

ALAN TURING: THE HIDDEN WARTIME MANUSCRIPT BY THE FATHER OF COMPUTING

Monday April 13, 2015

New York



Bonhams

NEW YORK



ALAN TURING: THE HIDDEN WARTIME MANUSCRIPT BY THE FATHER OF COMPUTING

Monday April 13, 2015 at 1pm
New York

BONHAMS

580 Madison Avenue
New York, New York 10022
bonhams.com

PREVIEW

By private appointment.

San Francisco: February 4-9

Los Angeles: February 12-15

Hong Kong: March 19-22

New York: April 9-13

BIDS

+1 (212) 644 9001

+1 (212) 644 9009 fax

To bid via the internet please visit
www.bonhams.com/22795

Please see pages 2 to 6
for bidder information including
Conditions of Sale, after-sale
collection and shipment.

SALE NUMBER: 22795

Lot 1

CATALOG: \$35

APPOINTMENTS

Cassandra Hatton, Senior Specialist
+ 1 (212) 461 6531
cassandra.hatton@bonhams.com

INQUIRIES

New York

Cassandra Hatton, Senior Specialist
+ 1 (212) 461 6531
cassandra.hatton@bonhams.com

Christina Geiger, Director, New York
+ 1 (212) 644 9094
christina.geiger@bonhams.com

Tom Lamb, Director
Business Development
+ 1 (917) 921 7342
tom.lamb@bonhams.com

Los Angeles

Dr. Catherine Williamson, Director
+ 1 (323) 436 5442
catherine.williamson@bonhams.com

Brian Kalkbrenner, Specialist
+ 1 (323) 436 5487
brian.kalkbrenner@bonhams.com

San Francisco

Adam Stackhouse, Senior Specialist
+ 1 (415) 503-3266
adam.stackhouse@bonhams.com

Automated Results Service
+1 (800) 223 2854

ILLUSTRATIONS

Front cover: Alan Turing, ca. 1936.

Image: King's College, Cambridge.

Inside covers: Rotors on the rebuilt

Turing Bombe used to break the

Enigma code. Image: REX USA/

Brian Harris/Rex.

Back cover: Alan Turing's portrait for

his election to a Fellowship of the

Royal Society, 1951. Image: National

Portrait Gallery, London.

**Bonhams thanks the following for
their help in the preparation of
this catalog:**

Andrew Hodges, author of *Alan Turing:*

The Enigma (Vintage: Random House,

London 2014); Patricia McGuire,

Archivist, King's College Cambridge;

Rachel Hassal, School Archivist,

Sherborne School; Professor Bob

Owen, University of Bedfordshire.

CONDITIONS OF SALE

The following Conditions of Sale, as amended by any published or posted notices or verbal announcements during the sale, constitute the entire terms and conditions on which property listed in the catalog shall be offered for sale or sold by Bonhams & Butterfields Auctioneers Corp. and any consignor of such property for whom we act as agent. If live online bidding is available for the subject auction, additional terms and conditions of sale relating to online bidding will apply; see www.bonhams.com/WebTerms for the supplemental terms. As used herein, "Bonhams," "we" and "us" refer to Bonhams & Butterfields Auctioneers Corp.

1. As used herein, the term "bid price" means the price at which a lot is successfully knocked down to the purchaser. The term "purchase price" means the aggregate of (a) the bid price, (b) a PREMIUM retained by us and payable by the purchaser EQUAL TO 25% OF THE FIRST \$100,000 OF THE BID PRICE, 20% OF THE AMOUNT OF THE BID PRICE ABOVE \$100,000 UP TO AND INCLUDING \$2,000,000, AND 12% OF THE AMOUNT OF THE BID PRICE OVER \$2,000,000, and (c) unless the purchaser is exempt by law from the payment thereof, any California, Arizona, Colorado, Connecticut, Florida, Georgia, Illinois, Massachusetts, Nevada, New York, Pennsylvania, Texas, Washington, D.C., Washington state, or other state or local sales tax (or compensating use tax) and other applicable taxes.

2. On the fall of the auctioneer's hammer, the highest bidder shall have purchased the offered lot in accordance and subject to compliance with all of the conditions set forth herein and (a) assumes full risk and responsibility therefor, (b) if requested will sign a confirmation of purchase, and (c) will pay the purchase price in full or such part as we may require for all lots purchased. No lot may be transferred. Any person placing a bid as agent on behalf of another (whether or not such person has disclosed that fact or the identity of the principal) may be jointly and severally liable with the principal under any contract resulting from the acceptance of a bid.

Unless otherwise agreed, payment in good funds is due and payable within five (5) business days following the auction sale. Whenever the purchaser pays only a part of the total purchase price for one or more lots purchased, we may apply such payments, in our sole discretion, to the lot or lots we choose. Payment will not be deemed made in full until we have collected good funds for all amounts due.

Payment for purchases may be made in or by (a) cash, (b) cashier's check or money order, (c) personal check with approved credit drawn on a U.S. bank, (d) wire transfer or other immediate bank transfer, or (e) Visa, MasterCard, American Express or Discover credit, charge or debit card. A processing fee will be assessed on any returned checks. Please note that the amount of cash notes and cash equivalents that can be accepted from a given purchaser may be limited.

The purchaser grants us a security interest in the property, and we may retain as collateral security for the purchaser's obligations to us, any property and all monies held or received by us for the account of the purchaser, in our possession. We retain all rights of a secured party under the California Commercial Code. If the foregoing conditions or any other applicable conditions herein are not complied with, in addition to other remedies available to us and the consignor by law, including without limitation, the right to hold the purchaser liable for the purchase price, we at our option may either (a) cancel the sale, retaining as liquidated damages all payments made by the purchaser or (b) resell the property, either publicly or privately, and in such event the purchaser shall be liable for

the payment of any deficiency plus all costs and expenses of both sales, our commission at our standard rates, all other charges due hereunder, attorneys' fees, expenses and incidental damages. In addition, where two or more amounts are owed in respect of different transactions by the purchaser to us, to Bonhams 1793 Limited and/or to any of our other affiliates, subsidiaries or parent companies worldwide within the Bonhams Group, we reserve the right to apply any monies paid in respect of a transaction to discharge any amount owed by the purchaser. If all fees, commissions, premiums, bid price and other sums due to us from the purchaser are not paid promptly as provided in these Conditions of Sale, we reserve the right to impose a finance charge equal to 1.5% per month on all amounts due to us beginning on the 31st day following the sale until payment is received, in addition to other remedies available to us by law.

3. We reserve the right to withdraw any property and to divide and combine lots at any time before such property's auction. Unless otherwise announced by the auctioneer at the time of sale, all bids are per lot as numbered in the catalog and no lots shall be divided or combined for sale.

4. We reserve the right to reject a bid from any bidder, to split any bidding increment, and to advance the bidding in any manner the auctioneer may decide. In the event of any dispute between bidders, or in the event the auctioneer doubts the validity of any bid, the auctioneer shall have sole and final discretion either to determine the successful bidder or to re-offer and resell the article in dispute. If any dispute arises after the sale, our sales records shall be conclusive in all respects.

5. If we are prevented by fire, theft or any other reason whatsoever from delivering any property to the purchaser or a sale otherwise cannot be completed, our liability shall be limited to the sum actually paid therefor by the purchaser and shall in no event include any compensatory, incidental or consequential damages.

6. If a lot is offered subject to a reserve, we may implement such reserve by bidding on behalf of the consignor, whether by opening bidding or continuing bidding in response to other bidders until reaching the reserve. If we have an interest in an offered lot and the proceeds therefrom other than our commissions, we may bid therefor to protect such interest. CONSIGNORS ARE NOT ALLOWED TO BID ON THEIR OWN ITEMS.

7. All statements contained in the catalog or in any bill of sale, condition report, invoice or elsewhere as to authorship, period, culture, source, origin, measurement, quality, rarity, provenance, importance, exhibition and literature of historical relevance, or physical condition ARE QUALIFIED STATEMENTS OF OPINION AND NOT REPRESENTATIONS OR WARRANTIES. No employee or agent of Bonhams is authorized to make on our behalf or on that of the consignor any representation or warranty, oral or written, with respect to any property.

8. All purchased property shall be removed from the premises at which the sale is conducted by the date(s) and time(s) set forth in the "Buyer's Guide" portion of the catalog. If not so removed, daily storage fees will be payable to us by the purchaser as set forth therein. We reserve the right to transfer property not so removed to an offsite warehouse at the purchaser's risk and expense, as set forth in more detail in the "Buyer's Guide." Accounts must be settled in full before property will be released. Packing and handling of purchased lots are the responsibility of the purchaser. Bonhams can provide packing and shipping services for certain items as noted in the "Buyer's Guide" section of the catalog.

9. The copyright in the text of the catalog and the photographs, digital images and illustrations of lots in the catalog belong to Bonhams or its licensors. You will not reproduce or permit anyone else to reproduce such text, photographs, digital images or illustrations without our prior written consent.

10. These Conditions of Sale shall bind the successors and assigns of all bidders and purchasers and inure to the benefit of our successors and assigns. No waiver, amendment or modification of the terms hereof (other than posted notices or oral announcements during the sale) shall bind us unless specifically stated in writing and signed by us. If any part of these Conditions of Sale is for any reason invalid or unenforceable, the rest shall remain valid and enforceable.

11. These Conditions of Sale and the purchaser's and our respective rights and obligations hereunder are governed by the laws of the State of California. By bidding at an auction, each purchaser and bidder agrees to be bound by these Conditions of Sale. Any dispute, controversy or claim arising out of or relating to this agreement, or the breach, termination or validity thereof, brought by or against Bonhams (but not including claims brought against the consignor by the purchaser of lots consigned hereunder) shall be resolved by the procedures set forth below.

MEDIATION AND ARBITRATION PROCEDURES

(a) Within 30 days of written notice that there is a dispute, the parties or their authorized and empowered representatives shall meet by telephone and/or in person to mediate their differences. If the parties agree, a mutually acceptable mediator shall be selected and the parties will equally share such mediator's fees. The mediator shall be a retired judge or an attorney familiar with commercial law and trained in or qualified by experience in handling mediations. Any communications made during the mediation process shall not be admissible in any subsequent arbitration, mediation or judicial proceeding. All proceedings and any resolutions thereof shall be confidential, and the terms governing arbitration set forth in paragraph (c) below shall govern.

(b) If mediation does not resolve all disputes between the parties, or in any event no longer than 60 days after receipt of the written notice of dispute referred to above, the parties shall submit the dispute for binding arbitration before a single neutral arbitrator. Such arbitrator shall be a retired judge or an attorney familiar with commercial law and trained in or qualified by experience in handling arbitrations. Such arbitrator shall make all appropriate disclosures required by law. The arbitrator shall be drawn from a panel of a national arbitration service agreed to by the parties, and shall be selected as follows: (i) If the national arbitration service has specific rules or procedures, those rules or procedures shall be followed; (ii) If the national arbitration service does not have rules or procedures for the selection of an arbitrator, the arbitrator shall be an individual jointly agreed to by the parties. If the parties cannot agree on a national arbitration service, the arbitration shall be conducted by the American Arbitration Association, and the arbitrator shall be selected in accordance with the Rules of the American Arbitration Association. The arbitrator's award shall be in writing and shall set forth findings of fact and legal conclusions.

(c) Unless otherwise agreed to by the parties or provided by the published rules of the national arbitration service:

(i) the arbitration shall occur within 60 days following the selection of the arbitrator;

CONDITIONS OF SALE - CONTINUED

(ii) the arbitration shall be conducted in the designated location, as follows: (A) in any case in which the subject auction by Bonhams took place or was scheduled to take place in the State of New York or Connecticut or the Commonwealth of Massachusetts, the arbitration shall take place in New York City, New York; (B) in all other cases, the arbitration shall take place in the city of San Francisco, California; and

(iii) discovery and the procedure for the arbitration shall be as follows:

(A) All arbitration proceedings shall be confidential;

(B) The parties shall submit written briefs to the arbitrator no later than 15 days before the arbitration commences;

(C) Discovery, if any, shall be limited as follows: (I) Requests for no more than 10 categories of documents, to be provided to the requesting party within 14 days of written request therefor; (II) No more than two (2) depositions per party, provided however, the deposition(s) are to be completed within one (1) day; (III) Compliance with the above shall be enforced by the arbitrator in accordance with California law;

(D) Each party shall have no longer than eight (8) hours to present its position. The entire hearing before the arbitrator shall not take longer than three (3) consecutive days;

(E) The award shall be made in writing no more than 30 days following the end of the proceeding. Judgment upon the award rendered by the arbitrator may be entered by any court having jurisdiction thereof.

To the fullest extent permitted by law, and except as required by applicable arbitration rules, each party shall bear its own attorneys' fees and costs in connection with the proceedings and shall share equally the fees and expenses of the arbitrator.

LIMITED RIGHT OF RESCISSION

If within one (1) year from the date of sale, the original purchaser (a) gives written notice to us alleging that the identification of Authorship (as defined below) of such lot as set forth in the **BOLD TYPE** heading of the catalog description of such lot (as amended by any saleroom notices or verbal announcements during the sale) is not substantially correct based on a fair reading of the catalog (including the terms of any glossary contained therein), and (b) within 10 days after such notice returns the lot to us in the same condition as at the time of sale, and (c) establishes the allegation in the notice to our satisfaction (including by providing one or more written opinions by recognized experts in the field, as we may reasonably require), then the sale of such lot will be rescinded and, unless we have already paid to the consignor monies owed him in connection with the sale, the original purchase price will be refunded.

If, prior to receiving such notice from the original purchaser alleging such defect, we have paid the consignor monies owed him in connection with the sale, we shall pay the original purchaser the amount of our commissions, any other sale proceeds to which we are entitled and applicable taxes received from the purchaser on the sale and make demand on the consignor to pay the balance of the original purchase price to the original purchaser. Should the consignor fail to pay such amount promptly, we may disclose the identity of the consignor and assign to the original purchaser our rights against the consignor with respect to the lot the sale of which is sought to be rescinded. Upon such disclosure and assignment, any liability of Bonhams as consignor's agent with respect to said lot shall automatically terminate.

The foregoing limited right of rescission is available to the original purchaser only and may not be assigned to or relied upon by any subsequent transferee of the property sold. The purchaser hereby accepts the benefit of the consignor's warranty of title and other representations and warranties made by the consignor for the purchaser's benefit. Nothing in this section shall be construed as an admission by us of any representation of fact, express or implied, obligation or responsibility with respect to any lot. THE PURCHASER'S SOLE AND EXCLUSIVE REMEDY AGAINST BONHAMS FOR ANY

REASON WHATSOEVER IS THE LIMITED RIGHT OF RESCISSION DESCRIBED IN THIS SECTION.

"Authorship" means only the identity of the creator, the period, culture and source or origin of the lot, as the case may be, as set forth in the **BOLD TYPE** heading of the print catalog entry. The right of rescission does not extend to: (a) works of art executed before 1870 (unless these works are determined to be counterfeits created since 1870), as this is a matter of current scholarly opinion which can change; (b) titles, descriptions, or other identification of offered lots, which information normally appears in lower case type below the **BOLD TYPE** heading identifying the Authorship; (c) Authorship of any lot where it was specifically mentioned that there exists a conflict of specialist or scholarly opinion regarding the Authorship of the lot at the time of sale; (d) Authorship of any lot which as of the date of sale was in accordance with the then generally-accepted opinion of scholars and specialists regarding the same; or (e) the identification of periods or dates of creation in catalog descriptions which may be proven inaccurate by means of scientific processes that are not generally accepted for use until after publication of the catalog in which the property is offered or that were unreasonably expensive or impractical to use at the time of such publication.

LIMITATION OF LIABILITY

EXCEPT AS EXPRESSLY PROVIDED ABOVE, ALL PROPERTY IS SOLD "AS IS." NEITHER BONHAMS NOR THE CONSIGNOR MAKES ANY REPRESENTATION OR WARRANTY, EXPRESS OR IMPLIED, AS TO THE MERCHANTABILITY, FITNESS OR CONDITION OF THE PROPERTY OR AS TO THE CORRECTNESS OF DESCRIPTION, GENUINENESS, ATTRIBUTION, PROVENANCE OR PERIOD OF THE PROPERTY OR AS TO WHETHER THE PURCHASER ACQUIRES ANY COPYRIGHTS OR OTHER INTELLECTUAL PROPERTY RIGHTS IN LOTS SOLD OR AS TO WHETHER A WORK OF ART IS SUBJECT TO THE ARTIST'S MORAL RIGHTS OR OTHER RESIDUAL RIGHTS OF THE ARTIST. THE PURCHASER EXPRESSLY ACKNOWLEDGES AND AGREES THAT IN NO EVENT SHALL BONHAMS BE LIABLE FOR ANY DAMAGES INCLUDING, WITHOUT LIMITATION, ANY COMPENSATORY, INCIDENTAL OR CONSEQUENTIAL DAMAGES.

SELLER'S GUIDE

SELLING AT AUCTION

Bonhams can help you every step of the way when you are ready to sell art, antiques and collectible items at auction. Our regional offices and representatives throughout the US are available to service all of your needs. Should you have any further questions, please visit our website at www.bonhams.com/us for more information or call our Client Services Department at +1 (800) 223 2854 ext. 23550.

AUCTION ESTIMATES

The first step in the auction process is to determine the auction value of your property. Bonhams' world-renowned specialists will evaluate your special items at no charge and in complete confidence. You can obtain an auction estimate in many ways:

- Attend one of our Auction Appraisal Events held regularly at our galleries and in other major metropolitan areas. The updated schedule for Bonhams Auction Appraisal Events is available at www.bonhams.com/us.
- Call our Client Services Department to schedule a private appointment at one of our galleries. If you have a large collection, our specialists can travel, by appointment, to evaluate your property on site.
- Send clear photographs to us of each individual item, including item dimensions and other pertinent information with each picture. Photos should be sent to Bonhams' address in envelopes marked

as "photo auction estimate". Alternatively, you can submit your request using our online form at www.bonhams.com/us. Digital images may be attached to the form. Please limit your images to no more than five (5) per item.

CONSIGNING YOUR PROPERTY

After you receive an estimate, you may consign your property to us for sale in the next appropriate auction. Our staff assists you throughout the process, arranging transportation of your items to our galleries (at the consignor's expense), providing a detailed inventory of your consignment, and reporting the prices realized for each lot. We provide secure storage for your property in our warehouses and all items are insured throughout the auction process. You will receive payment for your property approximately 35 days after completion of sale.

Sales commissions vary with the potential auction value of the property and the particular auction in which the property is offered. Please call us for commission rates.

PROFESSIONAL APPRAISAL SERVICES

Bonhams' specialists conduct insurance and fair market value appraisals for private collectors, corporations, museums, fiduciaries and government entities on a daily basis. Insurance appraisals, used for insurance purposes, reflect the cost of replacing property in today's retail market. Fair market value appraisals are used for estate,

tax and family division purposes and reflect prices paid by a willing buyer to a willing seller.

When we conduct a private appraisal, our specialists will prepare a thorough inventory listing of all your appraised property by category. Valuations, complete descriptions and locations of items are included in the documentation.

Appraisal fees vary according to the nature of the collection, the amount of work involved, the travel distance, and whether the property is subsequently consigned for auction.

Our appraisers are available to help you anywhere and at any time. Please call our Client Services Department to schedule an appraisal.

ESTATE SERVICES

Since 1865, Bonhams has been serving the needs of fiduciaries – lawyers, trust officers, accountants and executors – in the disposition of large and small estates. Our services are specially designed to aid in the efficient appraisal and disposition of fine art, antiques, jewelry, and collectibles. We offer a full range of estate services, ranging from flexible financial terms to tailored accounting for heirs and their agents to world-class marketing and sales support.

For more information or to obtain a detailed Trust and Estates package, please visit our website at www.bonhams.com/us or contact our Client Services Department.

BUYER’S GUIDE

BIDDING & BUYING AT AUCTION

Whether you are an experienced bidder or an enthusiastic novice, auctions provide a stimulating atmosphere unlike any other. Bonhams previews and sales are free and open to the public. As you will find in these directions, bidding and buying at auction is easy and exciting. Should you have any further questions, please visit our website at **www.bonhams.com** or call our Client Services Department at +1 (800) 223 2854 ext. 3550.

Catalogs

Before each auction we publish illustrated catalogs. Our catalogs provide descriptions and estimated values for each “lot.” A lot may refer to a single item or to a group of items auctioned together. The catalogs also include the dates and the times for the previews and auctions. We offer our catalogs by subscription or by single copy. For information on subscribing to our catalogs, you may refer to the subscription form in this catalog, call our Client Services Department, or visit our website at **www.bonhams.com/us**.


Previews

Auction previews are your chance to inspect each lot prior to the auction. We encourage you to look closely and examine each object on which you may want to bid so that you will know as much as possible about it. Except as expressly set forth in the Conditions of Sale, items are sold “as is” and with all faults; illustrations in our catalogs, website and other materials are provided for identification only. At the previews, our staff is always available to answer your questions and guide you through the auction process. Condition reports may be available upon request.


Estimates


Bonhams catalogs include low and high value estimates for each lot, exclusive of the buyer’s premium and tax. The estimates are provided as an approximate guide to current market value based primarily on previous auction results for comparable pieces, and should not be interpreted as a representation or prediction of actual selling prices. They are determined well in advance of a sale and are subject to revision. Please contact us should you have any questions about value estimates.

Reserves

Unless indicated by the  symbol next to the lot number, which denotes no reserve, all lots in the catalog are subject to a reserve. The reserve is the minimum auction price that the consignor is willing to accept for a lot. This amount is confidential and does not exceed the low estimate value.

Auction House’s Interest in Property Offered at Auction

On occasion, Bonhams may offer a lot in which it has an ownership interest, in whole or in part. Such property, if any, is identified in the catalog with a  symbol next to the lot number.

Similarly, Bonhams may have an economic interest in a lot beyond its commission as a result of making an advance against anticipated proceeds to the consignor which is secured by the consigned property or where it has guaranteed the consignor a minimum auction price for consigned property. Such property, if any, is identified in the catalog with a  symbol next to the lot number.

Bidding at Auction

At Bonhams, you can bid in many ways: in person, via absentee bid, over the phone, or via Bonhams’ live online bidding facility. Absentee bids can be submitted in person, online, via fax or via email.

Valid Bonhams client accounts are required to participate in bidding activity. You can obtain registration information online, at the reception desk or by calling our Client Services Department.

By bidding at auction, whether in person or by agent, by absentee bid, telephone, online or other means, the buyer or bidder agrees to be bound by the Conditions of Sale.

Lots are auctioned in consecutive numerical order as they appear in the catalog. Bidding normally begins below the low estimate. The auctioneer will accept bids from interested parties present in the saleroom, from telephone bidders, and from absentee bidders who have left written bids in advance of the sale. The auctioneer may also execute bids on behalf of the consignor by placing responsive or consecutive bids for a lot up to the amount of the reserve, but never above it.

We assume no responsibility for failure to execute bids for any reason whatsoever.

In Person

If you are planning to bid at auction for the first time, you will need to register at the reception desk in order to receive a numbered bid card. To place a bid, hold up your card so that the auctioneer can clearly see it. Decide on the maximum auction price that you wish to pay, exclusive of buyer’s premium and tax, and continue bidding until your bid prevails or you reach your limit. If you are the successful bidder on a lot, the auctioneer will acknowledge your paddle number and bid amount.

Absentee Bids

As a service to those wishing to place bids, we may at our discretion accept bids without charge in advance of auction online or in writing on bidding forms available from us. “Buy” bids will not be accepted; all bids must state the highest bid price the bidder is willing to pay. Our auction staff will try to bid just as you would, with the goal of obtaining the item at the lowest bid price possible. In the event identical bids are submitted, the earliest bid submitted will take precedence. Absentee bids shall be executed in competition with other absentee bids, any applicable reserve, and bids from other auction participants. A friend or agent may place bids on your behalf, provided that we have received your written authorization prior to the sale. Absentee bid forms are available in our catalogs, online at **www.bonhams.com/us**, at offsite auction locations, and at our San Francisco, Los Angeles and New York galleries.

By Telephone

Under special circumstances, we can arrange for you to bid by telephone. To arrange for a telephone bid, please contact our Client Services Department a minimum of 24 hours prior to the sale.

Online

We offer live online bidding for most auctions and accept absentee bids online for all our auctions. Please visit **www.bonhams.com/us** for details.

Bid Increments

Bonhams generally uses the following increment multiples as bidding progresses:

\$50-200	by \$10s
\$200-500	by \$20/50/80s
\$500-1,000	by \$50s
\$1,000-2,000	by \$100s
\$2,000-5,000	by \$200/500/800s
\$5,000-10,000	by \$500s
\$10,000-20,000	by \$1,000s
\$20,000-50,000	by \$2,000/5,000/8,000s
\$50,000-100,000	by \$5,000s
\$100,000-200,000	by \$10,000s
above \$200,000	at auctioneer’s discretion

The auctioneer may split or reject any bid at any time at his or her discretion as outlined in the Conditions of Sale.

Currency Converter

Solely for the convenience of bidders, a currency converter may be provided at Bonhams’ auctions. The rates quoted for conversion of other currencies to U.S. Dollars are indications only and should not be relied upon by a bidder, and neither Bonhams nor its agents shall be responsible for any errors or omissions in the operation or accuracy of the currency converter.

Buyer’s Premium

A buyer’s premium is added to the winning bid price of each individual lot purchased, at the rates set forth in the Conditions of Sale. The winning bid price plus the premium constitute the purchase price for the lot. Applicable sales taxes are computed based on this figure, and the total becomes your final purchase price.

Unless specifically illustrated and noted, fine art frames are not included in the estimate or purchase price. Bonhams accepts no liability for damage or loss to frames during storage or shipment.

All sales are final and subject to the Conditions of Sale found in our catalogs, on our website, and available at the reception desk.

Payment

All buyers are asked to pay and pick up by 3pm on the business day following the auction. Payment may be made to Bonhams by cash, checks drawn on a U.S. bank, money order, wire transfer, or by Visa, MasterCard, American Express or Discover credit or charge card or debit card. All items must be paid for within 5 business days of the sale. Please note that payment by personal or business check may result in property not being released until purchase funds clear our bank. For payments sent by mail, please remit to Cashier Department, 220 San Bruno Avenue, San Francisco, CA 94103.

Sales Tax

California, Arizona, Colorado, Connecticut, Florida, Georgia, Illinois, Nevada, New York, Massachusetts, Pennsylvania, Texas, Washington state and Washington DC residents must pay applicable sales tax. Other state or local taxes (or compensating use taxes) may apply. Sales tax will be automatically added to the invoice unless a valid resale number has been furnished or the property is shipped via common carrier to destinations outside the states listed above.

Shipping & Removal

Bonhams can accommodate shipping for certain items. Please contact our Cashiers Department for more information or to obtain a quote. Carriers are not permitted to deliver to PO boxes.

International buyers are responsible for all import/export customs duties and taxes. An invoice stating the actual purchase price will accompany all international purchases.

Collection of Purchases

Please arrange for the packing and transport of your purchases prior to collection at our office. If you are sending a third party shipper, please request a release form from us and return it to +1 (212) 644 9009 prior to your scheduled pickup. To schedule collection of purchases, please call +1 (212) 644 9001.

Handling and Storage Charges

Please note that our offices have requirements for freight elevator usage. Please contact us to schedule an elevator appointment for pickup of any large or awkward items. Bonhams will hold all purchased lots in our gallery until Monday April 20 without penalty. After April 20 collection of lots will be by appointment only. Please call +1 (212) 644 9001 at least 24 hours in advance to make an appointment.

Storage charges of \$5 per lot, per day will begin accruing for any lots not collected by the 31st day after the auction. Bonhams reserves the right to remove uncollected sold lots to the warehouse of our choice at the buyer’s risk and expense. Handling and storage fees will apply.

Auction Results

To find out the final purchase price for any lot following the sale, please call our automated auction results line at +1 (800) 223 2854 ext. 3400. All you need is a touch-tone telephone and the lot number. Auction results are usually available on the next business day following the sale or online at **www.bonhams.com/us**.

CONTACTS

OFFICERS

Laura King Pfaff
Chairman
Patrick Meade
Chief Executive Officer
James Hendy
Chief Operating Officer
Leslie Wright
Vice President, Trusts and Estates
Jon King
Vice President, Business Development
Vice Presidents, Specialists
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Mark Fisher
Martin Gammon
Dessa Goddard
Jim Haas
Scot Levitt
Frank Maraschiello
Mark Osborne
Hadji Rahimpour
Brooke Sivo
Jeffrey Smith
Catherine Williamson

REPRESENTATIVES

Arizona
Terri Adrian-Hardy, Tel: +1 (480) 994 5362

California - Central Valley
David Daniel, Tel: +1 (916) 364 1645

California - Palm Springs
Brooke Sivo, Tel: +1 (760) 350 4255

Southern California
Christine Eisenberg, Tel: +1 (949) 646 6560 †

Colorado - Denver
Julie Segraeves, Tel: +1 (720) 355 3737 †

District of Columbia/Mid-Atlantic
Martin Gammon, Tel: +1 (202) 333 1696

Florida
Jon King
Tel: +1 (561) 651 7876, Palm Beach
+1 (305) 228 6600, Miami
+1 (954) 566 1630, Ft. Lauderdale

Georgia
Mary Moore Bethea, Tel: +1 (404) 842 1500

Illinois
Ricki Harris
Tel: +1 (312) 475 3922, +1 (773) 267 3300

Massachusetts/Boston/New England
Amy Corcoran, Tel: +1 (617) 742 0909

Nevada
David Daniel, Tel: +1 (775) 831 0330

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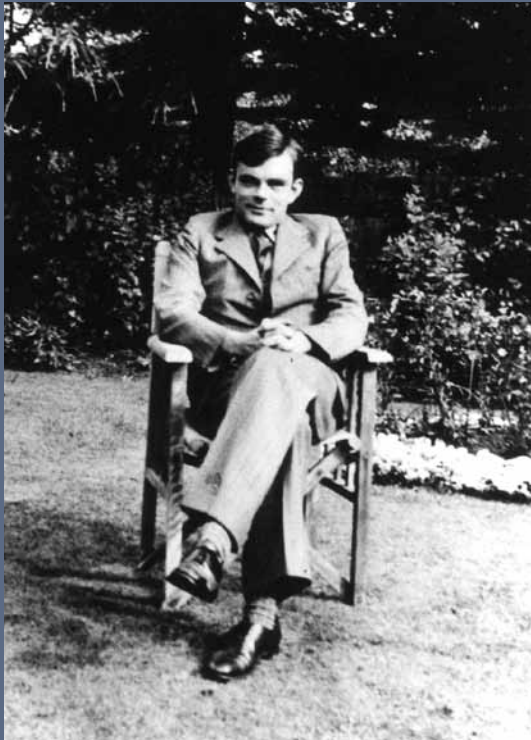
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“The fact remains that everyone who taps at a keyboard, opens a spreadsheet or a word-processing program, is working on an incarnation of a Turing machine.”

-Time magazine, Time 100 People of the Century.

Alan Turing, Age 16. Image: Sherborne School



Alan Turing ca. 1929. Image: King's College, Cambridge



Alan Turing ca. 1934. Image: King's College, Cambridge

SAVING PRIVATE TURING

Alan Turing died, ten years and a day after D-Day, on 7 June 1954. Shortly beforehand, on 11 February 1954, he had made a very distinctive will, whose provisions lie behind the present sale. As an unmarried young man of 41, he would have been expected to leave his estate to his family, perhaps with some gifts to charities or academic institutions. His elder brother John, a successful lawyer, was the obvious executor. Any such conventional expectations were entirely misplaced. For a start, Alan Turing appointed an executor unknown to his family: Nicholas Furbank, a shy young literary scholar who later became best known for his biography of E. M. Forster. The connection was, of course, that Furbank was an intimate and trusted gay friend.

Alan's brother was snubbed further by a small bequest, the same as to his cleaning lady. The bulk of the estate (£4600) was to be divided between five people, Nick Furbank being

one. Another was Neville Johnson, his regular boyfriend between 1948 and 1951. David Champernowne, the left-wing economist who had been a steady supportive friend since 1931, was a third. The others were his mother, and Robin Gandy. The five were, in fact, characterised by the support they had given Alan in his difficult life as a gay man. The inclusion of his mother as just one on that list was itself shocking, but for that very reason a far more positive statement about her than would have been adherence to a conventional family formula.

A recent British Government press release described these five as being his mother and four 'colleagues', but in fact it was Robin alone who fitted this description. He had been Alan's graduate student in mathematical logic since 1948, and an intellectual disciple. Their letters were signed off 'Love, Robin', 'Love, Alan', and Robin had the shock of losing an intimate friend.



Alan Turing, Age 15. Image: Sherborne School

Indeed, every person named felt a deep shadow cast by Alan Turing's dramatic death. Much could be said about the response of his mother to the trauma, but the recent republication of Sara Turing's 1959 memoir (together with a highly contrasting account by Alan's brother John) means that her own voice still speaks loud and clear. A much quieter part was played by Nick Furbank, who died in 2014. His six decades of service to his friend's wishes deserve one day to be properly described. But the present sale focusses attention on Robin Gandy. Another provision of Alan Turing's will was that he left Robin all his books and papers (even though Furbank, as executor, dealt with permissions and royalties). This provision has shaped the way that the record of Alan Turing's life has been preserved. It is also the reason why Alan Turing's wartime logic notebook, now for sale, became Robin's personal property.

In 1954 he was only a junior mathematics lecturer, but by the 1960s Robin Gandy was a distinguished logician in his own right. As such, he found himself taking over from Professor Max Newman as the editor of the long-promised Turing Collected Works. To cut a long story short, this project made little progress until the 1980s, and was not finished at the time of Robin's death in 1995. At this point, Robin's first student Mike Yates took over, and saw a completion in 2001. In 2012, this process went into a further generation, as Mike Yates's first student Barry Cooper conceived and saw through the volume *Alan Turing:*

His Work and Impact, which is now the largest and most accessible study of Turing's work.

One reason why this work took so long was that much of Alan Turing's work never appeared in a standard scientific journal of his own day, and that editing it required far more than mere compilation. It is often said that Alan Turing is an unknown, shabbily neglected figure, but in actual fact his work has probably been given as much detailed attention and publicity as any other contemporary mathematician. The key to this scholarship was, of course, Robin Gandy's guardianship of the papers Turing left to him. With the exception of some books, and of course of this notebook now for sale, he deposited them in the Turing archive at King's College, Cambridge, in the late 1970s. The cataloguing work of the Contemporary Scientific Archive project was instrumental in this transfer. In the 1990s, technology made it possible to scan the collection and place it on-line as www.turingarchive.org.

What was this Cambridge archive? It originated with Sara Turing, who persuaded King's College to accept her selection of her son's letters home, together with the letters and documents she had used in the late 1950s for writing her memoir. The union of this material with the papers left to Robin Gandy made a much more substantial collection. Even so, it is not voluminous. Alan Turing was parsimonious as a writer and kept little to document the origins of his thought. There are no diaries: no trace, for instance, of the diary of his feelings about Christopher Morcom's death, that he showed to David Champenowne as his close undergraduate friend in 1931. There is, however, that uniquely self-revealing short story, written in the wake of the 1952 trial, with its punning self-reference to the invention of a 'buoy'. And there are other items that more conventional guardians would have destroyed.

The mathematical papers amongst the collection consist mainly of items near to publication level, but which Turing had not finished off. (Indeed, some items have now been successfully completed by others.) The largest stack of paper is that of the work of 1953-54 on morphogenesis, recovered in the late 1970s from Turing's research students, who were so unfortunately left high and dry by Turing's death. This has been subsequently worked over and elucidated by expert *Collected Works* editors. Another slice of material consists of Turing's wartime work on logic — that is, the papers with material connected with the notebook now on sale. These likewise were edited and published in the *Collected Works*. The notebook enhances this existing cache by preserving Turing's rough notes and examples, material that Gandy would have found instructive when he took over this line of research in 1948 as Turing's student. It has no parallel in Turing's other lines of thought: there is nothing in the way of precursor or commentary material relating to Turing's great 1936 work, for instance.



Alan Turing, age 18. Image: Sherborne School

The King's College archive has also accreted various other examples of Turing's letters and papers, as kept by others and generously donated at various times from the 1950s to the present. Robin Gandy's own personal correspondence with Alan Turing, as both student and friend, is a prominent example.

But this archive is not the whole story. Since the 1970s, the scope of documentary material has widened with the release of government papers and more generally, the papers of all individuals and institutions Turing had contact with. As it is sometimes held that everything about Alan Turing's work was lost, it should be made clear that the (British) National Archives and the (London) Science Museum hold a good record of National Physical Laboratory papers on the ACE computer. (Indeed, the Science Museum has exhibited the Pilot ACE since 1958.) The National Archives also hold the internal, technical GCHQ documents released after 1996. Alan Turing's own report on the 1940 success of the Bombe and other methods for penetrating Enigma is supported by numerous clear and detailed accounts. Turing's reports from Washington at the turn of 1942-3 speak with his own individual voice, as do his two 1941 papers on probability and Bayesian statistics, which were held back until 2012 for release.

The written record has also been greatly enhanced by the growing scale and quality of Bletchley Park Museum curatorship. Memoirs and documents relating to the large

group within which Turing worked combine with a huge cache of decrypts. Reconstruction of machinery and methods have added much to the body of knowledge. The popular picture of records having been destroyed in 1945 is wide of the mark. And there is still scope for new discoveries, including material from US sources.

This brings us back to the 1943-44 period when this notebook was written. At that stage Turing had an overarching knowledge of all aspects of British, and some American, cryptological methods. A full assessment of his role in this period has yet to be given. His advanced speech scrambler, the Delilah, is even now being reconstructed; until recently we only had his preliminary report of 6 June 1944. There may well be fresh insights into the way Turing used this late period of the war to make his plans for the computer revolution of 1945. This period also involves a strange personal story: Robin Gandy was a witness to Turing's work at this time, in the top-secret Hanslope Park environment, yet Robin had no idea at that point that he would become a logician, or Alan Turing's student, let alone that he would inherit such a burden for the next fifty years. Dry as they may seem, the pages of this notebook carry a magic of time.

- ANDREW HODGES, AUTHOR OF *ALAN TURING: THE ENIGMA* (LONDON: VINTAGE/RANDOM HOUSE, 2014)



Hut 8, WWII workplace of Alan Turing at Bletchley Park. Image: Rex USA/Rex

ALAN MATHISON TURING

Born in 1912 to a civil servant and the daughter of a railway engineer, Turing distinguished himself as a child, showing a natural inclination towards mathematics and science. At the age of 15 he was already solving advanced problems despite not having studied even elementary calculus. He completed his undergraduate work in mathematics at Kings College, Cambridge, where he was subsequently elected a fellow. He then went on to complete his PhD at Princeton University, introducing the notions of ordinal logic and relative computing into his dissertation entitled *Systems of Logic Based on Ordinals* (1938). Turing is known as a hero for his work at Britain's code-breaking center Bletchley Park, where he was the principal figure in solving the German Enigma codes, using his ingeniously designed bombe. He is considered to be the father of theoretical computer science for his work including the discovery of the universal model of computation now known as the Turing Machine, his development of the notion of "oracle relativization," and his invention of the LU-decomposition method in numerical computation. His landmark paper "On Computable Numbers," written in 1936 when he was only 24 years old, led to his development of a universal computing machine and is now considered to be one of the most important scientific papers of the 20th century.

Turing had the type of mind that was able to see systems and patterns across fields, and his later work ventured into areas other than mathematics, most notably biology and chemistry. His hugely influential paper entitled *The Chemical Basis for Morphogenesis* (1952), which some consider to be the spark of modern chaos theory, has very recently been validated by researchers at Brandeis University and the University of Pittsburgh, confirming that Turing was a multi-disciplinary intellect. His tireless work in mathematics and science was tragically halted by his conviction in 1952 for the then crime of gross indecency (committing acts of homosexuality), followed by his sentence of chemical castration, and his subsequent suicide in 1954. He received an official royal pardon for his "crime" in December 2013 — 60 years after his suicide, one of only four Royal Pardons granted under the Royal Pardon of Mercy since the Second World War, a testament to Turing's status as a hero in the eyes of British people. Many books have been written about Turing, and his life has been memorialized in the award-winning film *The Imitation Game*, adapted from Andrew Hodges' excellent biography *Alan Turing: The Enigma*,¹ as well as in the Broadway play *Breaking the Code* by Hugh Whitmore. Despite all of the popular interest in his life, there are still many things about Turing that remain obscure. Some of these are illuminated by the contents of the present manuscript. The manuscript sheds light on the



Inside view of the rebuilt Turing Bombe. Image: REX USA/Brian Harris/Rex

problems that were of fundamental importance to Turing's work in the field of computer science, including deep issues in the foundations of mathematics such as the interpretation of symbols, and his quest to develop a universal language with the aim of allowing mathematics to be executed by machines rather than people. More than anything, the manuscript sheds light on Turing's great potential, giving us a glimpse into the types of work that he might have gone into had his life not tragically been cut short.

After completing his PhD dissertation in 1939 at the Institute for Advanced Study at Princeton under the supervision of Alonzo Church (1903-1995), Turing returned to Cambridge. There, before the Second World War broke out, Turing attended a series of lectures given by the philosopher Ludwig Wittgenstein (1889-1951) on the foundations of mathematics and the interpretation of mathematical symbols. These lectures were to have a profound influence on Turing's work in the field of computer science and type theory: as Juliet Floyd points out in *Alan Turing: His Work and Impact*, "Turing is explicit that 'the statement of the type principle' in this essay [*The Reform of Mathematical Notation and Phraseology*] was suggested by lectures of Wittgenstein."² These ideas would continue to be important to Turing's work for the duration of his life, and were very much on



3-Rotor Enigma Enciphering Machine. Sold for \$92,500 in these rooms, June 5, 2014.

R. B. Braithwaite

A. M. TURING.

ON COMPUTABLE NUMBERS, WITH AN
APPLICATION TO THE ENTSCHEIDUNGS-
PROBLEM.

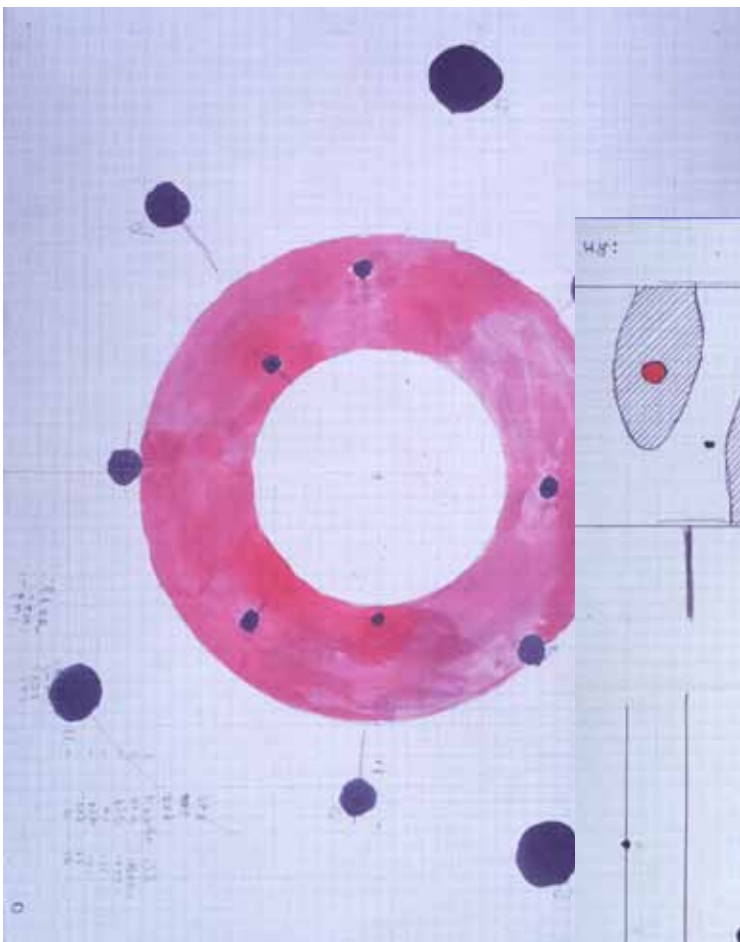
A copy of Turing's famous "On Computable Numbers" - this copy inscribed to R.B. Braithwaite in Turing's hand. Sold for £205,250 at Bonhams Knightsbridge on June 19, 2013

his mind as he wrote the present manuscript in which he, among other things, carefully examines the work of some of his predecessors who worked to develop a universal mathematical language, such as Leibniz and Boole, precisely because he himself was endeavoring to do the same thing. "In the 1800s Babbage wrote polemics about mathematical notation, and by the 1880s Frege, Peano and others were trying hard to create more systematic ways to represent mathematical processes. And no doubt that systematization was a necessary precursor to Hilbert's program, Gödel's theorem, and ultimately Turing's own work on defining

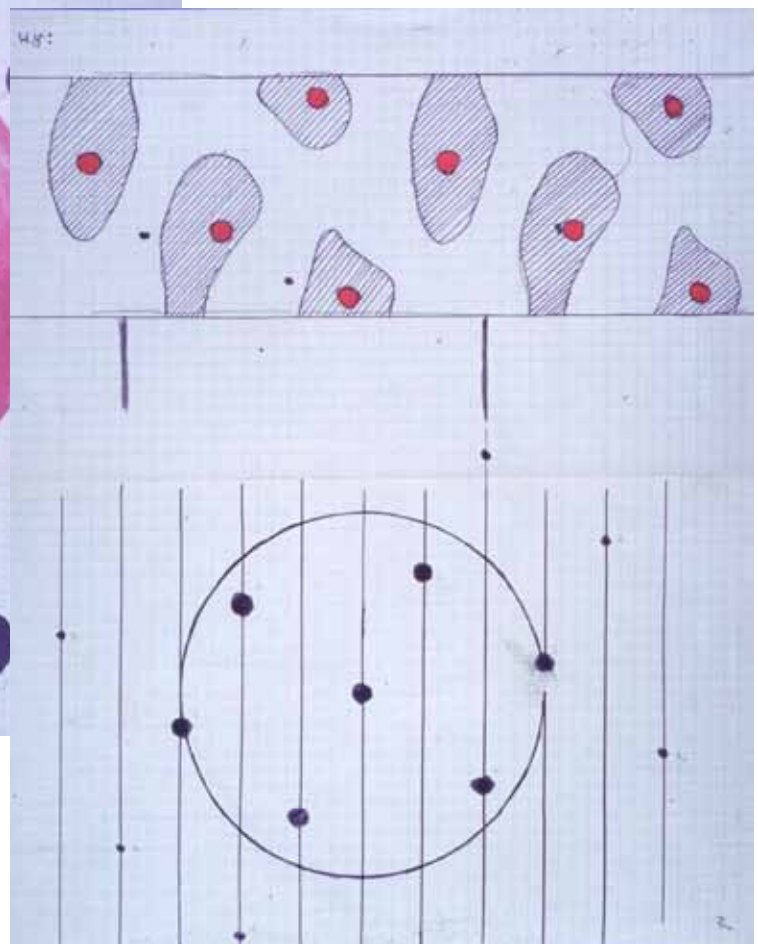
what amounts to a universal mechanism for mathematical processes ... I suspect Turing was curious about what would be involved in creating a higher level representation: a full systematic language for mathematics at the level people actually do it."³

The manuscript lends an unparalleled insight into the workings of one of the greatest minds of the 20th century.

Cassandra Hatton, Bonhams
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Daisy ring diagram, made by Turing in connection with his work on morphogenesis. Image: King's College, Cambridge. Copyright: Bob Owens



Colored diagram showing patterns of dappling and calculations made by Turing in connection with his work on morphogenesis. Image: King's College, Cambridge. Copyright: Bob Owens

“It is no exaggeration to say that, without his outstanding contribution, the history of World War Two could well have been very different... The debt of gratitude he is owed makes it all the more horrifying, therefore, that he was treated so inhumanely... While Turing was dealt with under the law of the time and we can’t put the clock back, his treatment was of course utterly unfair and I am pleased to have the chance to say how deeply sorry I and we all are for what happened to him. Alan and the many thousands of other gay men who were convicted as he was convicted under homophobic laws were treated terribly.”

Statement made on September 10, 2009 by then British Prime Minister Gordon Brown.



Turing, age 18, next to Ben Davis, head of Mathematics at Sherborne School. Image: Sherborne School



"We live in the age of computers, but few of us know who invented them. Because most of the pioneers were part of collaborative teams working in wartime secrecy, they aren't as famous as Edison, Bell or Morse. But one genius, the English mathematician Alan Turing, stands out as a heroic-tragic figure..."

Walter Isaacson *

HIDDEN WARTIME MANUSCRIPT BY THE FATHER OF COMPUTING.

Lot 1

TURING, ALAN MATHISON. 1912-1954.

Composition notebook. 4to (226 x 176 mm), 81 leaves. Original cloth backed marbled-paper covered boards supplied by Metcalfe and Co., Trinity Street, Cambridge, with their stamp to rear pastedown. Divided into three sections:

Part 1: TURING, Alan. Autograph manuscript, 27 pp, on leaves 1r-14r. In blue ink, written primarily on rectos with occasional notes on versos. No date, but approximately 1944. Treating in general Peano's notation and axioms.

Part 2: GANDY, Robin. Autograph manuscript, 26 pp on leaves 14v-32r. In blue, red, green and black ink, written primarily on rectos with a few notes on versos. May 26, 1956-October 24, 1956. The 70 pages from leaf 32v-67r are blank.

Part 3: TURING, Alan. Autograph manuscript, 29 pp, on leaves 67v-81v. In blue-black ink, written upside down from

end of notebook forwards, primarily on rectos, with a few notes on versos. No date but approximately 1944. Titled "Notes on Notations."

HITHERTO UNKNOWN WARTIME MANUSCRIPT OF THE UTMOST RARITY, CONSISTING OF 56 PAGES OF MATHEMATICAL NOTES BY ALAN TURING, LIKELY THE ONLY EXTENSIVE HOLOGRAPH MANUSCRIPT BY HIM IN EXISTENCE.

Turing material of any kind is extremely rare, and anything with a direct personal connection to him even more so. This, Turing's wartime notebook on logic, is the first time a manuscript by him has ever come to public market. Written during the Second World War, it has its origins in Turing's well-documented dialogues with Wittgenstein in 1939 on the interpretation of mathematical symbols.⁴

Estimate on request

* "Where Innovation Comes From," *The Wall Street Journal*, September 26, 2014, under "The Saturday Essay," <http://www.wsj.com/articles/a-lesson-from-alan-turing-how-creativity-drives-machines-1411749814> [accessed January 23, 2015].

+ means 'successor of' and with after words.
+ also means +

ie. ~~$a + 1$ means $a + 1$~~

$$a + = a + 1$$

N_0 is the class of natural numbers.

Peano axioms

$$N_0 \neq \emptyset, 0 \in N_0, a \in N_0 \Rightarrow a + \in N_0,$$

$$S \subseteq \emptyset, 0 \in S : x \in S, \exists x, x + \in S : \supset N_0 \supset S$$

$$\text{Also (also)} \quad a + = b + \supset a = b.$$

$$a \in N_0 \supset a + - = 0$$

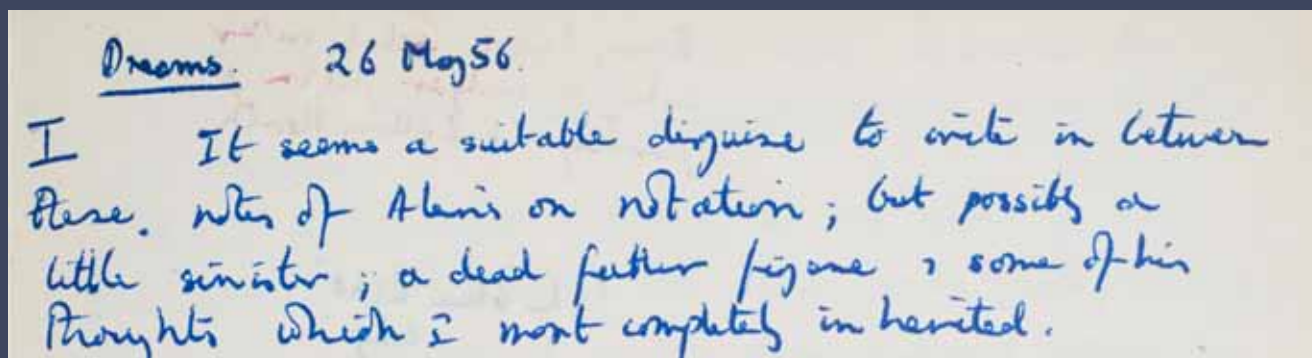
Peano does something rather reminiscent of Church's def. of
integers by defining

$$a \cup 0 = a$$

$$a \cup 1 = a \cup$$

$$a \cup 2 = a \cup \cup$$

$$\text{Hence} \quad a \cup (b + c) = (a \cup b) \cup c$$



Opening lines of Robin Oliver Gandy's dream journal

ORIGIN AND HISTORY OF THE MANUSCRIPT

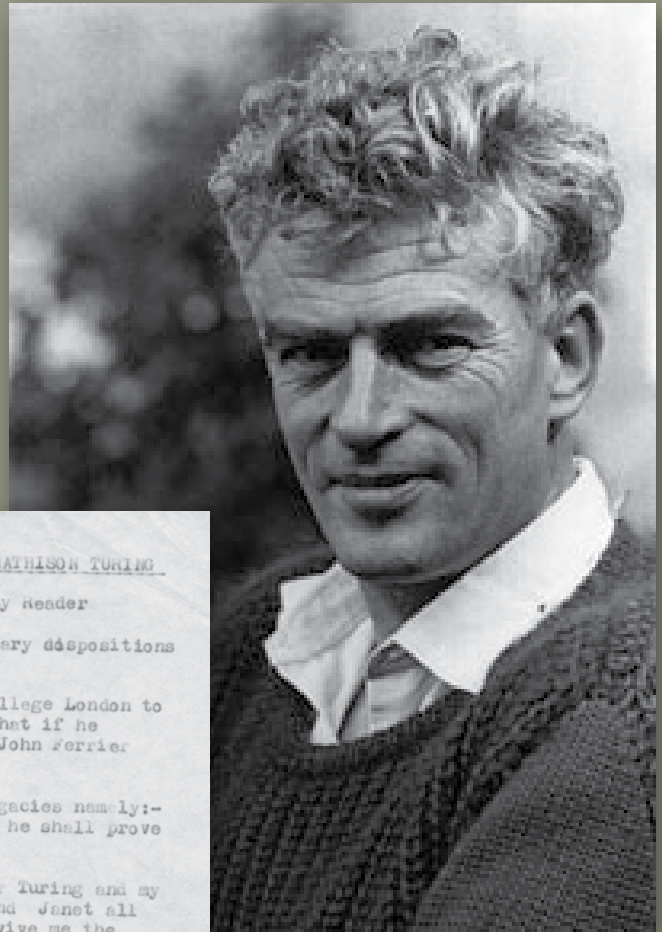
In his will,⁵ written on February 11th 1954 just a few months before his death, Turing gave all of his mathematical books, articles, and manuscripts to his close friend the British mathematician and logician Robin Oliver Gandy (1919-1995). Gandy studied for a PhD in mathematics at Cambridge under Turing's supervision, and is best known for his important work in recursion theory. He would later take up Turing's mantle, making significant contributions including the Spector-Gandy theorem and the Gandy Selection theorem, as well as to the understanding of the Church-Turing thesis. His generalization of the Turing machine is known as a Gandy machine. In 1977, Gandy deposited the material he had inherited in an archive at Kings College, Cambridge with the exception of one item: the present manuscript. Why? In 1952 following his conviction, Turing began seeing Dr. Greenbaum, a Jungian analyst who had Turing keep a series of dream journals. Along with the scientific papers, Gandy inherited these journals, and returned them to Greenbaum, who later destroyed them. Doubtless inspired by Alan's dream journals, Gandy decided to keep his own – in the middle blank pages of the present manuscript, stating in the opening lines:

"It seems a suitable disguise to write in between these notes of Alan's on notation; but possibly a little sinister; a dead father figure, some of his thoughts which I most completely inherited." (f. 15r)

As one could imagine, dream journals such as these would contain extremely private, and often embarrassing or painful information. Gandy chose what he felt would be the safest place to record his most intimate thoughts and dreams, though the sentimentality of placing his thoughts close to those of his late friend surely played a role in this choice. Indeed, Alan clearly made a frequent appearance in Gandy's thoughts, and is mentioned more than once in the journal:

"The more sinister as I handed over Alan's dream book to Greenbaum who I certainly at one stage thought of as responsible for A's suicide." (14v)

Keeping this dream journal hidden between Turing's notes must have been at once a comfort to Gandy, while at the same time, a painful reminder of his loss of a dear friend. As the material deposited in the Turing Archive was to be made publicly available to historians and scholars, and has indeed been accessed many times, it is clear that this item was simply much too personal to be shared in the archive. Indeed, Gandy kept the journal amongst his personal effects for the rest of his life, and it was not seen by another person until his death in 1995. It was then inherited by one of Gandy's executors, from whom the current owner acquired it.



Robin Oliver Gandy, ca 1970

THIS IS THE LAST WILL AND TESTAMENT of me ALAN MATHISON TURING
of Hollymeade Aulington Road Wilmslow University Reader

2. I HEREBY revoke all former wills and testamentary dispositions made by me

3. I APPOINT Philip Nicholas Furbank of King's College London to be the sole Executor of this my Will provided that if he shall not survive me then I appoint my brother John Ferrier Turing to be the sole Executor thereof

4. I GIVE the following pecuniary and specific legacies namely:-
(a) To the said Philip Nicholas Furbank in case he shall prove this my Will the sum of One hundred pounds
(b) To each of them my said brother John Ferrier Turing and my sister-in-law Joan and nieces Inagh Jean Shuna and Janet all of Glenthorne West Road Guildford who shall survive me the sum of Fifty pounds
(c) To Mrs Clayton of 6 Mount Pleasant Wilmslow in case she shall survive me the sum of thirty pounds together with an additional sum of 10 pounds for each completed year in which she shall be in my employ from and after the thirtyfirst day of December One thousand nine hundred and fifty three
(d) To Robin Oliver Gandy of University College Leicester
University
manuscripts
of money

2. I GIVE personal
Codicil
estate of
disposition unto such of them my mother Ethel Sarah Turing the said Philip Nicholas Furbank the said Robin Oliver Gandy David Gawen Champenowne of Ruffield College Oxford University Professor and Stanley Neville Johnson of 2 Derby Road Caversham Electrical Engineer as shall be living at the date of my death and if more than one in equal shares

5. ANY Executor or Trustee being a Solicitor or other person engaged in any profession or business shall be entitled to charge and be paid for all acts done by him or his firm in connection with the trusts hereof including acts which a trustee not being engaged in any profession or business as aforesaid could have done personally

IN WITNESS whereof I have to this my Will set my hand

Alan Turing's will

Image courtesy King's College, Cambridge.
Copyright Bob Owens

DATING THE NOTES

There are a few clues that help us find an approximate date for this manuscript. A careful comparison shows that certain pages of the manuscript have a relation to an unpublished typescript entitled “The Reform of Mathematical Notation and Phraseology”⁶ housed amongst the Turing papers held in the Archive Centre at King’s College, Cambridge. This typescript was later published in Turing’s collected works, where the date attributed to the typescript is 1944-45.⁷ Additionally, Turing refers to the work of several mathematicians (including his own) the majority having been written between 1927 and 1940. The latest reference being for one of Turing’s own papers, published in 1942.

FIRST PART OF THE MANUSCRIPT: PEANO’S AXIOMS

Giuseppe Peano (1858-1932) was an Italian mathematician known as one of the founders of mathematical logic and set theory, who axiomatized for the first time the theory of natural numbers. His five axioms were meant to provide a rigidly accurate foundation for the natural numbers. These five axioms would go on to play a key role in a number of questions posed by logicians and mathematicians, most notably by the German mathematician David Hilbert (1862-1943). Hilbert, in his 1928 address to the International Congress of Mathematicians in Bologna posed three famous challenges to the mathematical community:

1. To prove that all true mathematical statements could be proven, that is, the completeness of mathematics.
2. To prove that only true mathematical statements could be proven, that is, the consistency of mathematics.
3. To prove the decidability of mathematics, that is, the existence of a decision procedure to decide the truth or falsity of any given mathematical proposition.

The third of these three problems became known as Hilbert’s *Entscheidungsproblem* [Decision Problem]. The first two questions of completeness and consistency were famously answered two years later by the Austrian logician Kurt Gödel (1906-1978) in his “*Über formal Unentscheidbare Sätze der Principia Mathematica und verwandter Systeme I.*” [On Formerly Undecidable Propositions in Principia Mathematica and Related Systems.]⁸ In this revolutionary paper, Gödel introduced his incompleteness theorem, which “showed that even powerful logical systems could not hope to encompass the full scope of mathematical truth.”⁹ Gödel showed that, for any axiomatic system powerful enough to describe the natural numbers, such as the Peano axioms, 1: If the system is consistent, then it cannot be complete, and 2: The consistency of the axioms cannot be proven within the system. So what was Turing’s interest in the Peano axioms? We know that Turing was introduced to Hilbert’s *Entscheidungsproblem* as well as Gödel’s incompleteness theorem in a lecture course given by English mathematician and code-breaker Max Newman (1897-1984) at Cambridge in the spring of 1935; after learning about it, Turing immediately took up the challenge of solving the *Entscheidungsproblem*. It was his process of doing so that led to his development of a universal computing machine, as clearly expressed by Newman: “I believe it all started because he attended a lecture of mine on foundations of mathematics and logic . . . I think I said in the course of this lecture that what is meant by saying that [a] process is constructive is that it’s a purely mechanical machine and I may even have said, a machine can do it. And this of course led [Turing] to the next challenge, what sort of machine, and this inspired him to try and say what one would mean by a perfectly general computing machine.”¹⁰ Newman understood that the “machine” Turing was working on had applications that went far beyond that of the *Entscheidungsproblem*, and said that Turing’s now famous paper *On Computable Numbers with an Application to the Entscheidungsproblem* (1936) contained an “extraordinary definition of a perfectly general . . . computable function, thus giving the first idea . . . of a perfectly general computing machine.”¹¹

a, b or $a \cap b$	intersection of a and b ($a \cap b$?)
$a \cup b$	$a \vee b$.
$-a$	class of not a
$b - a$	class of b which are not a (does the follow for above class exist?)
Δ	empty null class.

$a = b$ $-(a = b)$ Hatred!

Dots are used as brackets, as in my paper. The more
dots the more powerful.

There is no very clear notion of hypothesis. It is however
suggested that on the first introduction of a variable it is specified
what class it belongs to.

The following examples of bound variables are given

$$(f(x))_{x=a} \quad \lim_{x=a} f(x) \quad \int_a^b f(x) dx$$

The expressions 'bound' and 'free' are not used.

The notation $\sup_{x,y,z}$ is used to mean 'for all x,y,z '
There seem to be no qualifications. $\sup_{x,y,z}$ can only be used in
main implication.

Dots are used as brackets, as in my paper. The more dots the more powerful.

With this in mind, it becomes clear that the notes contained in the manuscript are not simply an attempt to get non-logicians to use stricter notation, or simply a superficial study of Peano's axioms. Turing, like his intellectual forefathers Leibniz and Boole, was in fact working on a topic of profound importance: the development of a universal language; something that was to be at the core of modern computer science.

To this end, Turing not only examines the work of Peano, but also references and compares the work of other mathematicians who helped to lay the foundation for the development of a universal language, including Church, Descartes, Pell, Lagrange, and Arbogast amongst others. On page 5 of the notes, Turing states:

"Dots are used as brackets, as in my paper. The more dots, the more powerful."

Here, he refers to his paper "The Use of Dots as Brackets in Church's System"¹² in which he defines a new notation for Alonzo Church's λ -calculus (Church [1903-1995] oversaw Turing's PhD thesis at Princeton, and is perhaps best known for his λ -calculus), which Church introduced as part of his investigation into the foundations of mathematics. "The Use of Dots..." shows "Turing's ability to reason about important issues in computer science before there were digital computers to reason about. In this case, Turing essentially studies an important aspect of programming languages, a syntax for trees."¹³ In the manuscript, Turing offers some critiques on the notation, which are revealing of his passion for the subject, such as on page 5:

" $a - = b - (a = b)$ Hatefull!", and "There is no very clear notion of hypothesis. It is however suggested that on the first introduction of a variable it be specified what class it belongs to."

$a - = b$

$-(a = b)$

Hateful!

There is no very clear notion of hypothesis. It is however suggested that on the first introduction of a variable it be specified what class it belongs to.

2.) Weyl. Classical Aps p.3.

A formal expression

$$f(x) = \sum_{i=0}^n \alpha_i x^i$$

involving the 'indeterminate' (or variable) x , whose coefficients α_i are numbers in a field k , is called a $(k-)$ polynomial of formal degree n .

The idea of an 'indeterminate' is distinctly subtle, I would almost say too subtle. It is not (at any rate as van der Waerden sees it) the same as variable. Polynomials in an indeterminate x , $f_1(x)$ and $f_2(x)$, would not be considered identical if $f_1(x) = f_2(x)$ all x in k , but the coefficients differed. They are in effect the array of coefficients, with rules for multiplication and addition suggested by their form.

I am inclined to the view that this is too subtle and makes an inconvenient definition. I prefer the indeterminate k be just the variable.

Leaf 80 verso

SECOND PART OF THE MANUSCRIPT: "NOTES ON NOTATION."

The second half of the Turing manuscript, which he entitles "Notes on Notations" consists of Turing's remarks and observations on the work of various prominent mathematicians, including Weyl (1885-1955), Leibniz (1646-1716), Hilbert (1862-1943) Courant (1888-1972), Titchmarsh, and Pontryagin (1908-1988) amongst others. In this section, it is clear that Turing analyzes the work on these mathematicians with the aim of improving and building upon their work, as he writes of Weyl:

"The idea of an 'indeterminate' is distinctly subtle, I would almost say too subtle. It is not ... the same as variable. Polynomials

in an indeterminate x , $f_1(x)$ and $f_2(x)$, would not be considered identical if $f_1(x) = f_2(x)$ all x in k , but the coefficients, with rules for multiplication and addition suggested by their form."

It is clear that Turing is not merely criticizing the notation conventions used by Weyl, but rather is trying to analyze and make improvements to them, which the intent of building upon them, as he then writes:

"I am inclined to the view that this is too subtle and makes an inconvenient definition. I prefer the indeterminate k be just the variable."

6) The Leibniz notation $\frac{dy}{dx}$ I find extremely difficult to understand in spite of it having been the one I understood best once! It certainly implies that some relation between x and y has been laid down eg.

$$y = x^2 + 3x$$

(see A)

Detail from leaf 78 verso

Leibniz was Turing's intellectual predecessor in the development of a universal language, so it is only natural that Turing should examine his forms of logical notation. Leibniz, best known for developing the infinitesimal calculus independently of Isaac Newton was also known for his "wonderful idea," a special alphabet whose characters represented concepts rather than sounds, "A language based on such an alphabet should make it possible to determine by symbolic calculation which sentences written in the language were true and what logical relationships existed among them."¹⁴ Of this, Turing notes:

"The Leibniz notation dy/dx I find extremely difficult to understand in spite of it having been the one I understood the best once! It certainly implies that some relation between x and y has been laid down . . . "

Turing goes on to point out difficulties in dealing with the positioning of variables, and the pitfalls with the way they are commonly denoted. It is clear that this was a problem of importance to Turing, but one that he had not yet quite worked out, as he writes:

"What is the way out? The notation $(\frac{d}{dx} f(x, y))_{x=y, y=x}$ hardly seems to help in this difficult case."

On the other hand the $f(x, y)$ notation of course is not linearly arranged. What is the way out? The notation $(\frac{\partial}{\partial x} f(x, y))_{x=y, y=x}$ hardly seems to help in this difficult case.

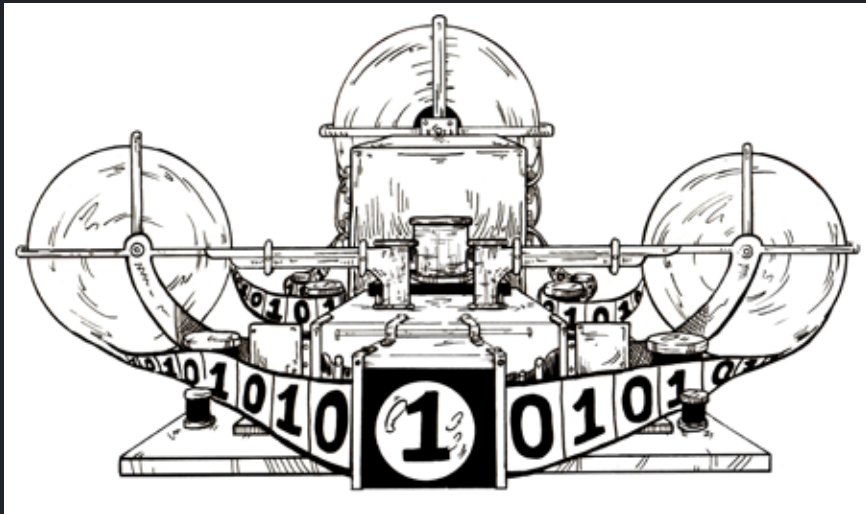
Detail from leaf 75 verso



Alan Turing, ca. 1936. Image: King's College, Cambridge

While the mathematical content is surely the most historically significant part of the notebook, containing ideas that are, and will surely continue to be relevant, the notebook helps to tell a larger part of Turing's tragic life story, placing his work within the context of who he was as a person. He was not just one of the most highly influential mathematicians of the twentieth, if not of any century, not just a hero who helped to put an end to the Second World War with his solution to the Enigma codes, not just the father of the computer age. He was also

a man who had fears and shortcomings like the rest of us, who wanted perhaps more than anything, to be free to live his life as he wished and to be himself without consequences. Because he was not permitted to do so, humanity has been deprived of one of its greatest minds, and we will never know what other groundbreaking ideas he would have developed had he not been put in the situation where taking his own life was preferable to having to live a life where he was not permitted to be his true self.



Conceptualization of the Turing Machine
invented by Turing in 1936.
Illustration: Robert Charleton

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1. Andrew Hodges, *Alan Turing: The Enigma*. (Princeton and Oxford: Princeton University Press, 2014).
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4. Cora Diamond, ed., *Wittgenstein's Lectures on the Foundations of Mathematics*, Cambridge, 1939. (Ithaca: Cornell, University Press, 1976).
5. Alan Mathison Turing, "The Reform of Mathematical Notation and Phraseology," ca. 1944. <http://www.turingarchive.org/browse.php/C/12>
6. Archive of Alan Mathison Turing at King's College, Cambridge <http://www.turingarchive.org/browse.php/A/5>
7. Archive of Alan Mathison Turing at King's College, Cambridge <http://www.turingarchive.org/browse.php/C/12>
8. Gandy, Robin, ed. *The Collected Works of A.M. Turing*. Mathematical Logic. (London: Elsevir, 2001), 211.
9. *Monatsheften für Mathematik*, XXXVIII, Band I. (Leipzig: Akademische Verlagsgesellschaft, 1931).
10. Martin Davis, *The Universal Computer: The Road From Leibniz to Turing*. (New York: W.W. Norton, 2000), 100.
11. Max Newman, interview by Christopher Evans, *The Pioneers of Computing: An Oral History of Computing*, London Science Museum.
12. Max Newman, interview by Christopher Evans, *The Pioneers of Computing: An Oral History of Computing*, London Science Museum.
13. *Journal of Symbolic Logic*, Vol. 7 (1942), pp 146-156.
14. Lance Fortnow, "Lance Fortnow Discovers Turing's Dots", *Alan Turing: His Work and Impact*. Edited by S. Barry Cooper and Jan van Leuween. (London: Elsevier, 2013), 227-228.
15. Martin Davis, *The Universal Computer: The Road From Leibniz to Turing*. (New York: W.W. Norton, 2000).

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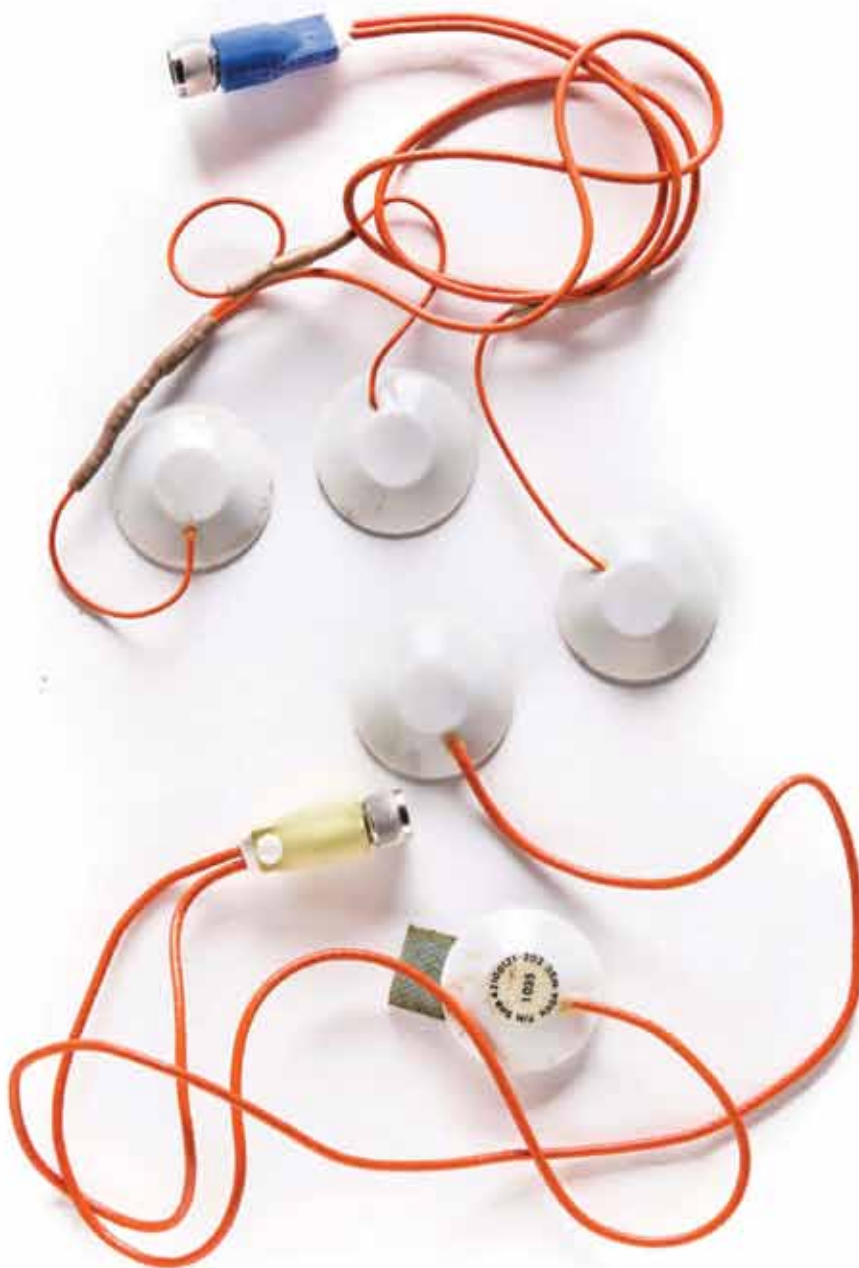
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