RESEARCH AND DEVELOPMENT BOARD
Committee on Electronics

This report has been approved by the Panel and has served as the basis for the Program Guidance Recommendations of the Committee.

2 December 1949

Panel on Components

PROGRAM GUIDANCE REPORT

PART I

As mentioned in LCP 17/3 dated 10 January 1949, the Panel and its Subpanels have drafted a Master Plan Program for Components including all projects considered to be essential to round out a balanced line of components with respect to both the old and newer requirements which are set up by operating environment conditions and equipment objectives. The plans of these Subpanels are combined in the attached document LCP 17/4.1. This document puts particular emphasis on that portion of the program that is not yet undertaken because of lack of funds.

PART II

1. Operational Category of Master Plan

The field of component development and research is now assigned category SR-6(D) in the master plan for research and development. This category should insure its having priority 2. However, appraisal of its importance in this category requires that the program on components be considered in the light of the following peculiar circumstances. The operational requirements common to many of the new weapons and devices demand a practically complete line of new components. This is a major undertaking which, under the most favorable conditions, would require periods of time much longer than those required for the electronic equipment or the tactical devices themselves. This time matter requires that component development and its companion research and development in materials receive first importance in category SR-6(D).

2. Deficiencies of Present Components in Meeting Requirements

The trends in design and application of new weapons, military vehicles and electronic gear for them, demand components meeting several requirements which are not met by any existing standard types. These are: (1) operating ambient temperatures over the range from -55°C (-67°F) to + 200°C (392°F); (2) improved reliability and stability; (3) reduction in size and weight, and (4) adaptation to packaged sub-assemblies.

LCP 17/4 (cont'd)

During the post-war period some progress has been made toward these objectives but due to insufficient funds the situation today is that very little of the component development in the post-war period has reached the commercial introduction stage.

3. Present Research and Development Program in Support of Requirements

3.1 It is considered feasible to develop components in all classes which will meet these requirements.

3.2 The military value of this program is the ultimate successful realization of new weapons and vehicles such as rockets, supersonic planes, personnel, radios, etc., and the greatly reduced maintenance effort in forward areas.

3.3 At the rate of progress of the components development program during the past three years, there is a very small probability of a successful outcome in a period of less than ten years. This is regarded as wholly unsatisfactory and hazardous to the success of all programs involving electronic equipment.

3.4 There is no escape from carrying out this component development program.

3.5 The program does not contain any duplication or work of questionable value.

3.6 A primary factor interfering with the effective conduct of the components program has been and is, the lack of sufficient funds provided by the Services.

4. Conclusions and Recommendations

The Panel has come to the conclusion that administrative levels in all three Services have not emphasized sufficiently the importance of development and research on components. This conclusion is based on observations of the insufficiency of funds as well as the delay in releasing funds until late in the fiscal year. The latter tends to result in errors in framing the technical objectives of specific projects due to the haste with which contracts have to be negotiated and placed. It also creates uncertainties throughout each fiscal year as to whether the Services will actually undertake projects for which they have assumed technical responsibility.

The Panel strongly recommends that the Committee on Electronics take appropriate steps to urge on all three Services the need for a more realistic and orderly approach to the matter of providing funds for component development. The Panel appreciates that in any fiscal year each

Service may be unable to get all the funds it desires for all the development programs planned. This unavoidably leads to the necessity of choosing between the urgent and less urgent. The Panel feels that component development projects should get high priority in this choosing process, because they are basic for the success of all electronic equipment, particularly those involving miniaturization and extremely high temperature operation.

The Panel urges that the following steps are vital and essential to place component development in its proper perspective:

1. Each Service should provide funds on a high priority basis for component development and actually earmark and allocate them at the beginning of each fiscal year.

2. Fixed minimum amounts should be assigned to development on components and materials within each Service so that the total for all Services combined should be a minimum of six million dollars per fiscal year. Because of the accumulation of projects previously recommended and not activated and the gaps which should be filled it is desirable that the total annual funds should be approximately 10 millions. The amount for each Service should bear a proper and reasonable relation to the total sums allocated in each Service for research and development of electronic equipment.

3. In cases where one Service is selected to perform or sponsor component and materials development work for one or both of the other Services, arrangements should be made for the prompt transfer of funds to the selected Service at the beginning of each fiscal year. This assumes that each Service budget its own needs regardless of whether it sponsors or carries out the work.

Research and Development on Electronic Components
As Planned and Coordinated by Panel on Components,
Committee on Electronics, Research and Development Board

Component parts are collectively the common denominator of all types of electronic equipment. There is hardly a single electronic equipment development project that does not depend fundamentally upon prior research and development programs on component parts. This common denominator characteristic of component parts starts early in the nascent research stage of electronic equipment programs and follows through to the final electronic equipment programs and follows through to the final electronic equipment end item delivered for use by the Armed Services.

Components must be provided for radar, countermeasures, communication, acoustics, and other systems. The aim should be to provide components adequate for system requirements, rather than to have systems characteristics excessively limited by the characteristics of available components. System people will produce pattern of trends of physical parameters which must be administered to by the components engineer at least two years prior to the design of the equipment.

Electronic circuits and associated mechanical devices, control elements, protective items, and in fact all the operating sub-assemblies in a complete electronic equipment designed for use by the Armed Services frequently are limited in reliability, length of useful life and ease of maintenance by the shortcomings of available component parts.

Many advanced electronic equipment developments, particularly in relation to miniaturization, impose the need for the development of new component parts capable of operation at elevated temperatures (200°C. or higher), at extremely high altitudes (up to 400,000 feet for guided missile applications) and of withstanding increasingly severe thermal and mechanical shocks, to name only a few of the more stringent requirements.

These needs apply not only to special purpose electronic equipments but also to more "run-of-mine" designs. For these latter designs, too, the development of a satisfactorily improved version is largely contingent upon the performance capabilities of the component parts available at the time of starting the improved equipment development.

For the administrative levels in the electronics groups of each of the three Armed Services this component part availability need imposes a definite obligation to insure that adequate fund allocations are made from fiscal year to fiscal year to permit component part research and development projects to lead electronic equipment needs by a period of two years or more. Only by such advance scheduling will it be possible to make improved component parts available on time to satisfy new electric equipment developments.

This request for a two year or more time lead for component part research and development programs is considered reasonable in view of the following facts:

1. Component research and development programs impose a necessity for synthesizing various engineering and technical arts. Such programs in many instances can be achieved only through the joint and integrated reports of a working team of, for example, metallurgists, ceramists, physical chemists, plastic specialists as well as electrical and electronic engineers.

2. The indispensable prerequisites to many of these component part programs are research studies in the fields of dielectrics, insulating materials, semi-conductors, magnetic materials, conductor materials, resistance alloys, lightweight metallic alloys, organic finishes and so forth.

The progress made to date in relations to component part research and development programs under the purview of the Panel on Components is described briefly in the following paragraphs. The descriptions are given for several series of component parts grouped in accordance with the fields of interest of the several Subpanels.

TRANSMISSION LINES

A continuous assessment of development programs is being made to provide the Armed Services with manufacturable designs of transmission line and associated component parts to implement the needs of forthcoming and future radar and allied electronic systems. Such programs are planned primarily to satisfy the requirements of radar and similar electronic systems and of their integral source oscillators as these are achieved. Additionally, these development programs must be planned to anticipate desirable future electronic system trends and the future transmission line requirements for transmitting and receiving oscillators which stem from such trends. The objective of all programs is to provide transmission lines adequate for new or improved systems requirements and early enough to permit their integration into such systems, thus insuring that the performance of these systems will not be limited by the performance or non-availability of the transmission line component parts. The Panel on Components feels that certain very important transmission line considerations flow inevitably and immediately from the existing and projected upsurges in the ranges and speeds of vehicular weapons being developed for possible future warfare, that is, of guided missiles, jet-propelled aircraft and other high-speed or supersonic vehicles.

Both in terms of defense and offense these increased vehicular weapon speeds predicate "early warning" electronic aids having much greater range performance. In the case of radar this increase must come largely through very appreciable increases of transmitter power (up to megawatts). Transmitter powers in the megawatts as applied to present or to new designs of radar systems are limited to maximums largely predicated by the performance capabilities of the waveguides or coaxial conductors involved. Similar limiting effects are imposed by the capabilities of high voltage pulse cables.

Present developments in radio frequency transmission lines and associated component parts provide waveguides and some waveguide fittings in the frequency range up to some 100 Kilomegacycles (Kmc)/second and capable of covering a 40% band. These waveguides will operate at power levels commensurate with breakdown levels of 15 to 30 Kilovolts/cm at sea level pressure. However, past experience shows that when a waveguide structure or fittings of any complex configuration are employed the breakdown level drops by a power ratio as high as 3 to 1. Some waveguide fittings are available for the 12% band, although their use is by no means universal. Other fittings are limited to a very few percent in bandwidth. Research is in progress to broadband existing fittings such as connectors and tees to make them usable over a 40% bandwidth.

These previously mentioned power and bandwidth requirements' place added emphasis on connectors and fittings with increased smoothness in impedance characteristics (low voltage standing wave ratio ("VSWR"), and several waveguide fittings with those improved characteristics are under development.

Stress will be placed in the development program on transmission lines to obtain satisfactory operation over a temperature range of perhaps -70°C to +200°C., coupled with other extreme conditions such as humidity, salt spray and dust. Minimal size and weight component parts, lower loss waveguides for use at the higher frequencies and a more comprehensive line of component parts for the various frequency bands will also be emphasized.

It is clear that the expeditious development of new or improved, high power, broadband transmission lines is dependent upon a synchronized development program in megawatt electron tubes and more detailed and accurate information concerning advanced needs of the megawatt radar equipment development programs.

CAPACITORS

Basic research and development work has been started on two types of capacitor dielectrics. This work is necessitated by the fact that there are no available commercial dielectrics which will satisfy requirements for the development of high temperature operating capacitors having capacity versus volume factors equal to or better than present types under JAN specifications.

In general, progress has been made in terms of improved characteristics for JAN type capacitors, but little has been achieved in developing capacitors required for extended temperature operating ranges encountered in new designs of all types of electronic equipments. An emergency would catch this country in an unfavorable position in relation to producing these high temperature capacitors in large quantities.

COILS, INDUCTORS AND TRANSFORMERS

Progress has been made in reducing the size and weight of power transformers for operating in 85°C. ambient by employment of a 115°C. temperature rise, resulting in a maximum permissible operating temperature of 200°C. Contrasted with 125°C. maximum operating temperature transformers, the average weight and volume of the 200°C. transformers was 38% of the 125°C. units. In the case of reactors the 200°C. types had 60% of the weight and 45% of the volume of their 125°C. counterparts.

Work has been completed under one project relating to the detection and measurement of corona in power transformers, and the study of the dielectric properties of a large number of insulations as affected by frequency, temperature, voltage and humidity.

Studies are under way of the properties of old and new magnetic alloys as related to completed cores used in transformers. The results of this study should provide realistic design data on such properties.

Another development project is producing samples of video transformers of extended frequency ranges and is providing generalized response curves which bridge a gap between electronic equipment circuit engineers and transformer design engineers, enabling the latter to design close tolerance transformers.

Another project has developed 456 Kc transformers of good electrical characteristics in a volume of only 0.475 cubic inches.

Another project has provided pulse transformers design data which can be converted readily into a very useful design manual.

FREQUENCY CONTROL DEVICES

Most of the research and development effort in this field is directed toward the improvement and extension of frequency range of the quartz crystal resonator as a frequency control device. Other studies, however, include magneto-striction, cavity resonators and printed circuit L-C pairs.

A study of the performance of crystals as a function of surface contours has produced results which are conducive to improved crystal performance and control of crystal operating characteristics. Findings having long-range significance have resulted from a study of oscillator circuits.

A study is under way in relation to methods and instrumentation required for the synthesis of quartz.

Substantial progress is being made in discovering means for controlling the aging of plated crystals.

Investigation is being made of the feasibility of improving overtone crystals in the range 75 to 125 megacycles per second.

A study of circuits for use with overtone crystals (above 100 Mcs./sec.) is leading to clarification of the problem and has produced to date one new and useful circuit.

Efforts are being made to increase the utilization of natural quartz by developing means for removing twinning.

Progress being made in the synthesis of quartz is sufficient to permit the removal of quartz from the list of critical materials in view of the present stockpiling.

Miniature crystal units packaged in miniature holders (1/2" x 3/4" x 1") have been achieved for satisfactory operation up to about 85°C.

Progress is being made in the measurement, specification, and control of the properties of crystal units for the aid and guidance of test equipment groups.

The current problem presently deemed most urgent is to improve means for the direct control of frequencies above 75 Mcs./sec. which control is needed for a number of specific electronic equipment applications. In this connection it is felt that a three year development period will be required to reach an upper value of 225 mcs./sec. and an additional three years to reach 450 mcs./sec. which is viewed as the ultimate limit for quartz.

Consideration is being given to initiating additional development work on frequency control devices at frequencies in excess of 1000mcs./sec.

DIELECTRIC MATERIALS

In the broad field of research on insulations, a large amount of fundamental data has been obtained on ferroelectric materials; dielectric properties of insulating materials up to 3 x 109 cycles per second; elastic breakdown of gases from low pressure to the liquid state; and breakdown studies with ultra-high-speed impulses.

One study project has yielded a theoretical correlation of the dielectric constant and power factor of some solid insulators, a theory explaining the crazing of polystyrene and other plastics, a basis for the production of satisfactory linear high polymers from cyclic compounds, a basis for the production of elastomers by curing low molecular weight polymers to high polymers, a basis for polymerization by use of diradical initiators, and a basis for the quantitative correlation of the mechanical properties of polymers with molecular structure.

Methods under this same study contract have been developed to cover:

1. Measurement of power factor and dielectric constant of insulating materials at radar frequencies.

2. The study of the various factors involved in arc resistance and tracking in insulating materials.

3. The determination of the impact strength of insulating materials.

Work performed under this same study contract has led to the development of:

1. One type of melamine-resin glass-cloth laminate having superior insulating properties even when wet, and a second type for low dielectric loss applications and having excellent wet-insulation properties.

2. Melamine-resin paper base laminates having superior arc resistance and one type of which is suitable for punching operations.

3. A transformer potting compound prepared from castor oil and diisocyanates.

4. A catalyst for silicone resins which greatly reduces curing time.

Work at the National Bureau of Standards has resulted in the following:

1. Methods and materials for shortening the gel time and final cure of NBS Casting Resins.

2. Study of new materials (in experimental quantities) for their dielectric properties.

3. Examination of high temperature characteristics (short time exposure at 200°C. or 500°C.) of various commercial dielectrics.

4. Determination of electrical properties of high polymer materials from 60 cycles to 9000 megacycles per second.

5. Measurement of electrical properties of gases at frequencies up to 24,000 megacycles per second.

In the general field of dielectric materials silicone resin dielectrics have been developed which are now being used widely for high temperature applications to electrical motors, generators, transformers, switch gear, wire and cable.

Melamine resin dielectrics have been developed and are now in general use for electrical power and lighting applications.

Phenolic asbestos molded dielectrics have been developed and are displacing phenolic cotton materials for electric power and lighting applications.

Polyethylene dielectrics are being applied widely to R.F. and other type cables and the yearly production of this material shortly will reach 50 million pounds per year.

Improvements are being made in glass fiber reinforcement for use in various insulating materials.

Progress is being made in the study of the changes in the dielectric constant and loss factor of certain plastics with time, and of the chemical deterioration of polyvinylformal.

Outstanding progress is being made in the synthesis of new fluorinated styrene monomers and electrical grades of catalysts.

To meet aircraft antenna housing and radome needs a high temperature resistant, polyester-glass, low pressure laminate possessing high flexural strength at 500°F. and possessing sutiable dielectric properties at microwave frequencies has been developed and rain erosion has been improved by the application of neoprenes as an outer coating.

Progress has been made in the synthesis of polygranular mica which is a low loss, high machineable material.

Ceramic plates have been dry-pressed from calcines of a series of barium-strontium titanates for application to multiple-plate, temperature-compensated capacitors.

Fundamental research and development work has been done in relation to the structure and changes of structure of titanates especially in relation to fabricated thin sheets.

Considerable progress has been made in improving the non-wetting characteristics of ceramic surfaces.

Considerable work is being done to improve the thermal endurance of various ceramic dielectric materials.

ELECTRO-MECHANICAL DEVICES

A relay has been developed which is hermetically sealed and capable of operation over a temperature range from -65°C. to 200°C. at altitudes up to 70,000 feet, and weighing only 2 ounces.

A sealed socket for miniature tubes has been developed which will permit mounting tubes externally to a sealed, pressurized assembly.

Work is in progress to develop an improved version of the existing A-N electrical connectors with relation to reducing corrosion effects, number of separate parts, efficacy of sealing and reduction in size among other characteristics.

A low speed shaft seal (up to 50 rpm) has been developed that can be incorporated in the mounting bushing of such devices such as potentiometers, variable capacitors, rotary switches, etc., without any increase in size. This seal is a gasket seal which will seal satisfactorily up to a pressure of 15 psi.

Considerable progress has been made on the development of an 8 position sealed ratary switch (up to 15 psi). The electrical rating is 1/2 amp at 500 volts.

Positive progress has been made on a miniature, sealed, magnetic circuit breaker of approximately 1½" x 1" x ½" having ratings of 10 milliamps to 10 amps in the same case size.

A miniature, sealed, high speed polarized relay has been developed. This relay is especially suited to teletype and other high speed communication equipment.

A satisfactory sealed plug and jack assembly (3 contact) has been developed which can be used on equipments other than switchboards.

METERS AND INSTRUMENTS

A ruggedized meter has been developed which will withstand shocks in excess of 300 g and vibration in excess of JAN Specifications.

A voltage indicator of the neon type has been developed which is accurate within seven percent and can easily be made in mass production.

Gaps in Programs on Components

Essential projects recommended by the various Component Subpanels and not yet initiated are given below:

This portion of the program has not been undertaken because of lack of funds:

1. I-F and R-F transformers and coils; exploration of new design methods for.
2. I-F and R-F transformers and coils; development of miniature units for 200°C operation.
3. Pulse transformers, high power; development of units with good moisture resistance yet capable of operating at high temperatures.
4. Pulse transformers, high power; development of units which will operate over a wider range of pulse widths.
5. Pulse transformers, miniaturized type; need for development of.
6. Gas-filled transformers; exploration of possibilities of.
7. Transformers for operating temperatures in excess of 300°C; development of.
8. Dielectric materials for high temperature operating transformers in excess of 300°C; development of.
9. High dielectric constant ceramic materials suitable for use in capacitors for wide temperature range (-55° to 200°C); development of.
10. Ceramics for electron tube structures; improvement of.
11. Dielectric materials for radome applications; development of.
12. Terminal assemblies for various components; improvement of.
13. Ceramic to metal seals; need for extensive development of.
14. Dielectric materials, plastic films, for wide temperature range (-65 to 250°C); development of.
15. High conductivity alloy having low value of temperature-coefficient-of-resistivity; need for development of.

16. Frequency control devices and filters; need for development and improvement of test and production methods for (300 Mc and up).

17. Frequency control devices and filters; need for work on miniaturization (300 Mc and up).

18. Frequency control devices and filters; need for control of characteristics of operational circuits (300 Mc and up).

19. Frequency control devices and filters; development of fabrication techniques.

20. Frequency control devices and filters; inadequacy of work for wide temperature range, aging, increased band width, increased frequency range, and pioneering research on.

21. Electro-mechanical devices (e.g. circuit breakers, relays, switches); need for work on miniaturization of. R-F selector switches are a specific example.

22. Electro-mechanical devices; need for development of components with high shock resistance.

23. Electro-mechanical devices; work needed on adequacy of seal of.

24. Electro-mechanical devices; development needed to meet high temperature (200°C), operation of.

25. Relays; improvement needed to withstand vibration of.

26. Sockets and connectors; inadequate work on those components, require considerable work particularly from standpoint of sealing and miniaturization of.

27. Meters and instruments; additional work needed on sealing, miniaturization, and shock resistance of.

28. Meters and instruments; need for reduction of new designs to production and inclusion in development models of electronic equipment.

29. Meters and instruments, materials for; additional work should be done on permanent magnet materials both from the standpoint of improvement of magnets and the reduction of the use of strategic materials such as cobalt.

30. Magnetic materials; further work indicated on development of core materials for high frequency components, such as R-F and I-F coils.

31. Resistors, composition and wire wound; need for further work on temperature coefficients, noise characteristics, and capability of operation at elevated temperatures.

32. Resistors; need for improvement of all types for higher frequency, application of.

33. Rectifiers; need for work for high temperature application, hermetic sealing, miniaturization of, and higher voltages types.

34. Capacitors; development work to extend temperature range of all types without increasing size of.

35. Capacitors; need for work on sealing problems at high temperatures.

36. Capacitors; need for improvement of temperature coefficient of capacitors for higher stability circuits.

37. Capacitors; further work needed to make glass, vitreous enamel and other mica capacitor substitutes available for.

38. Capacitors; need for work on capacitors having improved overall characteristics of smaller size, higher Q, higher operating temperature, and lower temperature coefficients of capacitance.

39. Capacitors, fixed ceramic types; need more work to improve temperature, voltage, and frequency characteristics of.

40. Capacitors, variable; need for development of standard series having sealed enclosures, gas or liquid-filled, suitable for usual transmitter receiver applications with particular emphasis on high stability.

41. Packaged sub-assemblies; need further development of a universal and encapsulating material for unitized construction of.

42. Packaged sub-assemblies; further development and adaptation needed for potting and encapsulating compounds.

43. Packaged sub-assemblies; development to improve interconnecting means with particular emphasis on plug-in arrangements.

44. Packaged sub-assemblies; need further development of packaged power supplies for.

45. Cooling; further work needed on heat transfer problems and development of components to cool equipment in view of miniaturization and high altitude operation.

46. Finishes; need for developing corrosion protecting high R-F conductivity type of.

47. Higher than present power R.F. and pulse lines, need for development of.

48. Extremely broadband lines to enable proper development of extremely broadband tunable systems, need for program on.

49. Component development needed for improved transmission line systems, need for.

50. Magnetic amplifiers, need for listing of available types and characteristics of, survey of military requirements for, and for standardization of.

51. Development of laboratory type measuring equipment for electronic components, need for. (Examples of particular deficiencies are as follows: the measurement of the temperature coefficient of capacitance, inductance and resistance; the measurement equipment for determining the effects of vibration and shock on components; the measurement of noise and frequency characteristics of resistors; the improvement of Laboratory measurement equipment as regards accuracy, wider ranges of temperature, frequency, and more continuous recording of characteristics as conditions are being changed, and the need for more automatic equipment for performing the measurements, particularly from the standpoint of saving man-hours and reducing the man-hours of highly skilled personnel is indicated.)

52. Dielectric material, need for development of a domestic source of very high purity aluminum for hard dry oxide coat capacitor dielectric to complete the present development of this type capacitor.

53. Dielectric material, investigation of availability and for development of extremely thin (-0002 in. thickness) and super-density (1.25) Kraft tissue for capacitor dielectric.