, published[1] The investigations mentioned above are now discussed in turn

1   a   Measurements in Liquid Argon

Status   The last Quarterly Progress Report gave results for the velocity and absorption in liquid argon at 84 2°K and at 15 Mc/sec   The absorption value was found to be in the neighborhood of the value calculated from viscosity and heat conductivity To obtain better accuracy of the absorption value, equipment has now been set up for measurements at 45 Mc (since absorption varies as the square of the frequency) Measurements are being made but results are not yet ready for publication

1   b   Measurements in Liquid Helium

Description of Project   A cooperative program with the Low Temperature Group[2] is under way for determining the ultrasonic velocity and absorption in liquid He I and He II as functions of temperature

1   See list of technical reports on page 2 of this report

2   For other low temperature experiments see Section II D

Acoustic gear designed to function within the helium liquifier makes possible the use of pulse techniques previously reported[1] The arrangement is shown in Fig 1 At the left the upper portion of the sound gear (A) may be seen protruding from the liquifier (B) The electronic gear, shown at the right of the picture, operates as follows A trigger is generated by the A/R Radar Range Scope (C) simultaneously with the start of the sweep This trigger sets off the pulse generator (D) which in turn drives the tunable oscillator-amolifier (E) The resulting r-f pulse passes through the electrical impedance-matching network (not visible in Fig 1) and into the sound gear (A) A 15-Mc/sec quartz crystal immersed in helium at the lower extremity of the sound gear transduces the electrical signal into an ultrasonic pulse

Figure 2 is an interior view of this portion of the gear, and shows the crystal (G) which projects the pulse upward against the fused quartz reflector (H) also immersed in liquid helium. The returned echo is reconverted to an electrical pulse by (G) The position of the reflector with respect to the crystal may be controlled through a calibrated screw arrangement by means of the hand wheel (I) shown in Fig 1. Stirring is accomplished by means of the electric motor (L) and the stirrer (M)

The electrical r-f signal due to the echo passes through the impedance-matching network, encounters a series of attenuators (J) and thence arrives at the receiver (K) The resulting video pulse, applied to the range scope, provides the observable signal Velocity is determined from the increased time delay introduced in the echo by an increased sonic path length Absorption is determined by keeping the ultrasonic attenuation within the liquid helium compensated electrically i e., the echo signal strength is held constant as the reflector is moved

The low density and low sound velocity in liquid helium together result in a very low characteristic acoustic impedance, causing narrow crystal bandwidth and increasing the difficulty of generating acoustic waves The primary problem at present is to reduce signal fluctuations presumably caused by boiling, attributable either to heat conduction or acoustic energy The total range of acoustic power available is limited by cavitation in the helium

Thus far measurements have been made at 15 Mc/sec The velocity results agree with values previously reported by investigators[2] using continuous-wave methods Absorption coefficients measured above the λ-point (2 19°K) are in order-of-magnitude

1   J R Pellam and J K Galt "Ultrasonic Propagation in Liquids I Application of Pulse Technique to Velocity and Absorption Measurements at 15 Megacycles", RLE Technical Report No 4, also published in J Chem Phys. 14, 608 (1946)

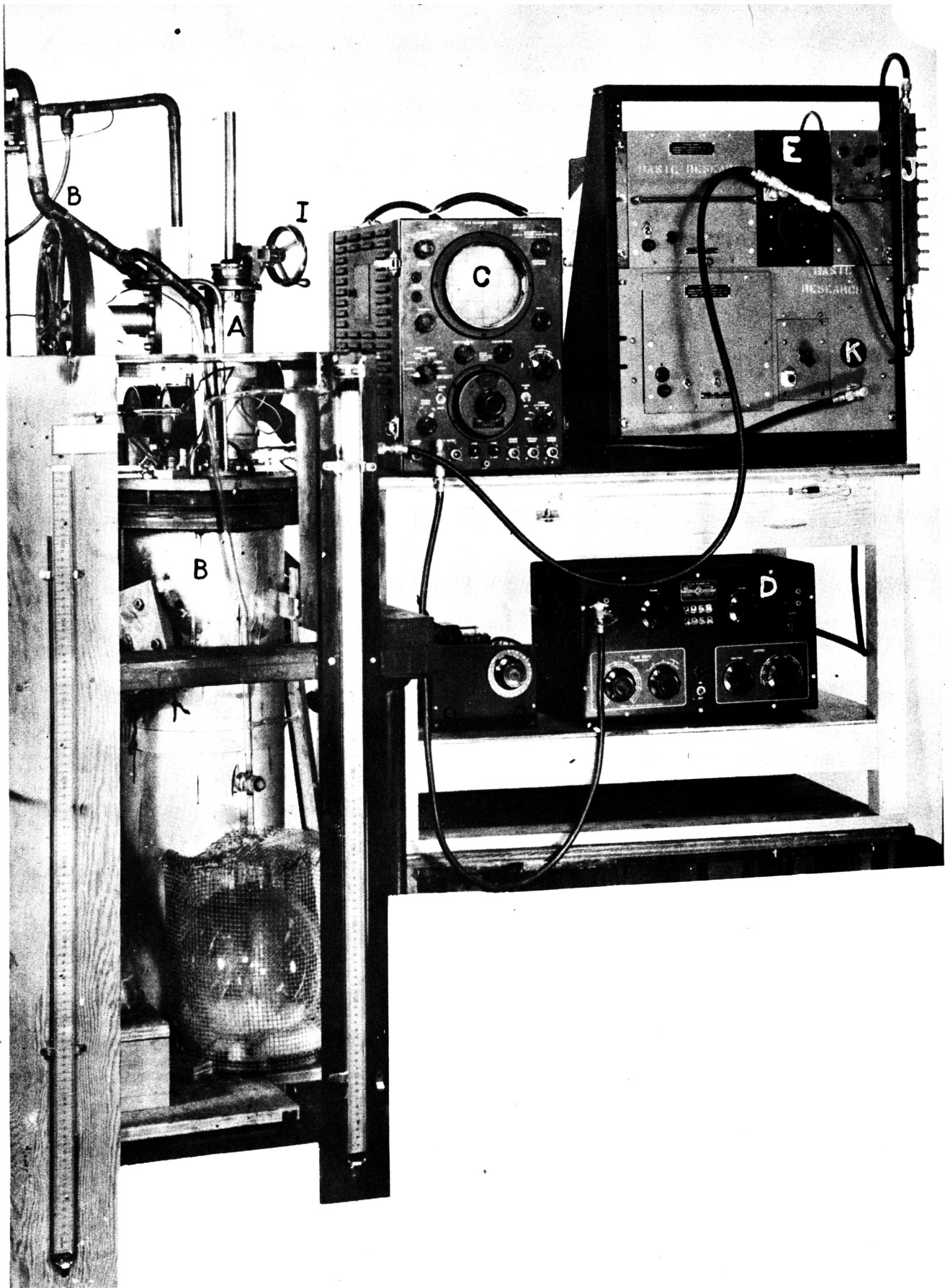2   J C Findley, A. Pitt, H Grayson Smith, and J O Wilhelm, Phys Rev 54, 506 (1938) 56, 122 (1939)

Figure 1. Low temperature and electronic gear. (A) sound gear, (B) helium liquefier,
(C) radar range scope, (D) pulse generator, (E) oscillator-amplifier,
(I) handwheel, (J) electrical attenuator, (K) receiver.
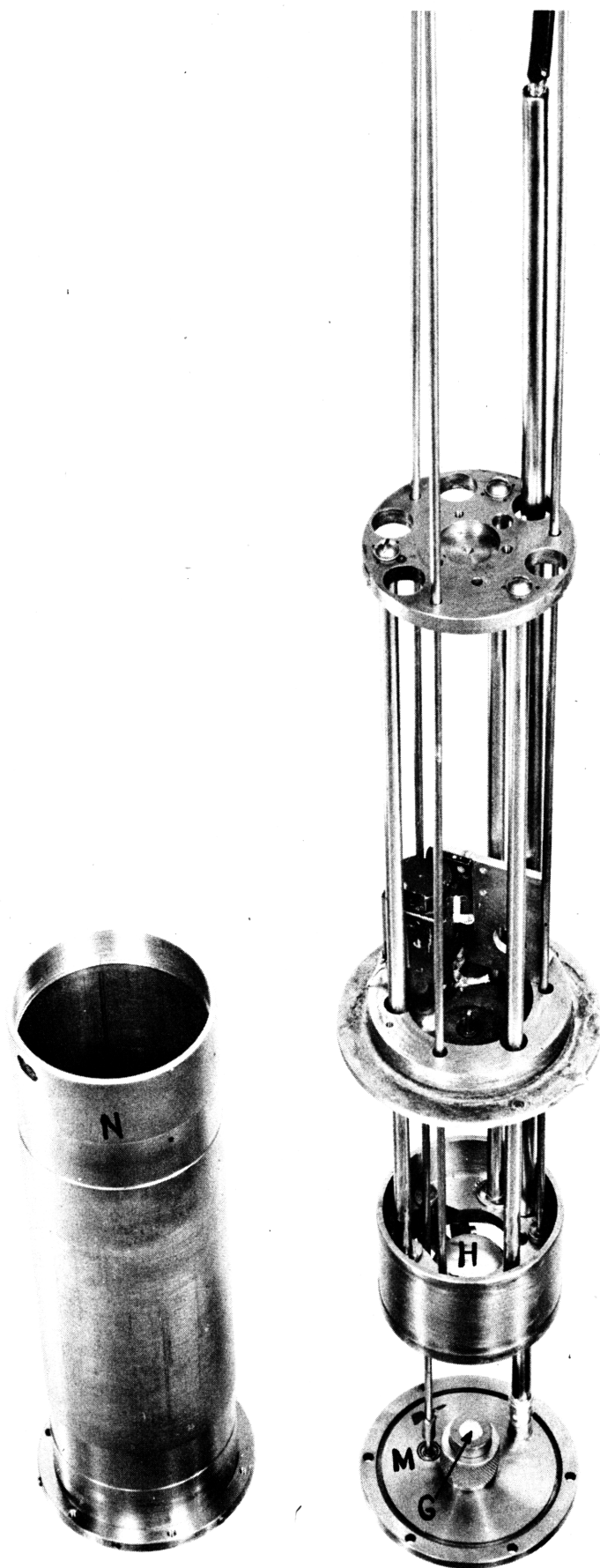
Figure 2. Transducer-reflector system (disassembled view).
(G) crystal, (H) fused quartz reflector,
(L) stirrer motor, (M) stirrer, (N) housing.

agreement with theoretically computed values based on viscous and thermal losses
A complete disappearance of the echo is ooserved in the immediate region of the
λ-point   Least absorption occurs just below the λ-point, the absorption again
increases as the temperature in He II is lowered (i e within the range thus far
measured)   The lowest temperature at which values have been obtained in these
experiments is 1 77°K

2. Absorption Measurements at 200 Mc/sec

Status   A quartz crystal operated at a high harmonic has been used to set up in
water ultrasonic waves of frequency 225 Mc   Crystal resonances have been measured
and show quite a strong increase in sharpness with order of harmonic   A program
of measurements over a wide band of frequencies is being planned and equipment is
being constructed for this purpose.

3 Absorption in Solids

Status   The main emphasis since the previous report has been on the design of
receiving equipment to operate continuously throughout the 1-100 Mc/sec region in
conjunction with the continuously variable carrier frequency pulse transmitter
mentioned therein

A review of possible receiving systems was made including such general
types as crystal video and superheterodyne   The latter was selected on the basis of
minimum detectable signal, ease of design, stability and convenience   In accordance
with this choice, the tuning unit of an AN/APR-1 receiver which operates from
40 to 100 Mc/sec is being modified to cover the desired frequency range

Before this work was attempted, an analysis of the complete loop (trans-
mitter, transmitting quartz crystal, acoustic load, receiving crystal, the receiver,
and in some cases, a transmit-receive switch) was made to determine the impedance
relations leading to optimum performance.₁ General equations were derived which are
applicable to any case under consideration   The system might comprise, for example,
(a) a single crystal for both transmitting and receiving with or without a transmit-
receive (TR) switch; (b) two crystals, thus separating the transmit-receive functions
(c) an acoustic medium in which length of sample under test can be varied so that
either single- or multiple-echo measurements may be made, (d) a fixed length acoustic
medium with which either single- or multiple-echo techniques may be used

A method for determining experimentally the loss upon reflection at the
crystal boundaries has also been worked out. This has not yet been tried so that
the accuracy is still not known   Knowledge of this loss permits correcting the
experimentally determined attenuation in the sample for the reflection at the surfaces
The theory indicates that the equipment now under construction will be roughly 70 db
more sensitive than existing equipment used for multiple-echo work

4 Relaxation in Paramagnetic Salts

Status   Equipment has been set up at 15 Mc/sec to observe the change in absorption
to be expected in solutions of paramagnetic salts under a magnetic field   This con-
sists of a bridge, one arm of which is a variable length acoustic delay line in series

with an attenuator   (The tank used for the liquid measurements reported in RLE
Technical Report No. 4 was slightly modified and serves as the variable delay line)
The other arm is a fixed delay line placed between the poles of an electromagnet
This second arm also has an attenuator in it   A pulser excites both arms at one end
and a receiver picks up the output from the other ends. The delay lines are filled
with the solution to be investigated and with the magnetic field off, the attenuators
and the length of the variable line are adjusted so that the signals from the two
arms of the bridge almost cancel each other in the input to the receiver. Then when
the magnetic field is turned on, the relaxation effect should produce a change in
this difference signal

The substance for which the largest effect is expected at 15 Mc is

$MnCl_2$ $4H_2O$ A two-normal solution of this was used in these experiments and no
effect was observed   A more concentrated solution would produce a larger effect, but
it would have too high an attenuation to transmit an adequate signal. The experimental
arrangement was such that an effect 50 db below the signal transmitted through eithei
arm of the bridge could be observed   Calculations indicate that the effect was down
55 to 60 db   Since the change in signal should be proportional to the square of the
magnetic field, it is hoped that it will be possible to repeat the experiment with a
larger magnet. The field used in this experiment was approximately 10,000 gauss

5   Attenuation in Single Crystals

Status   Equipment is being set up to make measurements correlating slip in single
crystals with sound attenuation   The first work will be done in NaCl and Al   Stresses
can be produced in sound waves of the same order as that which causes slip in the static
case in these materials   The question then is whether this means that sound atten-
uation will be a function of crystallographic direction, at least at high sound pressure
(or stress) amplitudes   Arrangements are being made to obtain crystals, and high-
powered pulsers are being constructed for the work at large signal amplitudes   It
should be mentioned that elastic constant measurements for these materials will also
come out of this work   This new method will thus provide a check on previous measure-
ments and permit data on some new materials to be obtained

6   Review Paper on Ultrasonics

Dr C Kittel

At the invitation of the Physical Society of London, a comprehensive review
has been written on ultrasonics research with particular reference to the properties
of matter in the gaseous, liquid, and solid states   The paper is to appear in
"Reports on Progress in Physics"

In the course of preparing the review, several original calculations were
made   Of particular interest   the Landau-Teller calculation[1] of the probability of

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1   L Landau and E Teller Physik Zeits Sowjetunion 10 34 (1946)

transfer of vibrational and rotational energy in gases was refined considerably by
use of the impact parameter method   A simple relation was derived between the
transfer probability and the vibrational frequency of the molecule, the result is
in qualitative agreement with a number of experimental findings

III   C   HIGH SPEED OSCILLOSCOPE AND HIGH VOLTAGE PULSE-MEASURING TECHNIQUES
        Staff   O   T   Fundingsland
                L   A   Harris
                D   F   Winter

Description of Project   The construction of two fast sweep synchroscopes capable of
measuring time intervals of 10^{-9} sec on single pulses has been completed.   Component
circuits have been tested in both units and found to meet design specifications   The
first unit has been successfully used for about 100 hours in several experiments in-
cluding measurement of rapidly rising voltage pulses applied to a 3-cm magnetron
load, and random noise generation in a 30-Mc/sec amplifier (designed by G E Duvall)
Status   Measurements of the input impedance of ten cathode-ray tubes, type K1017,
have been made at 150 Mc/sec.   The impedance was found to be capacitive and equiva-
lent to from 4 to 4 5 μμf   Measurements were also taken at 3000 Mc/sec, but at this
frequency there was no consistency in impedance from tube to tube   This project has
now been concluded and a detailed final report on it is in preparation (RLE Technical
Report No   27)

        D   DEVELOPMENT OF FLASH TUBE
            Staff   Professor H E Edgerton
                    B F Logan, Jr

Description of Project   Precision methods are being developed for measuring light
and electrical characteristics of the electric flash tube as used by the Air Forces
for night reconnaissance

        The program contemplates a careful study of overload charcteristics of
the tube   The object of these tests is to determine light-producing efficiency and
the fundamental physics of the flash tube so that a more efficient and useful form
may be developed
Status   By using an A/R ranging scope, oscillograms are being made of light
intensity and current as a function of time   during the discharge   A photoelectric
tube working into a cathode-follower circuit is used to feed a voltage proportional
to light intensity into the scope   The sweep is synchronized to trip when an
ionizing-voltage pulse is applied to the flash tube   Thus the oscillograms record
the ionization time of the tube

        A suitable network is being prepared to record the tube voltage as a
function of time during the discharge

Staff   J N Thurston
          P L Richman

Review of Previous Work   The Final Report of June 30, 1946 and the last Quarterly Progress Report have dealt with the progress made in the preliminary development of certain compact electronic units that are designed around subminiature tubes similar to those used in the proximity fuse   Some of the reasons for the development of such units are listed below

        a   Ease and speed in design and construction of complex circuits   All units to date have been constructed on an octal base so that they fit a standard octal socket

        b   Standardization of performance of the packaged unit

        c   Ease and speed of replacement of functional units in case of failure

        d   Decreased parts and labor cost in apparatus assembly

The units developed prior to the period covered by this report are

        a   D-c Amplifier No 1   This is a four-tube unit with cathode-follower output   The first stage is a parallel-balanced amplifier, with the circuit arranged to permit the subtraction of two independent inputs   No feedback is employed
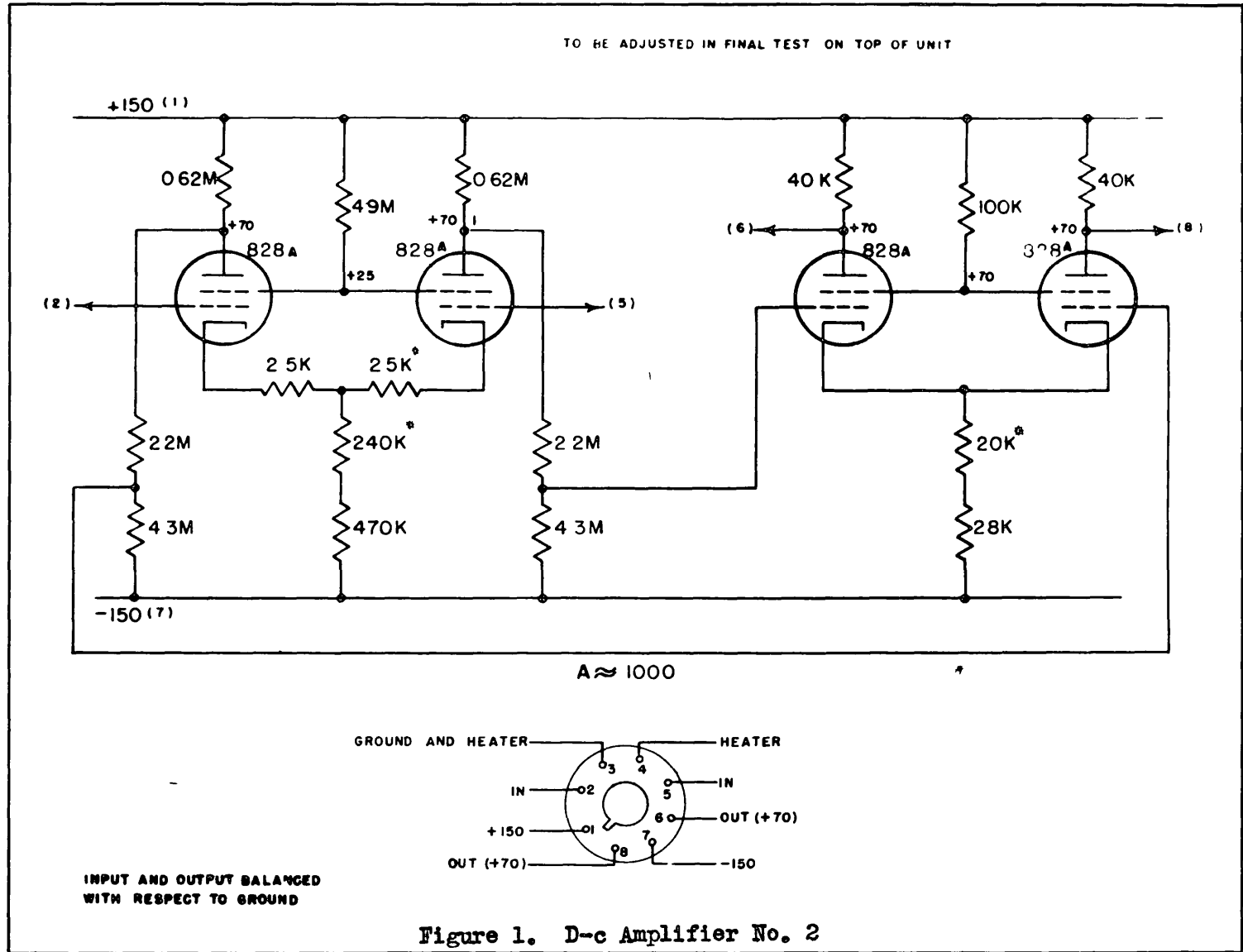
        b   D-c Amplifier No 2   This unit, which also employs four tubes, is similar to D-c Amplifier No 1 except that a second differential amplifier is used instead of the cathode-follower output stage   The operation of this unit is discussed in some detail later

        c   A-c Amplifier No 1   This is a three-tube amplifier with cathode-follower output   Negative feedback is employed to reduce the voltage gain from about 4000 to a standard value of 1000

        d   A-c Amplifier No 2   This utilizes two pentodes instead of triodes, but has a triode cathode-follower output stage   Here the voltage gain without feedback of approximately 10,000 is reduced to 1000 by adjustment of the feedback network   This circuit, which now practically supersedes A-c Amplifier No 1, has been adapted for tentative commercial production by Sylvania Electric Products Company

        e   Multivibrator Frequency Divider No 1   This unit, which employs three tubes, was designed to provide convenient means of obtaining timing pulses at frequencies of 20 10, 5, 1, and 1/5 cps

 e Units Developed and Tested   1 Direct-Coupled Amplifiers   As was described in some detail in the last Progress Report, a second design of the differential-input direct-coupled package unit amplifier was devised (see Fig 1) employing two pentode stages of differential amplification and having a relatively high output impedance (about 35K)   The entire package is the left-hand unit in Fig 2   This unit achieved an improvement over the previous design in that it was much less subject to fluctuations in the negative supply   These were introduced previously at the grid of the second stage, the first stage contributing but one one-hundreth of the amplification of the whole unit   This improvement is secured at the expense of sensitivity of

TO BE ADJUSTED IN FINAL TEST ON TOP OF UNIT

A ≈ 1000

INPUT AND OUTPUT BALANCED
WITH RESPECT TO GROUND

Figure 1. D-c Amplifier No. 2
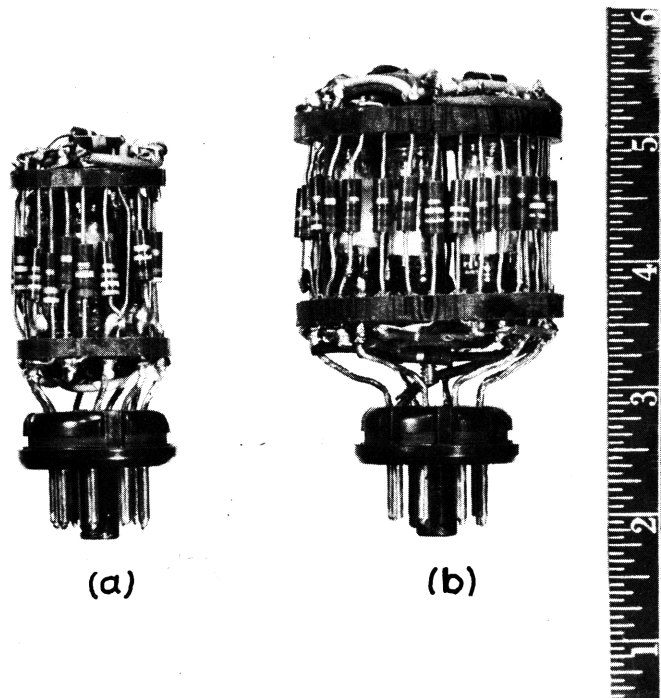
Figure 2. (a) D-c Amplifier No. 2
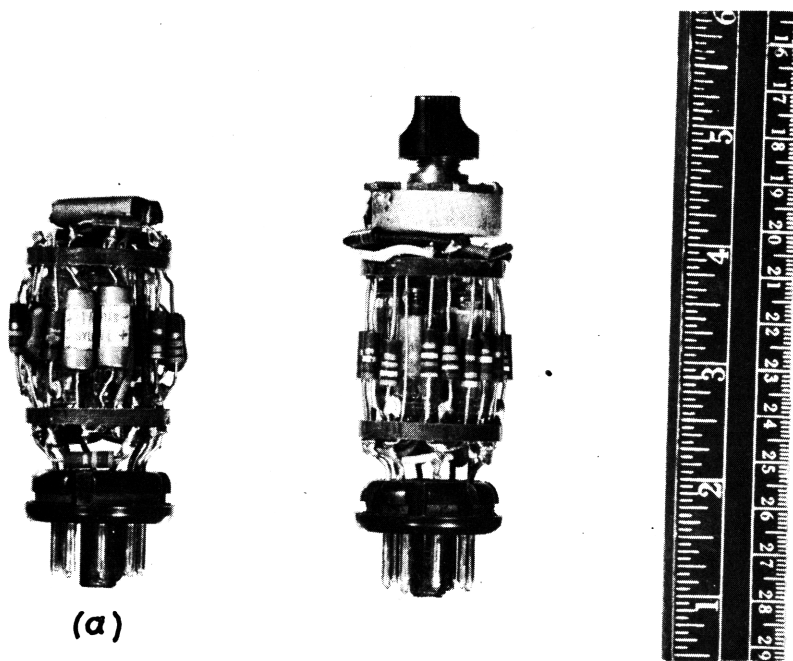   (b) D-c Amplifier No. 3.

Figure 3. (a) Square-wave Generator No. 1
            (b) D-c Amplifier No. 2 with
                incorporated potentiometer.

input grid balance, which is much greater with the new unit since the balance of the second stage depends on |A| times the balance of the first stage where |A| is the gain of the first stage   It is found that for an output-plate voltage difference of about 20 volts, the gain of the unit is reduced by 30-40 per cent   This is a serious disadvantage since it implies constant check of the output plates of each unit during the first few hundred hours of service   The gain of the unit is roughly 1000-1200, and input grid current is usually less than 0 005 μa with a noise level of 10-15 μv for a 10-kc bandwidth   The maximum differential formation (signal common to both input grids that will be just indistinguishable above the noise) averages about 1 mv for various units of this design which have been constructed   If balancing the tubes of the first stage with a suitable resistor network is accomplished, this figure may be increased to roughly 15 mv, corresponding to a crosstalk rejection or differential formation of about one part in 1000

Crosstalk rejection is an important feature of the differential amplifier which makes it suitable for use in applications wherein a voltage common to both grids - often larger than the signal - must be cancelled in order that the signal appear significant   It is expected that a differential amplifier unit capable of rejecting better than one part in 1000 will be packaged in the near future

Drift tests on D-c Amplifier No 2 give an average value for drift of about 2 mv/hr, with a flicker of approximately the same order of magnitude   (See Fig 4 for representative drift test as recorded on an Esterline-Angus recording milliammeter   Scales are 15 min/div and 2 mv/div   Drift is about 1 mv/hr in this particular run while flicker averages about 2 mv) A test unit of this amplifier incorporating a potentiometer appears on the right in Fig 3

In order to overcome the difficulties of (a) extreme sensitivity of gain to output plate balance, (b) sensitivity of unit to tube ageing, (c) high output impedance (d) sensitivity of output plate voltage balance to input grid bias, a direct-coupled amplifier was designed as an eight-tube unit, -- a radical departure from the four-tube and three-tube units designed and employed until now   There is still some doubt as to the practicability of employing more than four or five tubes in a single package, but the advantages of doing so for the direct-coupled amplifier seemed to warrant a trial   Subsequent use of the new unit in measurement applications (one of which is described later) offers some justification for the step   The diagram for the amplifier appears in Fig 5 and the unit as it looks when assembled is shown on the right-hand side of Fig 2, next to its four-tube predecessor

This latest direct-coupled amplifier has differential action in the first three stages, with separate cathode-follower outputs in order to facilitate closing the feedback loop, as well as to secure low output impedance when desirable   The first stage employs triodes (SD-917a) for two reasons   first so that the first stage gain will be relatively low and second in order to better the differential formation which improves by a factor of two or three when triodes are substituted for pentodes   The second and third stages afford the principal gain of the unit
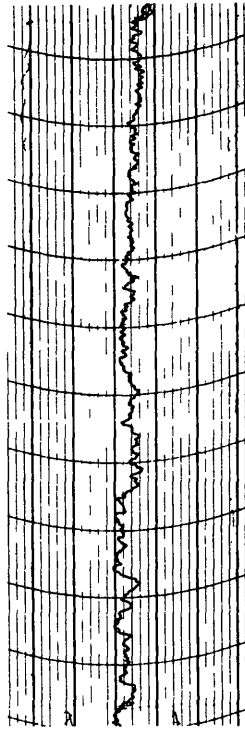
Figure 4   Representative drift test on D-c Amplifier No 2 as recorded on
Esterline-Angus milliammeter   Scales are 15 min/div and 2 mv/div

The open loop gain is about 2500 to 3000, which may be cut back to any desired value
(about 400 is advised in order to secure reasonable stability) by introducing feed-
back in the differential mode, closing the loops through the current-carrying tubes
as shown on the diagram   As a result of this feedback, it is possible to unbalance
the output by 20 volts or so with only a small percentage reduction in gain.

Provision is made for μ-balance in order to optimize the differential
formation (the 5M resistors in the first stage)   Gain balance may be secured in appli-
cations where it is necessary by means of adjusting the feedback resistors

Microphonics, grid current   noise, drift   and flicker are all about the same
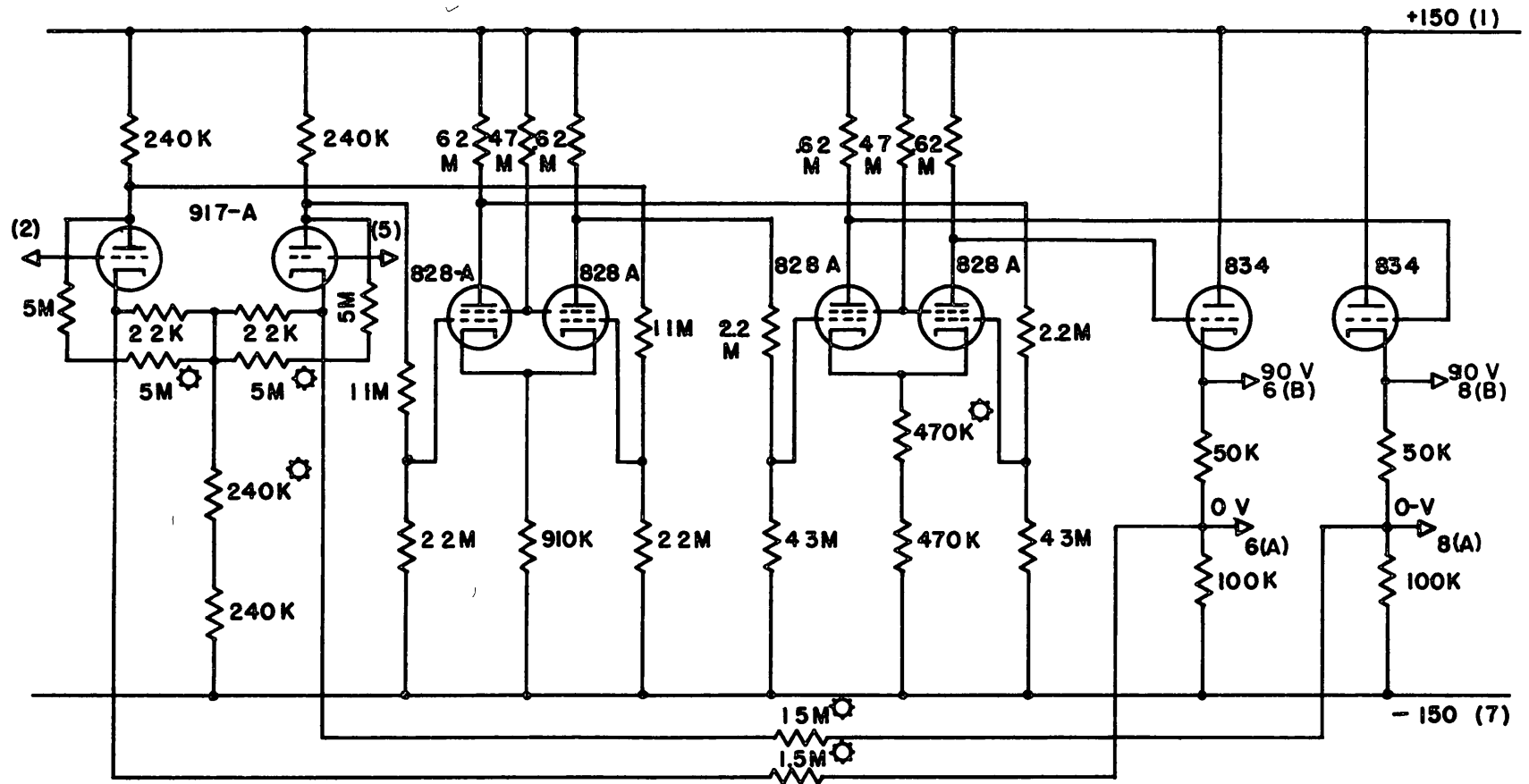for the D-c Amplifier No 3 as for the D-c Amplifier No 2

2   Square-wave Generator   The square-wave generator designed and constructed in
packaged form is only one of many possible types of such generators, and was selected
because it affords a demonstration of several techniques peculiarly adaptable to sub-
miniature package assemblies

The Germanium crystal diode is a relatively new feature in electronic
circuits,[1,2] and finds application as a substitute for vacuum diodes where a very large

1   B. Chance, "Some Precision Circuit Techniques Used in Wave-form Generation and
Time Measurement", RSI 17, 396 (1946).

2   W E Stephens, "Crystal Rectifiers", Electronics 19, 112 (1946)
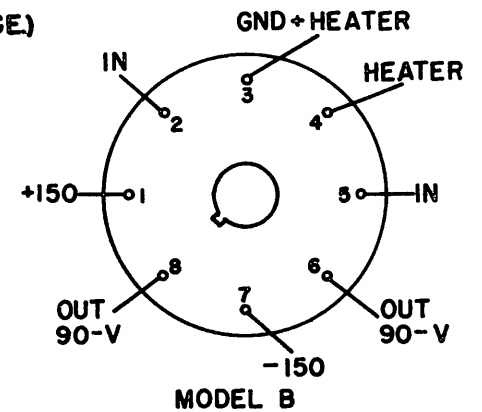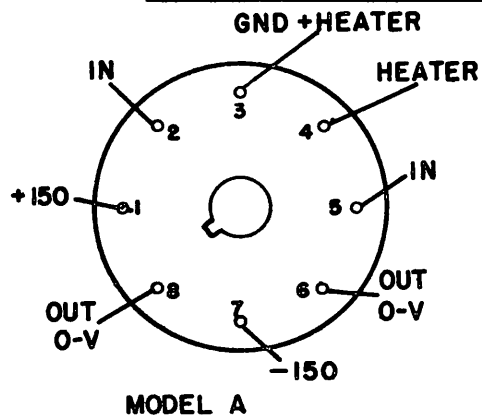
Figure 5   D-c Amplifier No 3

Figure 6   Square-wave Generator No. 1

+150 (1)

620K

917-A   917-A   834   834

(5)

(8)

5K

(3)

33K

47K   (4)   50μμf   10M   (2)

10M   50μμf   25K   25K

(6)

AS SHOWN ABOVE

GND AND HEATER

3   4   5   6

2   7   HEATER

+150   1   8   OUTPUT

※ON TOP ADJUST FOR WAVEFORM OR DESIRED SELECTIVITY

TO USE AS AN OSCILLATOR, CONNECT PIN 5 TO GND

TO USE AS A SELECTIVE AMPLIFIER, CONNECT INPUT
BETWEEN PIN 5 AND GROUND

Figure 7   R-C Oscillator-amplifier No. 1

reverse resistance is not required The advantage of the crystal diode in package assemblies is its small size and the fact that it has, of course, no filament dissipation The diagram of the square-wave generator appears in Fig 6 The coupling capacitor is fairly large electrically (0 1µf) but is of the "hearing-aid" or miniature variety and hence is physically quite small The entire unit is pictured in the left-hand side of Fig 3, showing the two Ge diodes (two are employed in series to effect a higher reverse resistance) in the main body of the assembly and the 0 1µf miniature coupling capacitor on the top

3 R-C Oscillator-amplifier No. 1 Many control and measurement devices require as a vital part of them a self-contained oscillator A package R-C oscillator-amplifier unit that utilizes the circuit of Fig 7 was developed to fill such a need The circuit is a cathode-coupled type, the frequency of which is determined by the constants of the ladder network shown between the second and third tubes. The output voltage from the second cathode follower is approximately 10 volts rms, when good sinusoidal waveform is obtained The frequency range can be extended above or below the frequency at which the circuit normally oscillates (about 300 cps) by means of external shunt resistors or capacitors Terminals 2 3 and 4 are provided at the socket for this purpose

When the circuit is used as an oscillator, terminal 5 should be grounded If this terminal is connected to an external signal instead the circuit can be used as an amplifier of adjustable selectivity The selectivity is controlled by the resistor used above to modify the waveform of the oscillator output The frequency is controlled just as it was for the circuit when used as an oscillator As indicated on the diagram, both the selectivity and frequency adjustments can be made externally as before

4 Voltage Stabilizers Work has begun and is almost completed on miniature stabilizer units with stabilized output voltages of plus and minus 150 volts, suitable for use with previously constructed assemblies using these supply voltages These units incorporate potentiometers for accurate adjustment, and employ a single stage direct-coupled amplifier to provide amplification of the error signal The circuit diagram for the -150-volt stabilizer appears in Fig 8 the +150-volt stabilizer is still in developmental stages

5 Null-indicating Gain Meter Employing Package Unit Techniques As an aid in the work with package unit amplifiers, both a-c and d-c, and as a demonstration of package unit techniques as applied to measurement problems, a gain meter was designed so that mid-band gains and frequency responses of the units already constructed, and any units which might be constructed in the future, might be measured accurately, rapidly, easily, and independently of the phasing of the output and input signals In its final form, the meter is a direct-reading instrument in the region of the null condition The circuit diagram of the meter appears in "ig 9 wherein package units are represented schematically The meter is simply a calibrated attenuator with a means for comparing the attenuated-amplified signal with itself When the null balance is secured, the gain of the amplifier unit in question is given by
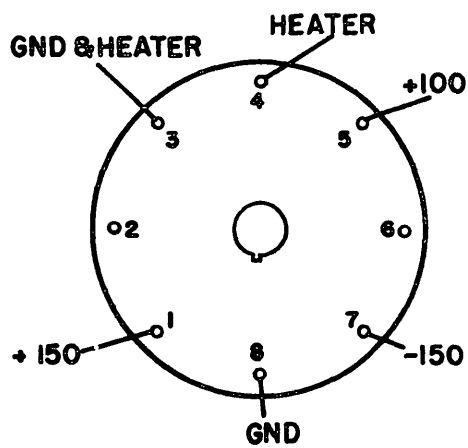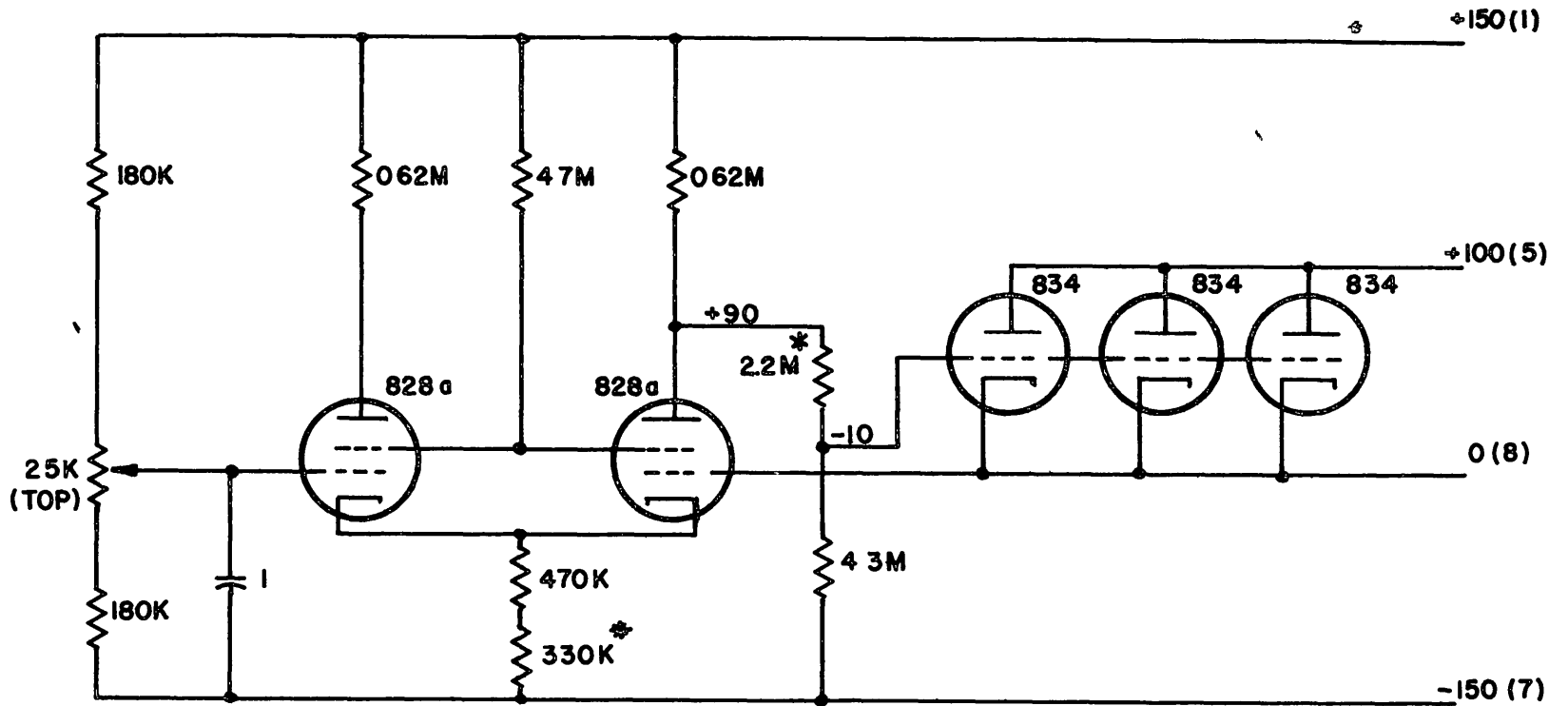
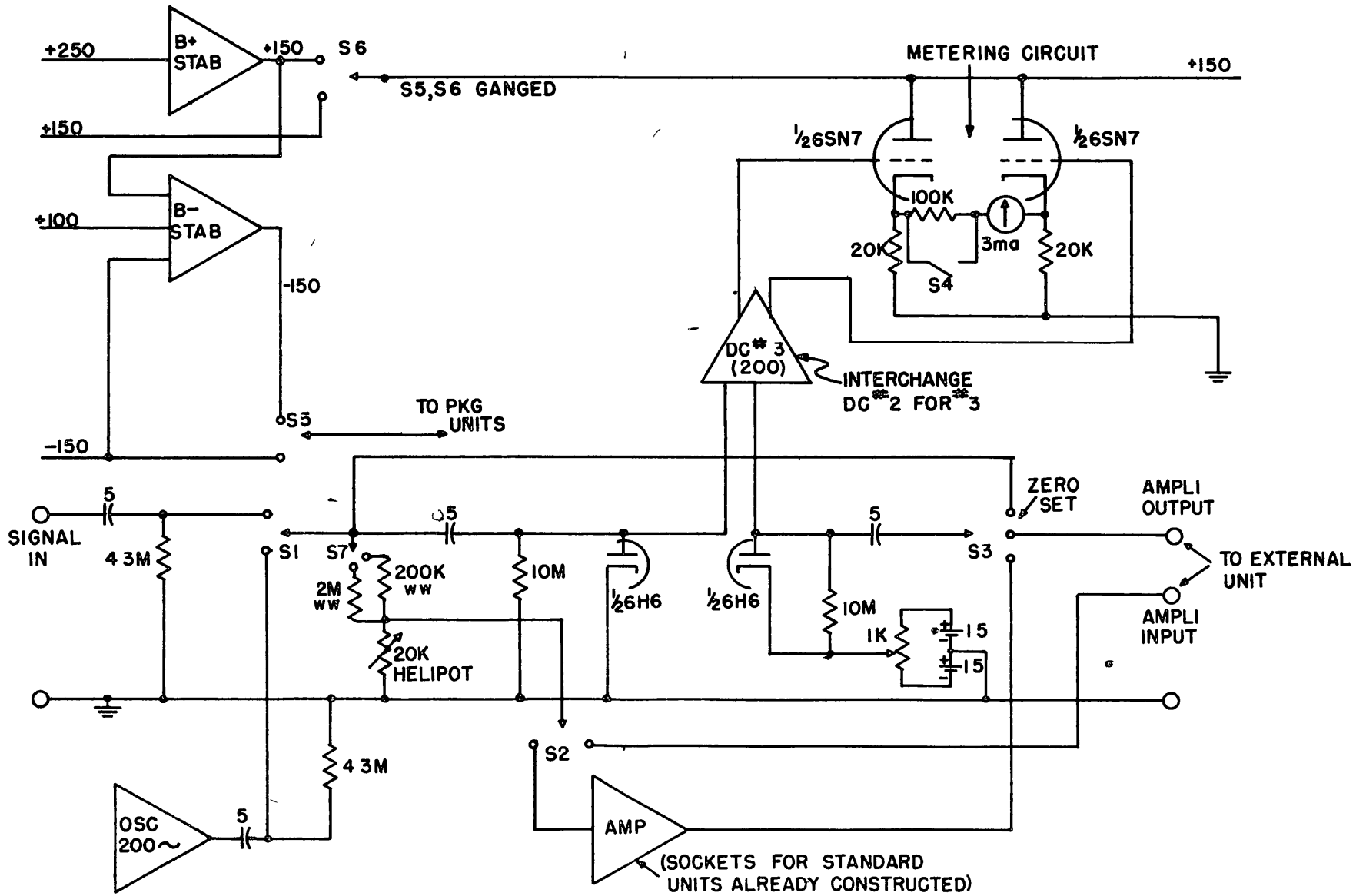Figure 8. B-Supply Stabilizer

Figure 9. Null-indicating Gain Meter

200K or 2M divided by the value of the 20K helipot, plus unity. Sockets equipped to handle already constructed amplifiers are incorporated in the meter, and arrangements are made for measuring mid-band gain - which often is all that is desired - by means of a package-unit oscillator previously described Means are also provided for the inclusion of the package-unit stabilizers - both plus and minus 150 volts - in the unit, so that the meter may be as independent of external equipment as possible

The meter as designed measures a range of gains from 10 to about 5000. In the region of null balance, maintaining the amplitude of the signal fixed while changing its frequency causes the meter to give a direct reading of the change in gain of the amplifier under test For this reason the instrument is adaptable for the recording of gain drift or variations A special dial is employed on the 20K helipot in order to secure a high degree of accuracy in the gain calibration.

      F   CYCLOTRON R-F DESIGN
          Staff   Professor G G Harvey
                 T Moreno
                 M Plotkin Brookhaven National Laboratories

Description of Project. The pupose of this project is to investigate the design of r-f resonant circuits suitable for large, frequency-modulated cyclotrons A variety of circuits has been proposed; the most promising will be more carefully analyzed, and experimental investigations conducted with the use of scale models at higher frequencies

The immediate object of the investigation is to design a resonant circuit for use with the 600-Mev proton cyclotron to be constructed at Brookhaven National Laboratories The magnet poles of this cyclotron will be twenty feet in diameter, and the operation frequency will be modulated over a range of 26 to 13 Mc/sec. It is most feasible at present to accomplish this frequency modulation with the use of a mechanically rotating condenser, giving a modulation frequency of 120 cycles

The large physical dimensions preclude the use of dee structures, such as are found in smaller, conventional cyclotrons. Cavity resonator techniques as developed at much higher frequencies are, however, applicable

Status A one-fifth scale model of one proposed resonator design has been constructed. Experimental checks of modes, tuning, and Q are being made and will be compared with the calculated values This resonator is essentially a quarter-wave section of flattened coaxial line, short-circuited at one end and open-circuited at the other The protons will be accelerated by the voltage developed across the open end of the resonator, and the frequency modulation accomplished by a pair of mechanically rotating condensers at the open end.

Staff   Professor J B Wiesner
H M Bollinger

<u>Description of Project</u>   In the development of the microwave sweep-frequecny oscil-
lator to be used in the measuring of component characteristics the problem of broad-
banding the detectors and directional coupler has been considered

<u>Status</u>   Load impedance of the bolometer detector has been determined experimentally
as a function of frequency   Investigation showed that load impedance is also some-
what dependent upon bolometer power level the impedance vs frequency character-
istics were taken at a relatively high power level, and at this level the power re-
flected from tre bolometer mount, due to mismatch, never exceeded 0 15 db over a
1C per cent bandwidth Taking similar data at the actual operating level of the
bolometer is difficult, as standing- ave ratio measurements at such a low level re-
quire a large probe depth which introduces error into the readings   Such error
is not believed to be greatly significant in this case and it has been assumed
that the bolometer reflects less than about 0 ?5 db over a 10 per cent bandwidth at
the actual operating power level Determination of similar frequency-response
characteristics of the thermistor mount used to measure the main generator output
showed an extreme dependency on power level Because of this the thermistor has
been abandoned, and an additional broadband bolometer is in process of construc-
tion in the machine shop

The problem of obtaining reasonably broadbanded detectors having been
dealt with attention has been shifted to the coupling characteristics of the
directional coupler used to sample the generator output power For accurate
sampling it is essential that the coupling coefficient be as frequency insensi-
tive as possible Measurements indicated a total variation of 0 5 db over the
10 per cent bandwidth, and these agreed within 0 25 db with theoretical calcula-
tions of frequency sensitivity Although not so important as coupling character-
istics directivity measurements have been made over the 10 per cent bandwidth
As expected there is a rather large variation with frequency from 33 db at the
high frequency end to 21 db at the low frequency end

F   THREE-C'1 SWEEP-FREQUENCY OSCILLATOR

Staff   R M Fano
R B Adler

<u>Description of Project</u>   For the investigation and alignment of microwave filters,
it is desirable that a relatively wide-band sweep oscillator be made available
The range of the sweep should cover approximately a 10 per cent band, and the rate
of sweep should be rapid enough to permit observation of the response on an oscil-
loscope Although work is already being done on a 10-cm oscillator, the 3-cm
application presents certain new features requiring separate investigation

<u>Status</u>   The Western Electric 2K49 tunable reflex oscillator furnishes the only
presently available 3-cm model of this type of tube with an external cavity The

design of an appropriate cavity for this application has been carried out, but final performance data on the oscillator are not yet available Preliminary tests have indicated that although the tube oscillates satisfactorily at about 3 cm, some revision of the coupling method is required to obtain sufficient output power

A rotatable vane which is expected to vary the frequency of the oscillator over the desired range is now under construction No tests can be carried out until the vane and drive-motor assembly are completed because of the small size of the cavity and the consequent close tolerances required in the alignment of the vane

The need for a broadband directional coupler led to consideration of a special type described in Sperry Report No 5224-1061 (by T Moreno), which should give a coupling constant of 20 ± 10 db over the band Design of such a directional coupler is in progress

The design of the reflector control circuit to work in conjunction with the available 1200-volt supply has been carried out, but construction will not be undertaken until more data on the operation of the tube are available