BIBLIOGRAPHY

Numbers such as Div. 7-112.11-M1 indicate that the document listed has been microfilmed and that its title appears in the microfilm index printed in a separate volume. For access to the index volume and to the microfilm, consult the Army or Navy agency listed on the reverse of the half-title page.

PART I

Chapter 1

1. *Corrections Necessary in Aiming a Machine Gun, Mounted on an Airplane, at a Moving Target,* J. R. Moore, K8064695, General Electric Company, June 1941.

   A good exercise in vectorial methods, and some fundamental ballistics for aerial gunnery, by one of the most active workers in this field.

2. *Gyroscopic Lead Computing Sights,* Report to the Services 13, NDRC Section D-2, August 1941. Div. 7-112.11-M1

   An exposition, on fundamental grounds, of the technique of lead computing, principally with regard to a single "disturbed" gyro of the eddy current dome variety. Derivations of the familiar formulas are included, as also is a compete physical interpretation of the theoretical steps.

3. *An Introduction to the Analytical Principles of Lead Computing Sights,* Saunders MacLane, OEMsr-1007, AMP Memo 55.1, AMG-Columbia, March 1944. AMP-503.6-M21

   Mathematically rigorous and accomplished treatment of the classical lead computing dynamics. Fundamental concepts are explained and developed to show the current stage of the theory. A glossary of notation (with translations) and a good bibliography are included.

4. *Pursuit Courses,* Walter Leighton, OEMsr-1007, AMP Memo 57.4, AMG-Columbia, Mar. 29, 1944. AMP-503.7-M1

   A study in detail of such courses, in the air and with respect to the target, with thoroughgoing rigor. Both pure pursuit and that with lead are treated, although "mushing" is not considered. Tables are included for several standard approaches.

5. *The Extrapolation, Interpolation and Smoothing of Stationary Time Series,* Norbert Wiener, OSRD 370, Research Project DIC-6037, Report to the Services 19, NDRC Section D-2, MIT, Feb. 1, 1942. Div. 7-313.1-M2

   An extension of some Russian work, using the methods of communications engineering, statistical theory, and Fourier analysis. The author's earlier work is relevant hereto. Not so difficult to read as is commonly supposed.

6. *Statistical Method of Prediction in Fire Control,* Norbert Wiener and Weaver, NDCrc-83, Report to the Services 59, Research Project 6, Dec. 1, 1942. Div. 7-112.2-M2

   Contains a discussion of some of the results of reference 5 above, and of their probable importance in the prediction of straight flight and of flight which is accelerated in various ways. Comparisons among known methods of prediction are included, together with certain historical material.

7. *An Exposition of Wiener's Theory of Prediction,* N. Levinson, OEMsr-1384, AMP Note 20, AMG-Harvard, June 1945. AMP-13-M21

   Develops the autocorrelation function more gradually, showing that the linear prediction problem reduces to that of the solution of an integral equation. Practical and mathematical difficulties in application are discussed, and errors in prediction are interpreted in mathematical form.

8. *Collision Courses by Method of Overcorrecting Changes in True Bearing,* (Capt.) V. A. Kimberly, USN, Letter to Chief BuOrd from Special Board on Naval Ordnance, September 1927.

   This letter gives an elementary explanation, in terms of surface vessels, of the method named, and shows how and why the method leads to a straight interception as the range closes up. There are not many such explanations available in the literature.

Chapter 2[a]

1. *Electrical Simulation of the Human Operator in Tracking Mechanisms as an Aid in the Study of Sight Dynamics,* R. H. Randall and F. A. Russell, OEMsr-1237, TR T-13, NDRC-Section 7.2, Columbia University Division of War Research, June 21, 1945.

   A report on work originally urged by the present writer. The attempt is described to employ a proposed representation of the operator ϕ in lieu of the real thing for laboratory tracking experiments.

2. *Investigation of the Operator's Response in Manual Control of a Power Driven Gun,* A. Tustin, C. S. Memorandum 169 (British).

   A review of this memorandum is given in the report last mentioned.

3. *Tracking Aircraft with Heavy Turrets,* Merz and McLellan, British Liaison Code WA-1711-1.

   Sets up and studies the hystero-differential equations which result for the ensemble when a direct time delay is attributed to the human operator. Conditions for stability and learning are considered somewhat qualitatively.

4. *Some Characteristics of Human Operators in Control Systems,* K. J. W. Craik (Cambridge University), Ministry of Supply Informal Panel on Servomechanisms, British Liaison Code WA-1641-6, Great Britain, Feb. 4, 1944.

   Apparatus and techniques are described whereby the human operator was studied when performing with direct tracking. Curves of pursuit agree substantially with those obtained in our laboratories. The effects of the excellence of the display and other psychological aspects of the problem are discussed. Also, the transient and harmonic methods of investigation are compared.

5. *The Conduction of the Nervous Impulse,* Keith Lucas, Longmans Green and Company, revised, 1917.

   Contains evidence that nerve conduction, in the large, is a linea- phenomenon, the time relations therein being apparently inder pendent of the strength of stimulus. (This is contrary to the popular conception.) Reflex phenomena are discussed as being a local affair connected with the nerves themselves.

6. *The Mechanism of Nervous Action,* E. D. Adrian, Eldridge Reeves Johnson Foundation, 1931 Lectures,

[a] The reader's attention is called to the related bibliography included in the list for Chapter 1. The writings of H. Whitney on tracking, which have been promulgated by AMG-Columbia of the Applied Mathematics Panel, should also be referred to. Whitney's views, which are arrived at through a minimum of quantitative experiment and a maximum of personal intuition, are nevertheless worthy of attention. Although most of his work has been in connection with turrets, see also his AMG-Columbia Working Paper 329, of Dec. 13, 1944, *Notes on the Tracking Problem for Fighter Planes,* which advances explanations for some of the anomalous results observed in this kind of tracking. For quantitative material, with extensive collation and analysis, relating to the man-machine interactions with standard types of tracking with lead-computing sights, see the rich body of literature which has accumulated under the program sponsored by Section 7.2 at The Franklin Institute. This work will be reported upon fully by S. H. Caldwell, J. B. Russell, and H. C. Wolfe of that section. For the contractor, the psychologists Preston and Irwin, who have been protégés of S. W. Fernberger at the University of Pennsylvania, were in control of the experimental and analytic procedures involved, and their reports are models of exhaustive disclosure and of zealous adherence to the dictates of the data.

Press of the University of Pennsylvania, 1932.

In this book evidence is given, and is referred to there as *proof*, that the workings of the nervous system are not beyond mechanical description.

7. *Pursuitmeters: Alcohol and Human Efficiency*, W. R. Miles, Carnegie Institute Publication.

Apparatus involves complex harmonic generation using wattmeter, error indicator, and manually operated slide-rheostat. Very modern in spirit and objective. Continuous records are shown.

8. "A Pursuit Device for Obtaining both Quantitative and Qualitative Records," R. M. Collier, *Journal of Psychology*, Vol. 2, 1936, pp. 295-300.

Description of curve-drawing apparatus similar to that constructed at The Franklin Institute in the earliest work on the human tracking response. In contrast to the pursuitmeters of this reference and reference 7, most such equipment is of the discontinuous, or averaging, variety.

Chapter 3

1. *Further Application of the Strain Gauge to Gyroscopic Measurements of Angular Rates*, J. D. Eisler, U. C. S. Dilks, and W. W. Felton, Report 152, Franklin Institute, Nov. 9, 1943.

Title is self-explanatory. The principal application in mind was to lead-computing sights. Methods and apparatus are described for compensation required for gyro speed changes, temperature, etc. The noise problem is explained, together with its possible solution. Circuits and photographs are shown.

2. *Symmetrically Constrained Gyros as Angular Rate Indicators*, M. Golomb, Report 218, Franklin Institute, July 27, 1945.

A theoretical treatment of the dynamics involved in the gyro suspensions proposed for the simultaneous measurement of angular rate about two axes with a single gyro. Several types of constraint are considered, and the stability conditions expressed. The effects are described of static friction in the gimbals.

3. *Servo-Controlled Gyroscope*, U. C. S. Dilks and M. Golomb, Report 238, Franklin Institute, Oct. 7, 1945.

Theory and construction of the two-dimensional, electric captive gyro under development for PUSS. Its effectiveness, in speed and accuracy for large and small absolute angular rates, is discussed along with its limitations. Circuits are given, as well as methods of testing, and the numerical data are included on the basic gyro component involved.

Chapter 4[b]

1. *Control Circuits for Radio Controlled Units*, J. R. Ragazzini and L. Julie, Diary of Columbia Project, OEMsr-1237, Dec. 8, 1943.

Contains a brief exposition of the simulative philosophy as applied to control problems. Electronic details are omitted but are implicit. Practical exercises, for sight-simulation, guided bombs, etc., should be consulted for circuits.

2. *Diary Concerning a Conference on November 29 on Subject of Columbia Project*, J. R. Ragazzini, OEMsr-1237, Dec. 14, 1945.

Proposals for simulation of control deflections having boundary conditions, as under human operation. Use of feedback amplifiers, as integrators, etc., outlined, preparatory to the simulative project on guided missiles.

3. *Simulation of PUSS Rocket Sight*, J. R. Ragazzini, OEMsr-1237, NO-265, Report M-35, Columbia University, June 11, 1945.

Shows the then proposed PUSS formulas, and details for their simulation electronically.

4. *Aerodynamic Constants for a Simulated Airplane*, F. A. Russell, OEMsr-1237, NO-265, Report M-38, Columbia University, June 13, 1945.

Arrangement of degrees of freedom, and their connecting relations, for the simulative project.

5. *Axis Conversion*, R. H. Randall, OEMsr-1237, Report M-36, Columbia University, June 21, 1945.

Application of rigid-body dynamics to the problem of airplane simulation. Coordinate systems are worked out, after much deliberation, which appear manageable for incorporation in the electronic model components.

6. *Airplane Simulator (for Small Angles)*, F. A. Russell and R. H. Randall, OEMsr-1237, NO-265, Report M-32, Columbia University, June 21, 1945.

Summary of the first working phase of the simulative development for PUSS. References to the aerodynamic literature are included, as are the schematic circuits employed in simulation.

7. *On the Study of Cyclic Dynamical Systems by Means of Equivalent Networks*, L. Jafek, Cossor Industries, Aug. 5, 1942.

[b] See also Chapter 8.

Chapter 5[c]

1. *Theory of Gyroscope Suspended in a GAP Linkage*, M. Golomb, Memo to G. A. Philbrick, Franklin Institute, Dec. 14, 1944.

An analysis of the orthopentax employed as a gyro suspension. Its possibility as forming a lead-computing system for PUSS was then being explored. Certain practical advantages were expected, but no practical application has yet been made.

Chapter 6

1. *Torpedo Director, Mark 32*, R. W. Pitman, OSRD 5079, OEMsr-330, NO-106, Report 172, Franklin Institute, Jan. 26, 1944. Div. 7-141-M1

Describes the final model of the torpedo director which resulted from Project NO-106. Foreword by A. L. Ruiz. Figures and rewriting by G. A. Philbrick. This document is in the form of an instruction manual, but is roughly definitive of the whole development prior to 1944.

2. *Torpedo Director, Model Number One*, R. W. Pitman, R. K. Marshall, F. W. Schlesinger, and others, NO-106, Report 120, Franklin Institute, Aug. 15, 1942.

Covers phases of work on this project during the first half-year of development. Describes vector theory and first mechanizations thereof. Discusses the problem of stabilization in azimuth. Appendices treat related problems, such as the optical ones connected with the pilot's sight head. References are included to even earlier documents.

[c] For documents on the computing linkages such as are being prepared for the PUSS project at The Franklin Institute, this contractor's final report, not received at the present writing, should be consulted. It is now expected that this work is to be extended under Navy auspices, so that another future source of information will be Section Re8c of the Bureau of Ordnance.

The final report of The Bristol Company under their contract (OEMsr-1387) with NDRC Section 7.2, may also be consulted, in connection particularly with manipulated linkage developed within the PUSS project.

See also Radiation Laboratory (MIT), and Librascope Corporation reports, for other computing linkages.

3. *The Electrical Solution for the Torpedo Director (NO-106)*, J. D. Eisler, Report 135, Franklin Institute.

Describes the a-c vector embodiment of the same theory as in mechanical directors. Certain advantages in flexibility of installation were thus sought, and a technique was experimentally developed for further applications. Many circuits and photographs are shown.

4. *Stabilization of the Mark 31 Torpedo Director for Motor Torpedo Boats*, J. D. Eisler, NO-134, Report 148, Franklin Institute, June 15, 1945.

Mainly a servo development which derived stabilization for the target velocity, as set in this director, by means of the Flux-gate compass. Details of the construction. Test data are not included, but good operation was experienced in field tests at the MTBSTC at Melville, Rhode Island.

Chapter 7

1. *U. S. Navy Bombsight Mark 20*, R. W. Pitman and others, Report 200, Franklin Institute, August 1943. Div. 7-122.2-M2

A descriptive manual of the theory and instrumental principles, and of the installation and maintenance of this bombsight. Detailed instructions for operation, with pictorial aids, are included.

2. *Auxiliary Ground Speed Computer*, John A. Bevan and others, Report 167, Franklin Institute, Dec. 12, 1943.

Description of, with instructions for use of, a miniature mechanical computer for use with hand-held bombsights. Of wider applicability, however.

3. *Automatic Altitude Adjustment for Bombsight Mark 20*, U. C. S. Dilks, OSRD 5080, OEMsr-330, NO-129, Report 161, Franklin Institute, Jan. 24, 1944. Div. 7-122.2-M1

Account of an experimental project wherein the altitude determined by the f-m radio altimeter is servoed into the bombsight continuously. Very small equipment resulted, attachable without interference to a hand-held instrument. A d-c resistive feedback principle is applied.

4. *Bombsight V, Model 3*, John A. Bevan, Report 168, Franklin Institute, Mar. 6, 1944.

This is one of the many adaptations of the basic principle of the Mark 20, although without chronometric extrapolation. Each modification led to diminishment in size and complexity. Very satisfactory results were obtained in flight tests at NAS Banana River.

5. *Bombsight VI, LTA*, John A. Bevan, Report 178, Franklin Institute, May 6, 1944. Div. 7-122.4-M2

An adaptation of bombsight V, so-called, to the bombing problem of blimps. This sight became bombsight Mark 24 and enabled a surprising accuracy of dropping.

6. *Slant Range Computer*, R. W. Pitman, Report 156, Franklin Institute, Nov. 5, 1943. Div. 7-123-M1

Description of a small, flat, manually operated computer, giving the slant range at which bomb release should occur, in horizontal flight at low altitude, in terms of altitude and closing speed. One-hand operation. Model submitted to BuAer.

7. *The Preset Computer Model 3*, John A. Bevan, OSRD 5088, OEMsr-330, NO-191, Report 189, Franklin Institute, July 7, 1944. Div. 7-123-M2

A mechanical computer, the final model of several developed, supplying preliminary information on how synchronizing run to the high-altitude bombsight operates. Inputs are manually applied, except azimuth stabilization, which is automatically provided.

8. *Report on the Strain Gauge BARB*, J. D. Eisler, Report 155, Franklin Institute, June 1943.

Experimental angular-rate measurement from precessing torque of a restrained gyro, strain gauges being applied to the restraining members. Also its tentative application to a low-altitude bombsight.

9. *Notes on Low Altitude Bombing, I—VII*, G. A. Philbrick and R. M. Peters, Research Project 33, NDRC Section 7.2, Franklin Institute, May 1943—March 1944. Div. 7-122.1-M3-9

A series of studies, concerned principally with the theoretical evaluation of bombing errors, for the various known methods (including BARB), in terms of the several variables of the problem. An account of the BARB theory is included, with predictions, later upheld, of the comparative results obtainable. Offset bombing and glide bombing are considered by various methods. A "hybrid" BARB is shown to be substantially unworkable, so that no time was wasted on it. The writing of L. Goldberg, under the auspices of Section 7.3, should also be referred to in these connections. BARB eventually became bombsights Mark 23 and 27. These are, more precisely, BARB and SuperBARB.

10. *Gyroscopic Lead Computing Sights*, Report to the Services 13, August 1941. Div. 7-122.11-M1

Chapter 8

1. *Norden Bombsight Attachment for Guiding AZON/RAZON Bombs*, John A. Bevan, OSRD 5740, OEMsr-330, AC-36, Report 194, Report to the Services 97, Franklin Institute, Oct. 10, 1944. Div. 7-122.4-M1

A description, briefly, of the theory and nature of the CRAB sight, with instructions for its installation, calibration, and employment operationally. Adapted by NDRC Division 5 to *Preliminary Technical Manual, CRAB, An Attachment to the Norden-Type Bombsight for Aid in Guiding Flare-Equipped Bombs*, issued in June 1945.

2. *Notes on Calibration, Installation, and Operation of CARP*, John A. Bevan, Report 199, Franklin Institute, Oct. 12, 1944.

Descriptive material on CARP, with an appendix giving theory, especially of the *artificial disk speed* technique. Includes functional diagrams, circuits, and photographs. No clues as to why CARP ROC combination failed as a collinear flare-guiding system. For related matters on ROC, and the other projectiles and vehicle-controls, the reader is referred to the report of NDRC Division 5 and its contractors, particularly Gulf Research and Development, and Douglas Aircraft. Note in particular the writings of W. B. Klemperer of the latter organization.

3. *Study of AZON Control and Regulation*, L. Julie, OEMsr-1237, Report 7-1, Columbia University, May 10, 1944.

Describing the initial simulative system whereby the dynamics of guiding were electronically reproduced in the laboratory. Records of the RDA No. 2 at MIT should be consulted for more precise data on trajectory shapes.

4. *Completion of Trainer Project*, L. Julie, OEMsr-1237, Report M-23, Columbia University, Oct. 21, 1944.

Exposition of the final experimental form of the universal guided-bomb simulator, for AZON, RAZON, and ROC. This device was later produced as a field trainer for guiders by Division 5 agencies. Circuits and alignment techniques are given.

5. *The AZON-RAZON Bombing Trainer*, (Models X-1010 and X-1020), NDRC Division 5, Aug. 15, 1945. Div. 5-233-M1

Based on writings and developments of Section 7.2, applied to guided bombing equipment. Attachment of electronic simulative equipment to Army A-6 and A-5 bombing trainers. Similar combinations, with the Navy 7A3 bombing trainer, were also carried out, in which a moving spot was projected on the synthetic landscape of the photographic trainer.

6. *Study of the Guiding Characteristics of the Television Bomb; including a Regulator for Guiding*, L. Julie, OEMsr-1237, Report 7-14, Columbia University, June 29, 1945.

Employment of electronic simulative techniques to study the stability of a proposed control system for attaining interception under remote manual guiding, even with target motion in the air mass. Cooperation of simulator and human operator was exploited. Criticalness of control parameters was exhaustively studied and later fully corroborated elsewhere.

Chapter 9

1. *Development of Rocket-Gunsights; Summary Report on NO-216*, Eugene P. Cooper, Report 233, Franklin Institute, Sept. 30, 1945.

A review in some detail of the development on rocket sights at The Franklin Institute, with attention to historical sequence. An attempt is made to supply the logical steps which were followed. A brief account of the various field-testing programs is included, together with connected references to other local reports on rocketry developments. This is essentially a final statement by the author, who was given considerable responsibility in this field.

2. *Sighting of Rocket Projectiles from Aircraft*, C. W. Gilbert, British Liaison Code, WA-3190-3, Gunnery Research Unit, RAF, Oct. 19, 1944.

The tactics and aiming problem are developed, with a breakdown of the sighting problem in terms of the allowances for relative speed, trail (attack angle and skid), and gravity. Proposals are made for future development, and a general vector theory included.

3. *On the Use of the Lead-Computing Characteristics of the Mark 18 to Solve the Super-Elevation Problem for Rocketry*, Eugene P. Cooper, Memo to G. A. Philbrick, Franklin Institute, July 18, 1944.

Cooper gives here the theory later embodied in the so-called British method of rocket aiming. Shows reasons for pessimism as to result. Note that this method ultimately generalized to PUSS.

4. *Gravity Drop Formulas for Airborne Rockets*, Harry Pollard, [OEMsr-1007], AMG-C Working Paper 347, AMG-Columbia, Jan. 4, 1945. AMP-603-M2

Fitting of firing-table data to second-order space paths. See also various CIT rocket publications and firing tables.

5. *The RASP Rocket Sight—Model I*, U. C. S. Dilks, E. C. Lewis, and others, OEMsr-330, NO-216, Report 188, Franklin Institute, Aug. 17, 1944. Div. 7-132-M1

A descriptive account of the RASP project in its primary phase. Includes the derivation of equations and their mechanization. A study of the theoretical accuracy is included, together with firing data from tests—with final reductions thereof, photographs, and circuits. Foreword by G. A. Philbrick of Section 7.2.

6. *The RASP Rocket Sight—Model III*, U. C. S. Dilks, E. C. Lewis, and W. C. Sheppard, OSRD 5091, OEMsr-330, NO-265, Report 206, Franklin Institute, Feb. 1, 1945 Div. 7-132-M2

Comparisons with Model I are included throughout. The computational technique is newly explained and an appendix is devoted to a more theoretical treatment of this technique, with general applications. Many photographs are included, and circuits and servo components are described in detail. Analyses of test data, with statistical reduction, are included. A foreword is attached, prepared by G. A. Philbrick.

7. [The] *GRASP Sight for Forward Firing Aircraft Rockets, Model I*, Eugene P. Cooper and Marjorie C. Cooper, OSRD 4991, OEMsr-330, NO-216, Report 211, Franklin Institute, Apr. 9, 1945. Div. 7-131-M1

The method is described, and a derivation is given of the equations to be employed. The details of the physical computation and of the instrumental components are elaborated upon, with a study of errors in firing. Very complete testing data are given. A foreword by G. A. Philbrick is attached.

8. *The GRASP Rocket Sight, Model II*, Eugene P. Cooper and Marjorie C. Cooper, OSRD 6040, OEMsr-330, NO-216, Report 213, Franklin Institute, Sept. 30, 1945. Div. 7-131-M2

Report 211 is here brought up to date for the newer model. (The Aircraft Rocket Sight Mark 2. For ARS Mark 3, the writings of H. Whitney, *et al*, of AMG-C should be referred to by the reader, where corresponding details of the jointly pursued PARS project are more fully covered.) In this report an exhaustive account of laboratory calibration is included, and, in the final edition, the results of firing tests at NOTS, Inyokern. A foreword by the present writer is attached.

9. *Measurement of Angle of Attack and Skid in Rocket Fire Problems*, H. L. Garabedian, OEMsr-1379, AMG-N Working Paper 61 (revised), AMG-Northwestern, Sept. 12, 1945. AMP-502.14-M13

A study of relations preparatory to a test program for skid. Camera techniques and coordinates. Bibliography of related writings.

Chapter 10

1. *Analysis of Optical Systems for PUSS*, I. M. Levitt, Report 241, Franklin Institute, Oct. 31, 1945.

Containing a review of the problems and proposals in connection with the development of universal sight heads for the pilot. Collimating lenses and mirror linkages are discussed, as are the possible modifications to this end of the interesting Fly's Eye design. Illumination problems are explored. Some tentative overall conclusions are arrived at. The final report of the Bristol Company contract—with Section 7.2—should also be consulted.

2. *Interim Report on PUSS*, John A. Bevan, Report 224, Franklin Institute, Aug. 24, 1945.

A compilation of recent documents, arranged as seven independent appendices, and with an introduction on the current status of the project, including theory and design. Instrumental techniques are discussed, with a review of the input components, computers (including PACT for toss bombing), and sight head. The electric and pneumatic versions of PUSS are described and compared.

The appendices of this report, which are worthy bibliographic items in their own right, include memoranda and theoretical papers on gyro systems, computing dynamics (with competing theories), roll stabilization, etc., and were prepared chiefly by M. Golomb and R. O. Yavne.

3. *Servo-Controlled Gyroscope*, U. C. S. Dilks and M. Golomb, Report 238, Franklin Institute, Oct. 2, 1945.

Theory and construction of the two-dimensional, electrically captured gyro in development for PUSS. Effectiveness for small angular rates is discussed, with limitations included. Electronic circuits are given in detail, together with the electrical and other properties of the basic gyro unit which was adapted for this purpose.

4. *Development of Pilot-Operated Fire Control Equipment; Outline of the General Project*, G. A. Philbrick, Apr. 25, 1944.

Preview of the PUSS Project. Aims and hopes for the development. Gives scope and instrumental specifications. Discusses aiming methods, including those without explicit range measurement. Proposed electronic tracking simulator for pilot-operated fire controls.

5. *Notes on Pneumatic PUSS; I*, L. Charles Hutchinson, [OEMsr-1007], AMG-C Working Paper 461, AMG-Columbia, July 17, 1945. AMP-502.1-M28

Considers pneumatic embodiment of computing dynamics. Gives theory and brief experimental data.

6. *Notes on Pneumatic PUSS; II*, L. Charles Hutchinson, [OEMsr-1007], AMG-C Working Paper 478, AMG-Columbia, Aug. 10, 1945. AMP-502.1-M30

Considers pneumatic component for the input giving rate of change of altitude. Circuits, theory, and numerical data. Includes nonlinearities.

7. *PUSS, Target, Sight, Horizon Presentation*, J. R. Ragazzini and R. H. Randall, OEMsr-1237, Report M-34, Columbia University, May 29, 1945.

Simulative computational arrangements for pilot's tracking simulator. Includes dynamics, coordinates to be employed, and the optical or oscilloscopic display.

8. *A Theory of Toss-Bombing*, Harry Pollard, OEMsr-1007, AMP Report 146.1R, AMG-Columbia, September 1945. AMP-803.5-M12

Principles of toss bombing on a revised basis. Measurables of the problem, including target motion. Mechanization of formulas, employing integral of normal acceleration. This is the definitive theory for PACT.

9. *The Azimuth Problem in Toss-Bombing*, Harry Pollard, AMG-C Working Paper 495, AMG-Columbia, Sept. 18, 1945. AMP-803.5-M13

Shows an exact solution for the target motion in azimuth. The effect of roll and bank is included, and the appropriate sighting dynamics, for use with PUSS and PACT, are specified.

PART II

The following reports were all issued by The Franklin Institute under Contract OEMsr-330.

1. *Reflecting Sight for Torpedo Director*, Report 330-1706-102, Apr. 17, 1942.
2. *Torpedo Director NO-106—Tests on Sight Containing a Miniature Ship Model*, Report 330-1706-103, May 6, 1942.
3. *Use of Radar Data in Torpedo Director NO-106*, Report 330-1706-105, May 12, 1942.
4. *Altitude Speed Range Slide Rule for Simplified Torpedo Director NO-106*, Report 330-1706-106, May 25, 1942.
5. *Torpedo Director NO-106: Principle and Operation of Experimental Director*, Report 330-1706-107, May 26, 1942.
6. *Torpedo Director NO-106—Stabilizing Systems Using a Turn Gyro*, Report 330-1706-108, June 1, 1942.
7. *Proposed Continuous Electrical Solution for Torpedo Director*, Report 330-1706-109, July 25, 1942.
8. *A Stabilizing Method which Might be Applied to the Torpedo Director*, Report 330-1706-110, July 25, 1942.
9. *Explicit Relation Between Present Range and Torpedo Run in the Torpedo Director NO-106*, Report 330-1706-111, Aug. 6, 1942.
10. *A Two-Phase Stabilizer for Torpedo Director NO-106*, Report 330-1706-112, Aug. 15, 1942.
11. *An AC Current Controller for Stabilizing the Torpedo Director NO-106*, Report 330-1706-113, Aug. 15, 1942.
12. *Reflecting Sight for Torpedo Director NO-106*, Report 330-1706-114, Aug. 19, 1942.
13. *Torpedo Director NO-106—Further Notes on Two-Man Operation*, Report 330-1706-115, Aug. 20, 1942.
14. *Wind Effects Relative to Torpedo Director*, Report 330-1706-116, Aug. 15, 1942.
15. *Effects of Interchange of Torpedo Run and Range on the Performance of Torpedo Director in Attacks on Bow of Target*, Report 330-1706-117, Aug. 17, 1942.
16. *Torpedo Director NO-106 Model Number One: Principles, Construction, Operation, Accuracy and Specifications*, Report 330-1706-120, Aug. 15, 1942.
17. *Calibration of Torpedo Director for Use by Army Air Forces*, Report 330-1706-121, Aug. 8, 1942.
18. *Torpedo Director NO-106, Flight Tests at Norfolk, Virginia*, Report 330-1706-123, Sept. 30, 1942.
19. *Preliminary Studies Leading to the Development of a Photoelectric Stabilizer for the NO-106 Torpedo Director*, Report 330-1706-124, Oct. 15, 1942.
20. *A Photoelectric Stabilizer for the NO-106 Torpedo Director*, Report 330-1706-125, Oct. 25, 1942.
21. *Conditions of Torpedo Running Time Affecting the Use of Torpedo Director NO-106*, Report 330-1706-128, Oct. 12, 1942.
22. *Tables and Graphs for Calibration of Torpedo Director NO-106*, Report 330-1706-129, Oct. 10, 1942.
23. *Calibration Tests, Torpedo Director NO-106, Type "D"*, Report 330-1706-130, Oct. 26, 1942.
24. *Preliminary Study of Japanese Torpedo Director*, Report 330-1706-132, Nov. 10, 1942.
25. *Use of Torpedo Director—Errors in Lead Angle to be Expected from Errors in Estimation of V_s, Target Speed*, Report 330-1706-133, Dec. 7, 1942.
26. *Two-Autosyn Controller for Stabilizing the NO-106 Torpedo Director*, Report 330-1706-134, Dec. 21, 1942.
27. *The Electrical Solution of NO-106 Torpedo Director*, Report 330-1706-135, Jan. 12, 1943.
28. *Mark 32 Torpedo Director—Inaccuracies in Theory and Design*, Report 330-1706-137, Mar. 14, 1943.
29. *General Solution of the Determination of Minimum Range, Time of Travel to This Point and Angle Between Course of M.T.B. and Minimum Range*, Report 330-1706-140, Mar. 24, 1943.
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