III. Modern Electronic Techniques Applied to Physics and Engineering

A. Studies Leading to the Design of a Microwave Accelerator.

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Problems which require study before one can apply microwaves to the acceleration of electrons and protons are:

1. The problem of coupling energy from a magnetron into a high Q circuit.

2. The operation of many magnetrons into a cavity system such that the proper RF phase relationships are maintained between the several magnetrons.

3. The coupling of many cavities together so that the coupled cavity system will be excited in one desired mode.

4. The problem of space and phase focusing of charged particles accelerated in a system of coupled cavities.

A systematic study has been begun of these problems separately with the goal in mind of a linear type accelerator in the hundred million volt region. It would be hoped that such a device would have advantages over cyclotrons, betatrons, and synchrotrons in cost of construction and ease of utilizing the final accelerated beam of charged particles. The following will indicate the manner in which these problems are being attacked, and the results so far obtained.

1. A tunable high power magnetron operating at a wave length of 10.7 cm. and pulsed at two microseconds has been coupled to a cavity with unloaded Q of 16,000. To prevent moding difficulties in the system, loss was introduced in series with the cavity such that 30% of the total available power from the magnetron was fed into this loss. The magnetron then locked to the cavity, and with about a megawatt of peak power produced, the electric field generated in the cavity was such as to produce a peak voltage of 2.2 million volts between top and bottom of cavity. The height of cavity was 5 cm. It seems reasonable to assume, then, that when a final assembly of cavities is made, it will be possible to couple energy from a magnetron into this system.

2. To study the locking of several magnetrons in phase, two magnetrons have been coupled in parallel and fed into a matched load. Phase-locking

has been accomplished under certain conditions of coupling, but a study of how the power output of this system will finally compare with what can be obtained from each tube individually has yet to be made.

3. A study is being made of frequency and shunt resistance of re-entrant cavities of such dimensions as to be suitable for proton as well as electron acceleration. Mode separation in a long system of coupled cavities is being studied as well as methods of shifting modes in frequency.

4. An electron gun capable of producing electrons with energies up to 300 kv is being assembled, and an analyzer for studying electron energy spectra has been built. It is hoped soon to send this electron beam through the cavity described above and to study problems of phase and space focusing with this gun.

III. B. Ultrasonics Research Program.

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The purpose of the ultrasonics research program is to develop the applications of radar techniques to the study of the mechanical properties of solids, liquids and gases at high frequencies. The two principal technical developments in radar are connected with pulse technique and microwave power supplies. Pulse technique applied to ultrasonic work enables the convenient and accurate measurement of the velocity and absorption of sound waves in different media, and to the possibility of detecting inhomogeneities in materials. Microwave power opens up for scientific exploration the whole region in the acoustic spectrum between the frequency limit of pre-war studies at about 100 megacycles and the lower limit of thermal vibrations at about 100,000 megacycles. This work is associated in part with the work of the Acoustics Laboratory under Profs. Morse and Bolt.

(1) Application of Pulse Techniques to Ultrasonic Measurements

The idea in the determination of acoustic properties by pulse measurements is to measure on a radar range scope the elapsed time between the application of an electrical pulse to a quartz crystal sound transmitter and the time the signal is returned to the transmitter from a reflecting plate. The signal strength is also measured. From the elapsed time and the round-trip distance the velocity of sound is computed. From the variation in signal strength with distance the attenuation is computed.

The velocity and absorption of sound at 10, 15, and 30 mc. in various related organic liquids are being measured to find the correlation with the chemical structure of the liquids. Equipment units designed for use in radar trainers and in supersonic delay lines have been used in making the measurements. Velocity measurements are made to an accuracy of 5 parts in 10,000 and absorption to 2 parts in 100, in favorable cases. The best previous absorption measurements are only reliable to about 50 parts in 100, so that the pulse method is a particularly important tool in absorption measurements. Thus far eleven liquids have been studied. This work is being reported on at the Cambridge meeting of the American Physical Society and at the New York meeting of the Acoustical Society of America.

Equipment is now being designed for the purpose of studying the acoustical properties of liquefied gases, including liquid helium. The low temperature phase of liquid helium (Liquid Helium II) will be particularly interesting because of its property of superfluidity and zero viscosity.

Some work has been done on the possible application of acoustic echo-ranging to the plotting of brain tumors. This is being carried on with the advice of Harvard Medical School.

A student of Professor P. W. Bridgman of Harvard is being trained in the laboratory as a preliminary to a measurement program on the acoustic properties of matter under high pressures. This program, to be carried out at Harvard, will utilize pulse methods at pressures up to 100,000 atmospheres.

(2) Ultrasonics at Microwave Frequencies

It is planned to try to drive quartz crystal transducers at both S and X band frequencies. The S band work is somewhat further along. Here a 750 kilowatt pulsed power system is used, employing a rotary gap modulator with a one microsecond pulse at a repetition rate of 400 per second.

Three possible ways by which vibrations may be detected are being studied:

(a) A cartridge containing a piezoelectric crystal with a fundamental frequency of 30 mc is inserted in the flat side of a wave guide. To one side of the crystal a fused quartz rod is soldered. When the cartridge is placed in the side of a tapered wave guide (tapered to obtain high electric fields across the crystal) it may be possible to set up vibrations which will be transmitted through the fused quartz and then reflected back to the crystal, which in turn will send a radar wave down the guide to the receiver.

(b) Optical examination of the quartz rod for diffraction effects, when excited either by a wave guide or a resonant cavity.

(c) A cavity has been designed similar in some respects to a T-R cavity in which the above cartridge may be inserted. It may be possible by measurements of the Q of the cavity to determine whether the crystal can be set into vibration.

Equipment has been set up at X-band which makes both high and low power r.f. signals available at this frequency. It is expected that it will be possible to scale to X-band any successful S-band transducer design which may be evolved.

A theoretical program on design considerations for transducers at microwave frequencies has made considerable progress. An analysis has been carried out on the problem of producing ultrasonic energy by coupling a piezoelectric crystal into a resonant cavity, and driving the crystal at a high overtone of its natural frequency of vibration.

It turns out that the calculated rate of production of sound energy for a voltage of one volt across a one cm thick crystal is about 8.8×10^{-5} watts per sq. cm. per sec, assuming that the piezoelectric mechanism of quartz is maintained at microwave frequencies. A study of equivalent circuits shows that the maximum power output occurs for critical conditions of mechanical loading of the crystal. For example, if the crystal fills the entire gap between the condenser plates of a resonant circuit it will impart energy most efficiently if the specific acoustic impedance of the test specimen is 0.07 of that of quartz. By leaving a gap between the crystal and the condenser plates the value of the critical loading may be varied at will.

III. C. High Speed Oscilloscope and Magnetron Moding

Staff: Mr. O. T. Fundingsland
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(1) High Speed Scope. This project was initiated under Radiation Laboratory auspices in October, 1944. The need for an instrument to measure times of the order of milli-microseconds became evident during an investigation of the abnormal behavior of magnetron oscillators in pulsed radar systems. In particular there seemed to be some correlation of the occurence of cathode sparking (and rf moding) in magnetrons which were subjected to voltage pulses which produced plate current rise times of the order of 3×10^{-9} seconds. The

time measurement was an extrapolation of the range of measurements then possible by complicated means inherently subject to errors.

The accurate measurement of "leading edge" effects was hindered by the scopes then available in two major ways: (1) sweep speed and (2) writing speed. The first limitation was removed by employing specially designed sweep circuits, the second by using a cathode ray tube built by A. B. DuMont in collaboration with the Radiation Laboratory. In an experimental test set-up sweep speeds of greater than 100 inches per microsecond and writing speeds upwards of 300 inches per microsecond have been obtained.

At present, progress is being made on the construction of two cabinet models of this fast sweep scope. It is hoped that the first of these two scopes will be completely tested and ready for experimental application by April 15, 1946. With present disposition of manpower the second scope is expected to be completed about September 15, 1946.

(2) Proposed Research. The new high-speed scope offers the possibility of measuring high voltage and high current pulses which have durations of the order of a few hundredths microsecond and rise times of the order of millimicroseconds. However, pulse attenuators of present design are not adequate for pulses shorter than 0.1 microsecond. Our preliminary objectives are to develop improved attenuators which will cause minimum disturbance of the pulse generator circuit, to devise improved methods of matching attenuators to cable and scope, and to obtain a quantitative evaluation of the fidelity of pulse response, (or video frequency response) of the overall viewing system. Ultimately, when the characteristics of an improved viewing system have been determined, it would prove desirable to perform brief survey tests with magnetrons, gas discharge tubes, etc. to determine the applicability of such direct viewing techniques to various problems in physics and engineering.

A series-compensated R-C voltage attenuator has been conceived which is expected to cause less disturbance of a pulser circuit than conventional capacitance dividers. Also, the use of an L-R compensating network at the cable input offers the possibility of an improved video match to minimize cable reflections. Tests will be made to determine optimum values of these circuit parameters.

Direct pulse measurements of the characteristics of various samples of viewing cable should be made.

It may prove necessary to modify the design of R-C differentiators for voltage rate-of-change measurements and of coaxial current viewing resistors.

Certainly the response of these attenuators and their disturbance of the pulse generator circuit should be investigated for short pulse conditions.

Simultaneous measurements of voltage and current pulses and of the time derivative of voltage should be made to obtain cross-checks of the several types of attenuators. This should be done with rapidly rising pulses, probably with a magnetron load.

A 15 kv pulse generator will be adapted to give rapidly rising pulses at the 1000 ohm impedance level, and the various types of attenuators will be calibrated and tested on both resistance and magnetron loads.

III. D. Electronic Instruments for Measuring High Speed Particles in Nuclear Experiments

Staff: Prof. M. S. Livingston
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Work is under way on three major detection problems encountered in nuclear reactions, namely:

1. Detection of gamma and beta rays and measurement of their energy.

2. Detection of heavy charged particles in high backgrounds and measurement of their energy.

3. Detection of neutrons.

In general, the design objectives are short resolving times (best probable minimum = 0.2 micro sec.) and fast recovery time to permit high backgrounds. High pressures will be used with the more penetrating radiation to increase the ionizing efficiency, and high fields to keep collection time short. Electron collection with high gain linear amplifiers is to be used throughout to eliminate the problem of slow positive ion collection. This method has been tested on standard counters and has been found to operate satisfactorily.

Gamma Ray Detection. A parallel grid proportional counter has been built for the detection of gamma and beta rays and is undergoing preliminary tests. It operates satisfactorily in the ionization chamber region with alpha rays but tests in the proportional range are awaiting construction of a purifier for the filling gas. This chamber is designed to operate up to twenty atmosphere pressure. Investigation of its operation as a Geiger counter will also be investigated.

Heavy Particle Detection. A precision multiple plate chamber using parallel geometry for detection and energy measurement of heavy charged particles will be ready for test this week.

Output pulses proportional in amplitude to the specific ionization at three separate intervals along the path are obtained from the chamber. These three outputs are amplified and compared in a circuit so that an output pulse is obtained only when the ionization has a predetermined value at each of the three points selected. That is, the Bragg curve of a particle to which the counter will respond can be set into the counter.

The pressure in the chamber is adjusted so that the path ends at the proper point and the Bragg curve is determined by two attenuator settings.

This device is expected to be very useful in such experiments as determining the number and energy of protons produced when a target is bombarded with a deuteron beam in the cyclotron. There is also a possibility of using it to detect low mass mesons.

A single multiple plate ionization chamber, using cylindrical geometry, has also been constructed and is being prepared for tests.

High Velocity Electron Detectors. The methods described for measurement of heavy charge particles are not applicable for electrons as their light mass and corresponding high velocities result in very sparse ionization. The use of pressures so high that window thickness would exclude the electrons would be required. Work has been done elsewhere using silver chloride as a detector in the dark at liquid air temperatures (requiring periodic reactivation). The detection in this case is performed through a process similar to the photo-conducting process.

Dr. F. C. Brown of this Laboratory has done work on the photo-electric properties of silicon crystals at room temperature, finding a rather high efficiency in the short infrared. It is hoped that by using these crystals, measurement of electrons may be possible, if the energy requirement per electron production is sufficiently low to offset the higher noise figure. Both effects are expected, but which will be of the larger magnitude is not yet known. The high drift velocity (400 meters per second) as measured by Dr. Brown and the high density of a solid are very vital factors in a detector for electrons.

Neutron Detectors. As the deuteron-neutron reaction is one of the more probable occurring when deuterons are the bombarding particles, an instrument to detect the number and energy of neutrons is of prime interest. Neutrons can of themselves cause no observable effects on matter, but secondary processes such as collision recoil or nuclear reaction can be observed. An instrument for measurement of neutrons of energy in the one-half million volt to twenty million volt range is being constructed. By measuring the ionization produced by a hydrogen nucleus struck by an incident neutron the energy of the neutron may be found if collisions in the forward direction only are considered.

Glyceral trystearate that has been vacuum distilled is plated onto a thin metal plate by a vacuum evaporation process. This is the source of the hydrogen nuclei. When incident neutrons strike this material the protons travel through a collimator (to obtain forward motion only) into the high pressure ionization region. The total charge collected by the plates of the ionization chamber is amplified as a pulse and amplitudes selected by a pulse height discriminator. In this way the number vs. energy curve for neutrons may be determined.

The chamber is now completed as well as the vacuum distillation apparatus and the evaporation chamber. The circuitry is completed and high pressure gas purifiers are now being awaited. Use of charged particles and a 1/4 microsecond pulsed X-ray tube will be used to determine electron attachment and drift velocities (collection time). Mr. Bridge of the Cosmic Ray Research Group will give us considerable help on this phase of the project as they are interested in the use of high pressure equipment for cosmic ray work. Vacuum equipment has been assembled to evacuate the distillation apparatus, the evaporator, X-ray tube, and the chambers for pure gas filling.

The use of high pressures (200 atmospheres) will necessitate rather high collection voltages so that less than one microsecond collection time may be encountered. This requires the construction of an r.f. power supply similar to that used in the RCA electron microscope but of lower current drain. The supply will be oil filled and give 100 microamperes at 40 kv. with less than one millivolt ripple. Parts for such a supply are now being collected.

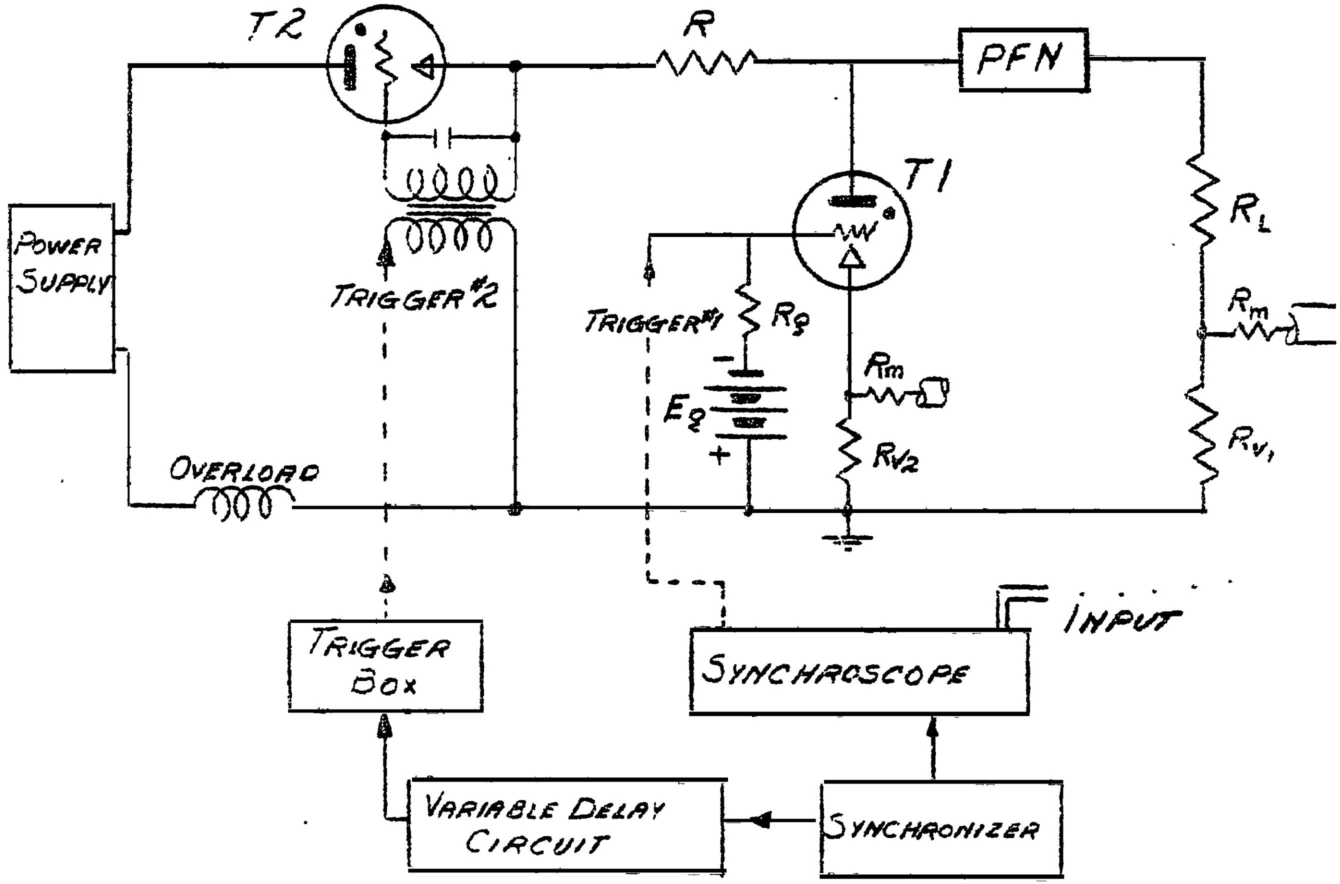
The use of pulsed cyclotron with slow neutron counters for measurement of velocities under one-half million volts is being considered but will not be started until the need is felt.

III. E. Measurement and Control of De-ionization Time in Thyratrons.

Staff: Mr. F. M. Verzuh
Prof. H. E. Edgerton (Adviser)

The initial stages of this work were devoted to the construction of the experimental set-up and the associated measuring equipment such as resistance-compensated dividers, constant-temperature bath, etc.

The most satisfactory arrangement for measurement of de-ionization time (hereafter referred to as $t_{\underline{d}}$) is shown below:



The thyratron T1 in the figure is the tube under test. Application of a variably-delayed trigger to the grid of T1 initiates the discharge of a constant pulse of current from the PFN, through the non-inductive load and T1. At some later variably-delayed time, a trigger is applied to the grid of T2 (charging tube). This allows the network to charge up. By sufficiently reducing the time interval between application of triggers, a point is reached at which time de-ionization of T1 has not been completed and T1 goes into continual conduction. The time interval between cessation of conduction in T1 and the minimum time t2 at which plate voltage may be reapplied to T1 without it going into continual conduction is defined as the de-ionization time of the tube.

Preliminary measurements were confined to the hydrogen thyratrons 3C45 and 4C35. The value of t_d is dependent upon applied grid bias, thyratron current, grid circuit parameters and gas pressure. The value of t_d for the 3C45 varies from 2 - 24 microseconds depending upon the above factors. Similar tests on the 4C35 gave values of t_d ranging from 10 to 40 microseconds.

In order to consider the effects of the nature of the enclosed gas upon t_d, various mercury thyratrons are under test. In this case an accurate control of the condensation temperature of the mercury, which governs the gas pressure, is essential to minimize erratic behavior. A constant-temperature oil bath is used for this purpose. The value of t_d for the FG67 varies from 30 - 50 microseconds. Other tubes which have been tested are the KU627 and the FG17.

Some of the remaining factors which strongly influence the value of t_d are the electrode geometry and orientation, specifically, the grid-anode distance, grid-cathode distance, areas of electrodes, the grid hole radius and the volume of the plasma discharge. There is some question as to the best approach in the evaluation of the effects of these parameters. Commercially available tubes provide some information on this; however, it seems that experimental tubes in which only one variable, e.g. grid-cathode distance, is varied would best provide quantitative data which may be intelligently interpreted.

It is felt that this method of measurement of t_d under dynamic conditions is superior to methods which are essentially static condition measurements. The obvious similarity of the above circuit to that used in line-type modulators is evident, and therefore the value of t_d thus obtained should be an accurate indication of the maximum operating frequency of the thyratrons.

III. F. Experimentation in Photoelectric Spectrophotometry

Staff: Dr. B. Chance

Apparatus is being developed for the measurement of a change of intensity of absorption at 380 and 420 µ with the response speed of 0.01 sec. and a sensitivity of one part in 10^5. This apparatus is to be used for biophysical experimentation on the mechanism of reaction of enzymes responsible for cellular respiration. But the apparatus design requires a careful study of the limitations of highly sensitive photoelectric methods, and is, therefore, useful for <u>general experimentation</u> along these lines. The various aspects of the research follow:

<u>Spectral Intervals</u>. The spectral shift to be measured represents a 30 µ shift of a band 50 µ wide at nearly constant intensity. Measurements are then made differentially by balancing the outputs obtained from two spectral intervals, each approximately 30 µ wide and centered at the wavelengths corresponding to the initial (380 µ) and final (420 µ) positions of the absorption band. Corning glass filters give spectral intervals of desired width with a reasonable optical efficiency.

Light Source. Comparative tests have been made of the suitability of tungsten and mercury arc sources for this purpose. Under a particular set of conditions, the light output from a Westinghouse S-4 mercury arc was approximately 3 times that obtained from a type C-8 exciter lamp. Operation of the tungsten filament at 50% greater than the rated voltage will give a light output roughly equal to that obtainable from the 100 watt mercury arc. A reasonable life is expected, suitable for the experimental conditions. It is hoped in further experimentation to use the 1 kilowatt water-cooled arc and also the Western Union Zirconium arc lamps. On the other hand, the stabilization of the intensity of these sources is not as straightforward as that of the tungsten filament.

Light Source Stabilization. The sensitivity required cannot be obtained from a light source operated from unstabilized power lines. A straightforward method of stabilizing the light intensity is by photocell control. A breadboard model of this has been based upon the amplifying circuits of the next section. The spectral characteristic and high intrinsic sensitivity of the S-4 surface make it highly desirable for these purposes. No attempt has been made to employ electron multiplier photocells in place of the ordinary high vacuum type, as the published figures on photo-sensitivity for the multipliers is roughly 1/3 that of the ordinary type. As sufficiently large light intensities are used to make the intrinsic photo-sensitivity the limiting factor and not the thermal agitation noise of the input circuit, the ordinary tubes are more suited to these needs.

Amplification Techniques. A survey of available amplification techniques has been made. Direct coupled amplifiers have been rejected because of two important difficulties: (1) drift (2) flicker or "island emission" noise. While considerably improved circuits are available for d.c. amplification, drift rates on the order of several μv/min are the best presently obtainable. For operation at the desired value of sensitivity and bandwidth, the full scale output must correspond to a signal of 10 microvolts, thus giving a drift equal to the full scale in several minutes. The other consideration, flicker noise in the first stage, would reduce the resolution obtainable by a considerable factor.

For this reason, carrier amplification schemes have been tested, first, using the Brown Converter at 60 cps. because of its established stability, and later employing direct modulation of the photocell supply voltage at higher frequencies. Satisfactory 60 cycle carrier amplifiers have been made having noise levels which are roughly in accord with the theoretical values in view of the input impedance and bandwidth employed. For example, peak noise voltages of 0.2 μv were obtained with a bandwidth of 40 cps. For these purposes plug-in types of subminiature tube amplifiers and twin-T selective circuits have been employed.

Performance Data. No data have been obtained with the complete apparatus operating at peak performance, but several fragmentary bits of information give some indication that the desired end may be achieved. For example, a breadboard light control circuit and photocell amplifier operating at the desired spectral intervals has given an overall dr't rate measured at the output of the photometer corresponding to 1 part in 13,000 per minute. It is believed that the required factor of improvement of 10 may be easily obtained by more carefully built apparatus, as these experiments were made with inadequate electrostatic shielding and improper control of the bandwidth of both the measuring and light control circuits. The signal to noise ratio under these conditions permitted an intensity discrimination of one part in 60,000.

Summary. A sensitive photoelectric spectrophotometer operating differentially between the bands of 380 and 420 µ is under construction. With preliminary designs of light control and measuring circuits using type C-8 exciter lamp, a sensitivity of one part in 60,000 and a stability of 1 part in 13,000 per minute of the differential intensity between the two spectral intervals was obtainable. Future work is directed towards the completion of an engineered design of the present apparatus and the investigation of more intense light sources.

III. G. Liquid Filled Chamber to be Used in the Photographing of Very High Energy Ionizing Particles

Staff: Dr. W. H. Bostick

The preeminent utility of a high pressure Wilson cloud chamber in studying the creation and decay of mesons and associated processes is common knowledge to physicists acquainted with cosmic rays and nuclear phenomena. The building of a high pressure cloud chamber is a difficult, expensive and time consuming engineering feat.

The aim of this particular project is to create in a liquid bubbles of gas or vapor along the path of an ionizing particle, thereby rendering the path of the particle visible. A liquid filled chamber designed to accomplish this process will be called, for lack of a better name and because of the aptness of the colloquialism, a "fizz chamber."

The various proposed schemes for creating the bubbles have been described in a hectographed note entitled <u>Fizz Chamber</u>, W. H. Bostick, December 15, 1945. The apparatus which is now being built is designed to reduce suddenly the pressure on a liquid by opening a valve which permits the air (at atmospheric pressure) above the liquid to flow into an evacuated chamber. It is hoped that the bubbles may be formed of the liquid's vapor rather than by gas coming out of solution, because the former process obviates the necessity of redissolving gas in the chamber before each successive release of pressure. The apparatus has now been in the shop for two weeks and the machine-work is about one-third completed.

Obviously, if the number of ions formed in the liquid by ionizing particles are to be a large percentage of the total number of ions in the liquid, the amount of dissociation in the liquid must be vanishingly small. The conductivity of normal hexane given by the <u>International Critical Tables</u> is $\sigma < 1 \times 10^{-18} ohm^{-1} cm^{-1}$, and it is stated that the conductivity is reduced when the chamber is covered by a "lead mantle." At 760 mm Hg pressure normal hexane boils at 68° C, and at 186 mm pressure, it boils at 20° C. The chamber which has been designed in this project will provide a sudden change in pressure from 760 mm to about 75 mm. It is hoped that the liquid hexane will vaporize along the path of ionizing cosmic ray particles which penetrate the chamber approximately coincident with the release of pressure.

A clearing field will, of course, be used to clear the chamber of unwanted ions which are formed during the time between pressure releases.

Pending the completion of the machine work, library work is being carried out. Two interesting German papers have been uncovered on the embryonic build up of additional phases in supersaturated systems.

III. H. Synchrotron Project

Staff: Prof. I. A. Getting

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Mr. J. S. Clark

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Note: This project has been transferred (with personnel) to the Laboratory for Nuclear Science and Engineering.

A joint venture for the production of high energy Beta and Gamma rays was set up by the Electronics Laboratory and the Laboratory for Nuclear Science and Engineering -- January 1, 1946. A study was made of the known and suggested methods for producing high energy electron beams. It was concluded that the induction generator, commonly referred to as the Betatron, was the most successful existing piece of equipment. However, the high cost of such a machine for extremely high energy particles, 300 mev and above, and the difficulty resulting from radiative losses at energies in excess of about 200 mev, indicated the desirability of investigating the Synchrotron. The Synchrotron, suggested independently by V. Veksler in the Journal of Physics, USSR, 9, 153, 1945, and E. W. McMillan in the Physical Review, 68, 143, 1945, showed promise of attaining energies of the order of one billion volts and costing less to manufacture. Therefore, it was decided to develop and build a Synchrotron.

A design figure of 150 million electron volts was chosen rather arbitrarily, representing a reasonable compromise between the usefulness of the device and the cost of the first development. A preliminary design figure indicates that this requires an AC magnet weighing approximately 30 tons and a 12,000 kva condenser bank. The orbit diameter is one meter at a magnetic field of 10,000 gauss. A high frequency oscillator at 95 mc is required as the primary source of power for the electron beam. It is estimated that approximately $2\frac{1}{2}$ kw will be required at this frequency.

The following points have been reached as of March 15, 1946:

1. The design constants of the magnet have been settled.

2. Drawings and specifications of the magnet have been prepared and submitted to two companies for bids.

3. Permission to use Room 24-041 for the installation has been obtained.

4. Modifications of the room have begun to provide office space and a concrete mat 20' x 20', 1000 lbs. sq. foot loading.

5. Measurements have been made on two types of cavities at 100 mc.

6. A decision was made to use a single tube triode in an oscillator similar to the light-house type of cavity oscillator.

7. A bank of condensers originally intended for use by the Army in night aerial photography has been secured (through the efforts of Professor Edgerton).

8. A steel rack with enclosure and cooling facilities has been designed and contracted for.

9. Work has begun on the design of self-synchronous timing circuits.

10. An investigation has been started on the use of ignitrons for controlling single cycle operations involving the flow of 3000 amp. at 17 kv.

On or about March 1, 1946, a decision was reached between Professors Stratton, Director of the Electronics Laboratory; and Zacharias, Director of the Laboratory for Nuclear Science and Engineering that the nature of the project fitted more closely into the program of the Laboratory for Nuclear Science and Engineering. Therefore, the project was transferred wholly to the jurisdiction of that laboratory