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HISTORY OF SCIENCE & TECHNOLOGY

INCLUDING THE NOBEL PRIZE AND PAPERS OF RICHARD P. FEYNMAN

NEW YORK | 30 NOVEMBER 2018

FRONT COVER
LOT 47

BACK COVER
RICHARD P. FEYNMAN'S BLACKBOARD AT THE TIME OF HIS DEATH, 1988
(COURTESY OF THE ARCHIVES, CALIFORNIA INSTITUTE OF TECHNOLOGY)

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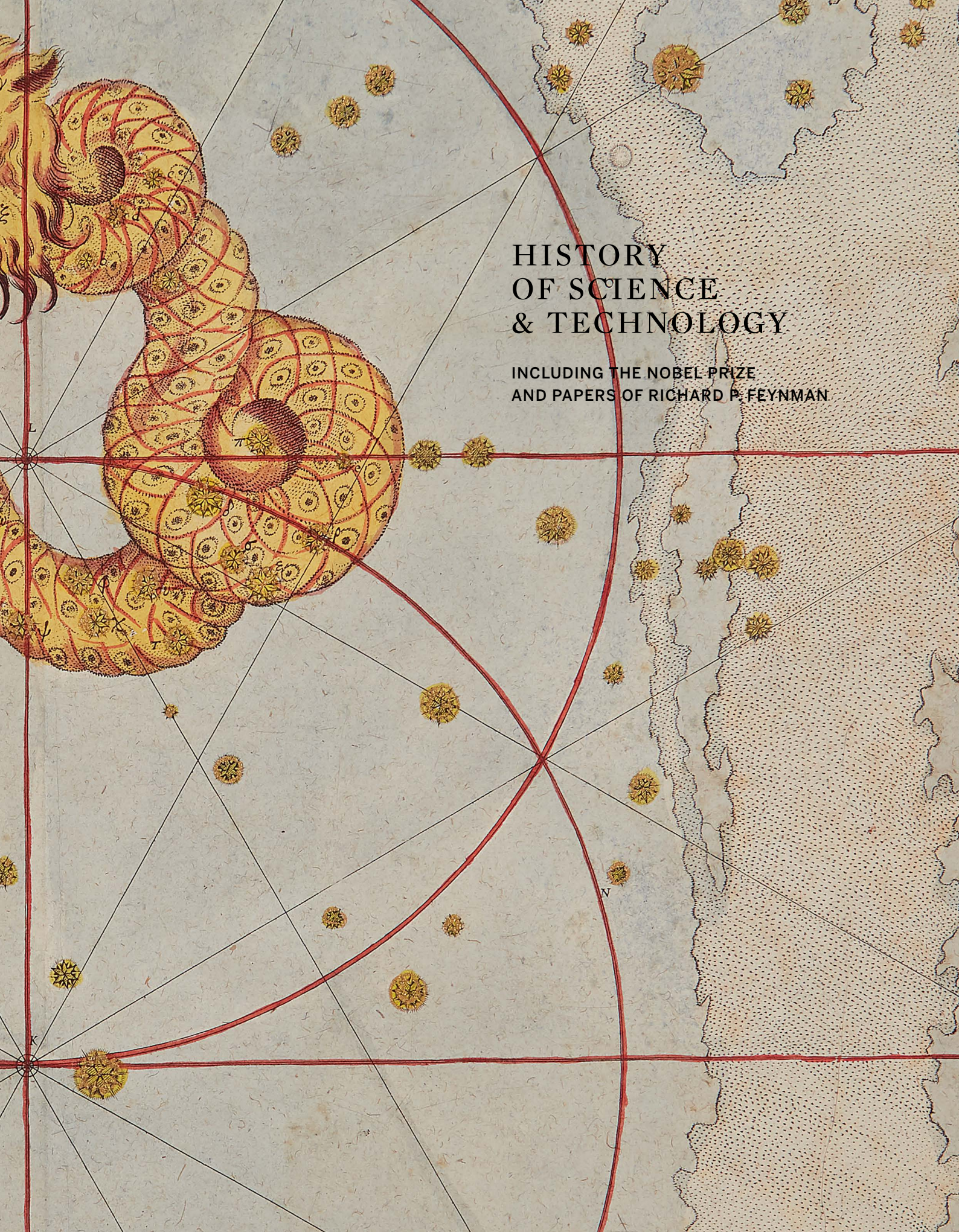
LOT 15

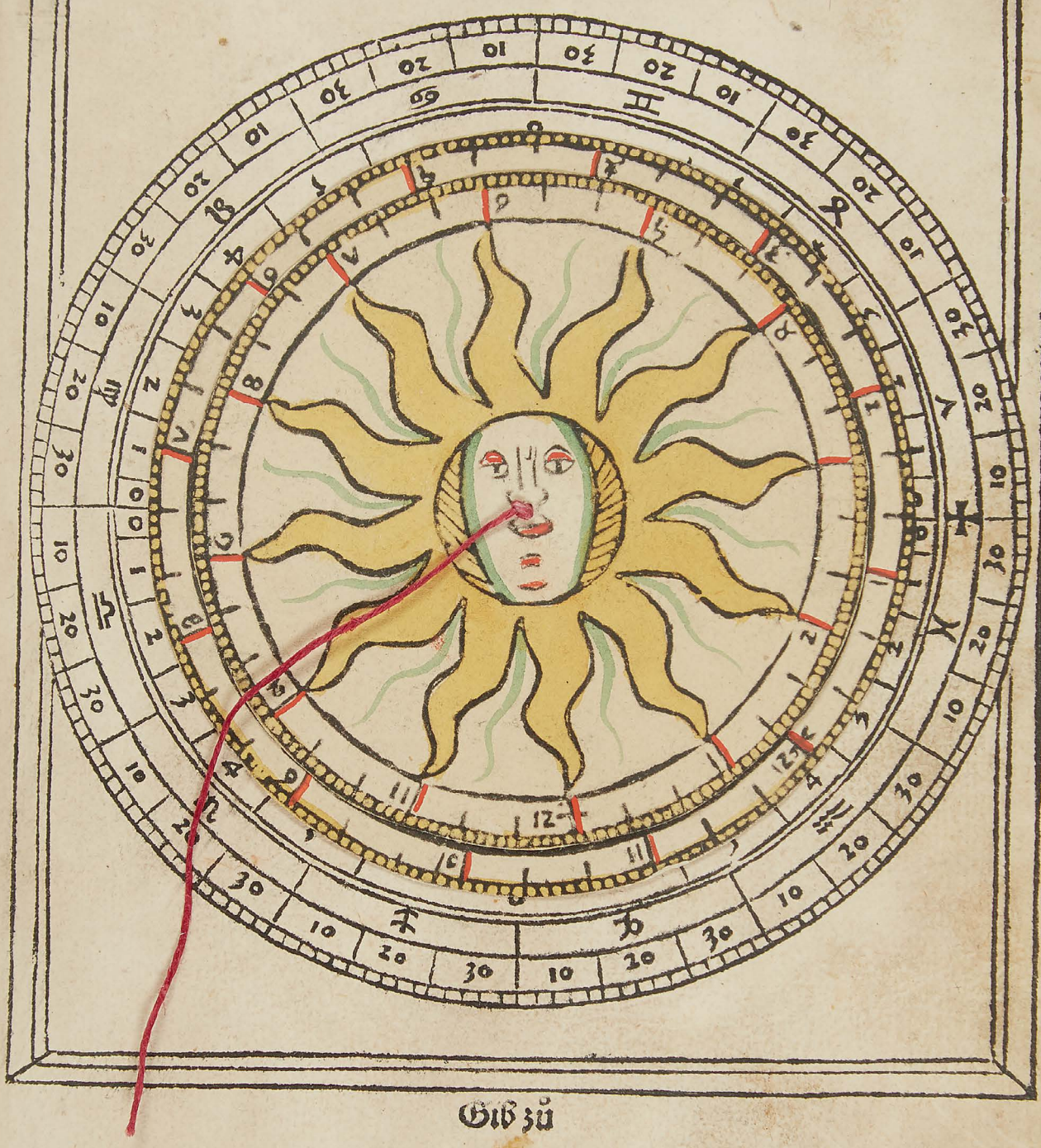


HISTORY OF SCIENCE & TECHNOLOGY

INCLUDING THE NOBEL PRIZE AND PAPERS OF RICHARD P. FEYNMAN

Instrumentum Lune

Nym ab



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HISTORY OF SCIENCE & TECHNOLOGY

INCLUDING THE NOBEL PRIZE AND PAPERS OF RICHARD P. FEYNMAN

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30 NOVEMBER 2018
SALE N09886
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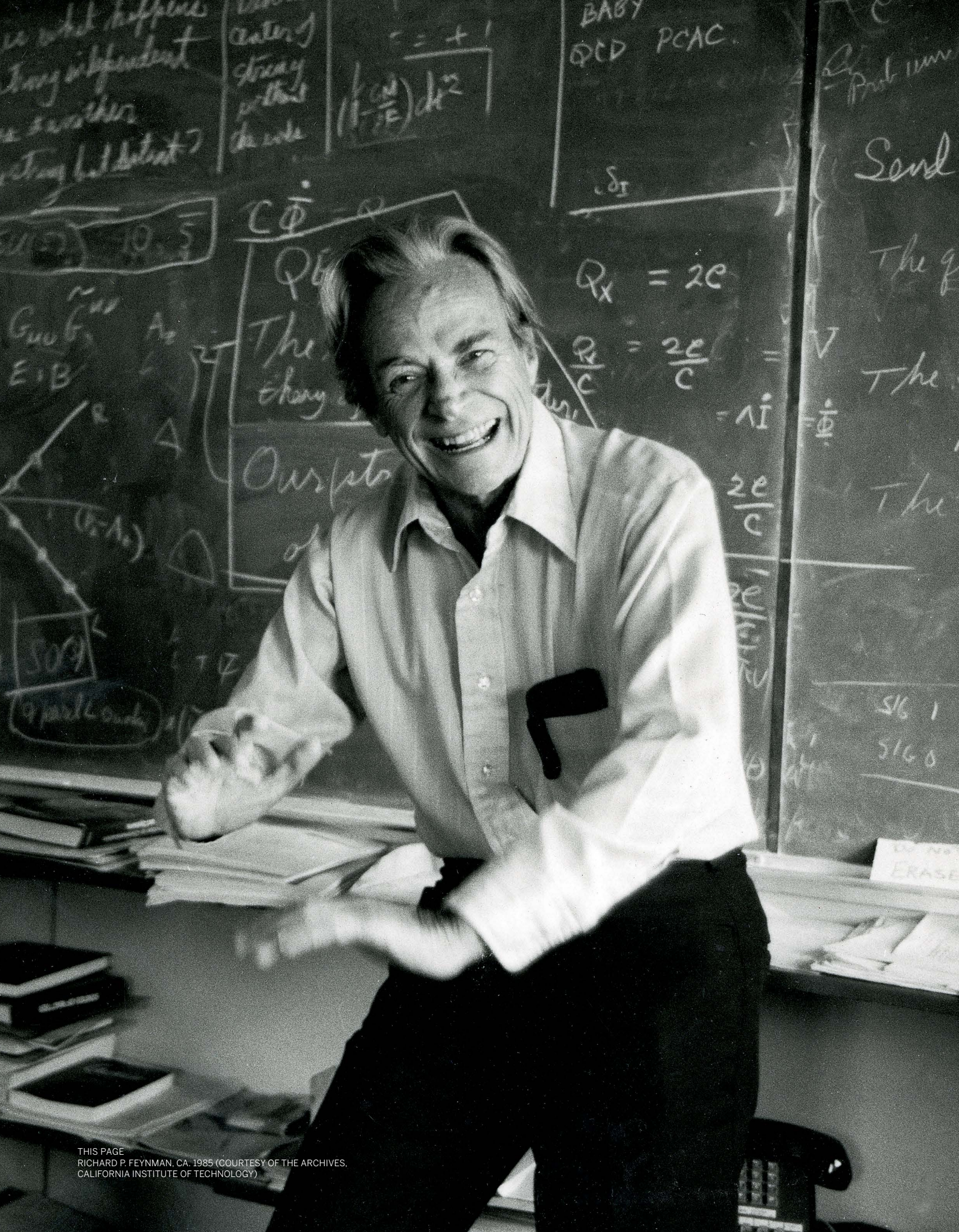

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RICHARD P. FEYNMAN, CA. 1985 (COURTESY OF THE ARCHIVES, CALIFORNIA INSTITUTE OF TECHNOLOGY)

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Sotheby's Books & Manuscripts Department would like to thank Prof. Tim Halpin-Healy for his tremendous contributions to the cataloguing of the Richard P. Feynman papers & books. We are very grateful for his invaluable assistance.

Classical theory self energy difficulties (field on self)

Quantum theory - still trouble - emit quant & reabsorb.

→ infinity as we go to infinite energy quanta

(also Vac Pol.)

Experiment of Lamb. → Bethe & Weisskopf. difference of bound & free self energy

(ambiguous ?)

Lewis & Oppy — Radiative scattering - subtract guessed terms

representing change in mass.

Schwinger - Formulate which terms to omit from Ham. 1st order

I - make theory which gives finite result for all effects such

as self energy ∴ can get complete answers. Any subtraction

would be of finite quantities & ∴ not ambiguous. (open question)

Idea In class. pot. when $\Delta t = r/c$ or $t^2 - r^2 = 0$.

Influence $\delta(t^2 - r^2)$

Charge to $f(t^2 - r^2)$

at large distances no effect ($t - r$ of order a^2/r)

at small wavelengths effect. Self energy finite

Quantum Interaction thru superposition of quanta various directions & wave length & frequency ($\omega = k$ on variables).

∴ Have to integrate matrix elements over $\int \frac{d\kappa}{\kappa}(\ldots)$

Now + needs different distribution of ω, κ. Need $\int \mathcal{G}(\omega,\kappa)\, d\kappa\, d\omega\,(\ldots)$

$\mathcal{G}$ is fourier transform of f. ∴ Most convenient in form

$$\mathcal{G}(\omega,\kappa) = \int_0^\infty G(\lambda)\, d\lambda \left[\delta(\omega^2 - k^2) - \delta(\omega^2 - k^2 - \lambda^2)\right]$$

Least action $\int \sqrt{1-\dot{x}^2}\, dt + \int A_\mu \frac{dx_\mu}{ds} ds$

$\rightarrow m_a \int \sqrt{\dot{a}_\mu \dot{a}^\mu}\, d\alpha + \iint e_a e_b\, \delta(s_{ab}^2)\, db_\mu\, da_\mu\, d\alpha\, d\beta$

Idea charge δ to $f(t^2 - r^2)$ $f =$

at large distances no effect $t - r$ of order a^2/r. at small wavelengths effect.

Self energy finite ← Shaughnessy. other results not describe

Quantum Need non Hamilt form. Define $S(2,1)$ = ampl. at x_B time t_B if at t_A particle in $S(x_A)$

Eg particle $\frac{mc}{2\pi}\left(\frac{x_a - x_b}{t_a - t_b}\right)^2$ for Dirac eqn particle S_{ab} operator $\not{S}$.

Discuss $\psi(x_B, t_B) = \int S(B,A)\, \psi(x_A, t_A)\, dx_A$ is soln of $\frac{\hbar}{i}\frac{\partial \psi}{\partial t} = H\psi$

Idea with no interaction is S_0. 1st order pert by pot $U(x_1)$ at time t_1 in Δt_1

$S = S_0 + S_1$ $\quad S_1 = \frac{i}{\hbar}\int S_0(B,1)\, U(1)\, S_0(1,A)\, dx_1 \Delta t_1$

$= \frac{i}{\hbar}\int S_0(B,1)\, U(1)\, S(1,A)\, d\tau_1$ $\quad S_2 = -\frac{1}{\hbar^2}\iint S(3,2)\, U(2)\, S(2,1)\, U(1)\, S(1,A)$ etc.

Exp mass $= m = M + \delta M$

There we do not get all the mass. Even for λ very high $\delta M < \mu$.

Stuff $= \delta\mu \frac{\partial \sigma(\mu)}{\partial \mu}$ ∴ Result Old(μ) + Stuff $\ln \frac{\lambda}{\mu}$ + Const + $\frac{\mu^2}{\lambda^2}$..

Hence propose suff. accurate Old(m) + Const. Result Old(m) + Const + $\frac{m^2}{\lambda^2}$ (small)

terms that mass terms eliminate divergences. Let $\lambda \to \infty$ helping in const actually proposed first by

all expected to be finite. In particular Bethes self energy.

Compton effect total emission rate decreased a little (order $\frac{1}{\lambda^2}$) by

λ quanta. Q: 2nd order Mass. Polarisation of Vac.

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LOT 75

Contents

UNDERSTANDING THE HEAVENS: BOOKS AND INSTRUMENTS FROM A PRIVATE COLLECTION

LOTS 1-37

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1

HYGINUS, CAIUS JULIUS

Poeticon Astronomicon. Venice: Erhard Ratdolt, 14 October 1482

4to (190 x 138 mm). 58 leaves including initial blank. 31 lines. Title printed in red, floriated initials, 47 half-page woodcuts of constellations and zodiac figures; first two leaves and d1 with marginal stains, but generally a crisp copy. Early vellum over boards with ties renewed.

First illustrated edition and THE FIRST DEPICTIONS OF THE CONSTELLATIONS IN A PRINTED BOOK, THE BEGINNING OF CELESTIAL CARTOGRAPHY

REFERENCES

BMC V, 286; CIBN H-334; Essling 285; Goff H-560; HC 9062; Pol 2039; Sander 3472

PROVENANCE

Sir George Shuckburgh (bookplate)

$ 12,000-18,000

2

HYGINUS, CAIUS JULIUS.

Poeticon astronomicon (edited by Jacobus Sentinus and J.L. Santritter): Venice: Thomas de Blavis: 7 June, 1488

4to (205 x 140 mm). 56 leaves, 34 lines, Roman letter, woodcut initials, full-page woodcut of an armillary sphere on verso of a1, astronomical woodcuts in text colored by an early hand, contemporary manuscript notes; minor stain to last leaf. Modern vellum.

Reprinted from Ratdolt's 1485 edition, reproducing some woodcuts in reverse. The series of woodcuts is the first to illustrate the allegorical figures of the constellations and planets and as such is a mixture of Renaissance science and mythology.

REFERENCES

BMC V 318; Essling 287; Goff H562; HC *9065; IGI 4961; Klebs 527.4; Sander 3474

$ 5,000-8,000

3

AVIENUS, RUFUS FESTUS

Arati Phaenomena. Venice: Antonius De Strata, de Cremona, 25 October 1488

4to (211 x 160 mm). 121 leaves (of 122, first blank lacking). 38 lines. 38 woodcuts depicting signs of the zodiac and constellations; early marginalia faded, tiny hole to n3 affecting one letter, marginal repair to a9. 19th century gilt morocco with silk pastedowns.

FIRST EDITION of the author's astronomical and geographical works, Included is 'Ora Maritima', an account of Greek and Carthaginian maritime routes and the only surviving translation of the lost 6th-century B.C. merchants' handbook *Massaliote Periplus.* THE FIRST RECORDED USE OF "ABRACADABRA" OCCURS ON P3V.

REFERENCES

BMC V, 294 (IA. 21262); BSB-Ink A-969; Essling 431; Goff A-1432; GW 3131; HC *2224 = H 2223; Klebs 137.1; Sander 718

PROVENANCE

Thomas Gaisford (bookplate); F B Lorch (morocco book label); sale, Christie's Paris, 20 June 2002, lot 3

$ 15,000-20,000

4

LEOPOLD OF AUSTRIA

Compilatio de astrorum scientia decem continens tractatus. Augsburg: E. Ratdolt, 9 January 1489

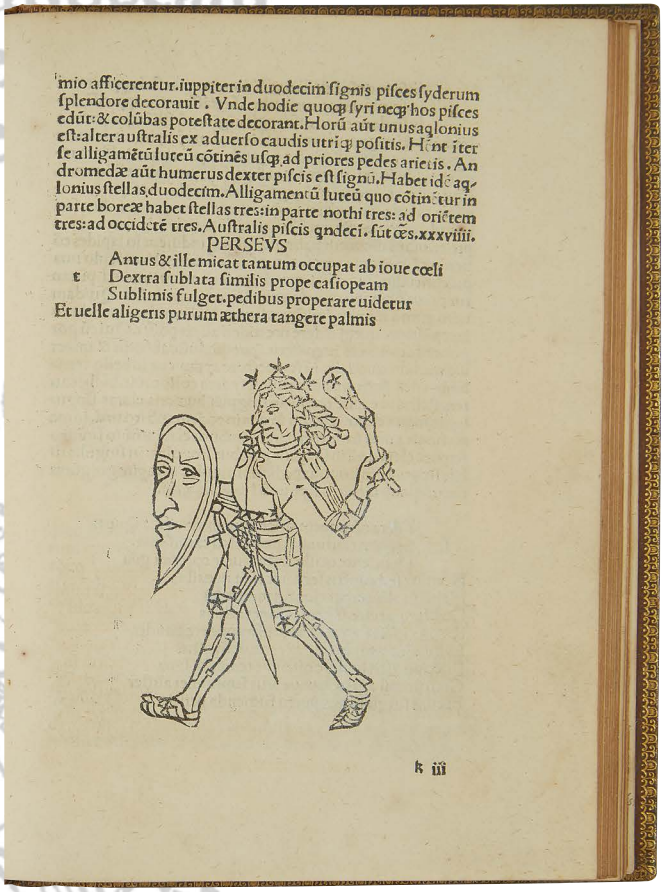
4to (210 x 145 mm). 109 leaves; lacking final blank. 41 lines. Woodcuts throughout of mythological figures and Zodiac signs, many with early hand coloring including large "Sphaera mundi" (a2r), 35 woodcuts in text and 54 half-page diagrams; marginal repair to one leaf, faint stain to upper margin of last quire, marginal notes in a contemporary hand; 19th century crushed morocco, gilt.

FIRST EDITION OF THIS IMPORTANT THIRTEENTH-CENTURY ASTRONOMICAL WORK, and one of the earliest books illustrated with scientific diagrams, here with contemporary annotations. In his introduction, Leopold gives his goal as explaining the motion of the stars. An influential work for Medieval and Renaissance astronomy, it was reprinted in 1520 (the edition most often available, the present being somewhat scarce).

REFERENCES

Adams L516; Brunet III, 1033 "rare edition; Goff L-185; Sander 3948; cf. Stillwell (Science) 71 and 771

$ 6,000-9,000

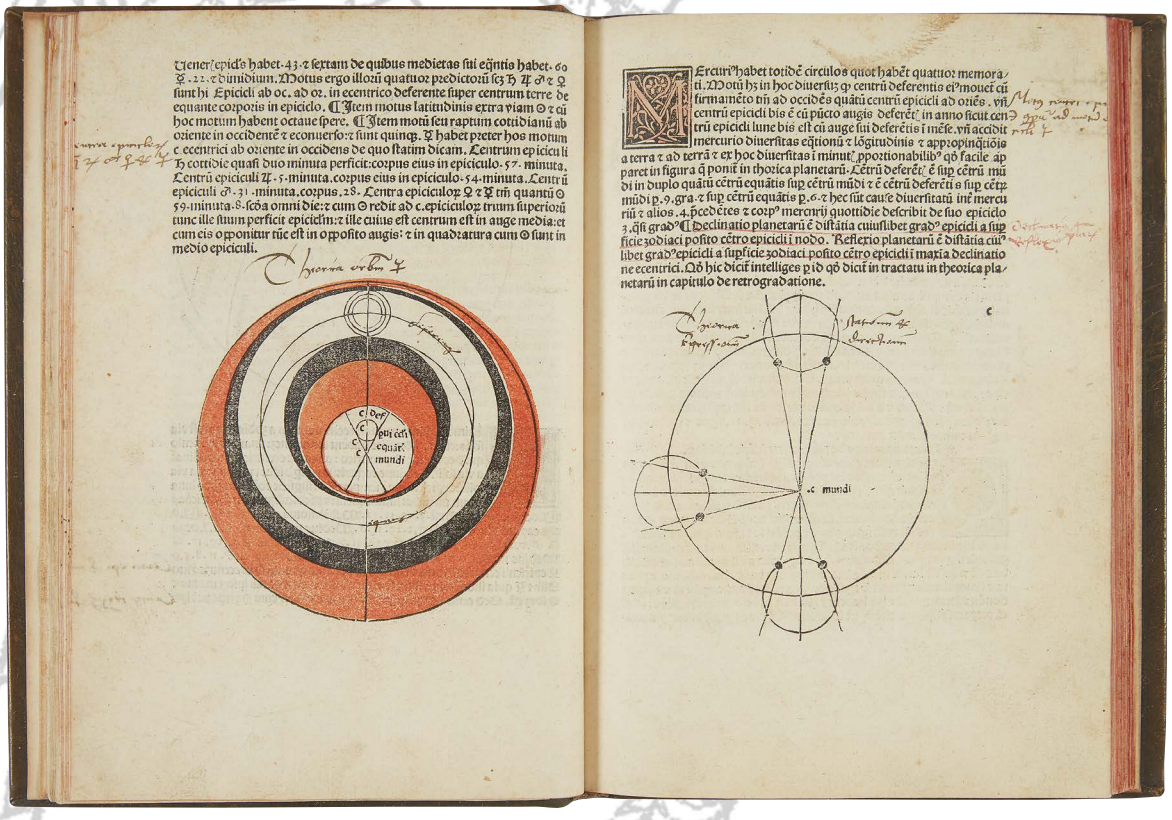

mio afficerentur. iuppiter in duodecim signis pisces syderum splendore decorauit. Vnde hodie quoq; syri neq; hos pisces edūt: & colūbas potestate decorant. Horū aūt unus aq̄lonius est: alter australis ex aduerso caudis utriq; positis. Hent iter se alligamētū luteū cōtinēs usq; ad priores pedes arietis. Andromedæ aūt humerus dexter piscis est signū. Habet idē aq-lonius stellas duodecim. Alligamentū luteū quo cōtinetur in parte boreæ habet stellas tres: in parte nothi tres: ad oriētem tres: ad occidētē tres. Australis piscis q̄ndeci. sūt cēs. xxxviiii.

PERSEVS

Antus & ille micat tantum occupat ab ioue cœli
Dextra sublata similis prope cassiopeam
Sublimis fulget. pedibus properare uidetur
Et uelle aligeris purum æthera tangere palmis

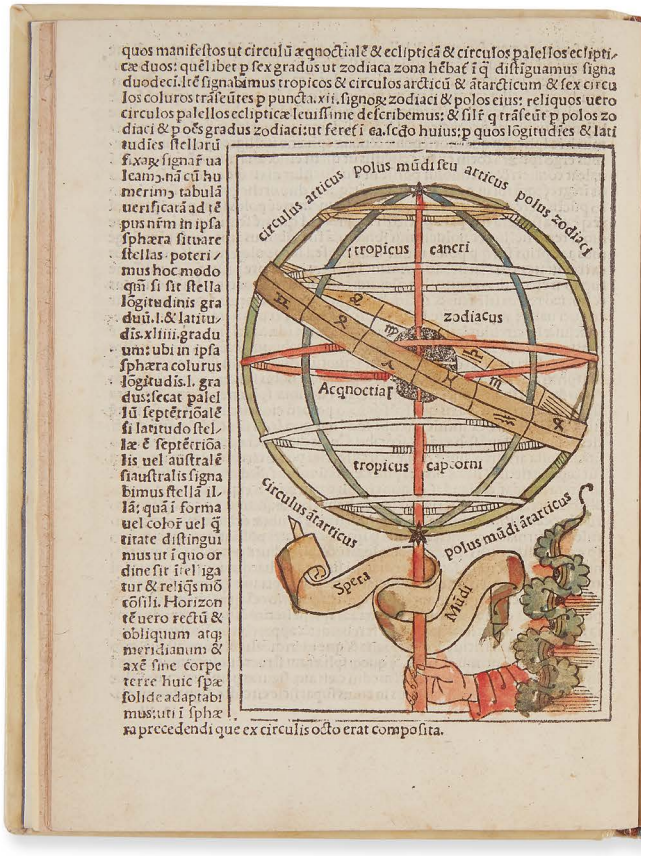
k iii

3


Uener? epicl's habet. 43. z sextam de quibus medietas sui eḡntis habet. 60 ☿. 22. z dimidium. Motus ergo illoꝝ quatuoꝛ predictoꝝ sc̄z ♄ ♂ z ♀ sunt hi. Epicicli ab oc. ad oz. in eccentrico deferente super centrum terre de equante corporis in epicicło. ¶ Item motus latitudinis extra viam ☉ z cū hoc motum habent octaue spere. ¶ Item motū seu raptum cotidianū ab oriente in occidentē z econuerso: z sunt quinq. ♀ habet preter hos motum c. eccentrici ab oriente in occidens de quo statim dicam. Centrum epicicli ♄ cottidie quasi duo minuta perficit: corpus eius in epicicło. 57. minuta. Centrū epicicli ♃. 5. minuta. corpus eius in epicicło. 54. minuta. Centrū epicicli ♂. 31. minuta. corpus. 28. Centra epicicloꝝ ♀ z ☿ tm̄ quantū ☉ 59. minuta. 8. scōa omni die: z cum ☉ redit ad c. epicicloꝝ trum superiorū tunc ille stum perficit epicicłm: z ille cuius est centrum est in auge media: et cum eis opponitur tūc est in opposito augis: z in quadratura cum ☉ sunt in medio epicicli.

Mercurij habet toridē circulos quot habēt quatuoꝛ memorati. ¶ Motū hꝰ in hoc diuersiꝰ; q̄ centrū deferentis eiꝰ mouet cū firmamēto vñ ad occidēs quātū centrū epicicli ad oriēs. vñ centrū epicicli bis ē cū pūcto augis deferēt; in anno sicut centrū epicicli lune bis est cū auge sui deferētis i mēse. vñ accidit mercurio diuersitas eḡtionū z lōgitudinis z appropinq̄tiōis a terra z ad terrā z ex hoc diuersitas i minut; ꝓportionabilib? qō facile apparet in figura q̄ ponit in theorica planetarū. Centrū deferēt; ē sup cētrū mūdi in duplo quātū cētrū equātis sup cētrū mūdi z ē cētrū deferēti s sup cētrū mūdi p. 9. gra. z sup cētrū equātis p. 6. z hec sūt causę diuersitatū inē mercurij z alios. 4. pcedētes z corꝓ? mercurij quottidie describit de suo epicicło 3. q̄si grad? ¶ Declinatio planetarū ē distātia cuiuslibet grad? epicicli a superficie zodiaci posito cētro epicicli i nodo. Reflexio planetarū ē distātia cuiꝰ libet grad? epicicli a supficie zodiaci posito cētro epicicli i maxia declinatione centrici. Qō hic dicit intelliges p id qō dicit in tractatu in theorica planetarū in capitulo de retrogradatione.

4



5

6

5

JOHANNES DE SACROBOSCO

Sphaera mundi. Venice: Guilelmus Anima Mia, Tridinensis, 14 January, 1491

4to (199 x 150 mm). 48 leaves. 42 lines. Full-page woodcut on verso of title-leaf showing Astronomia enthroned flanked by Urania and Ptolemy, large woodcut of the "Sphaera mundi" on a3v, each partially hand colored and 7 of the diagrams of planetary orbits partially colored or with outline color; first line of text on f5r cropped, d6r-v with first lines shaved, manuscript headlines and a few manuscript side notes cropped, small rust hole to b1 with minor intrusion to text, some faint spotting and browning. Modern gilt vellum with ties.

This edition of Sacrobosco's much reprinted *Sphaera mundi* contains two further treatises, J. Regiomantanus, *Disputationes contra Cremonensia* and G. Peurbach, *Theoricae novae planetarum.*

REFERENCES

BMC V, 412; Essling 262; Goff J-410; HC 14114*; Klebs 874.15; Oates 2008; Polain 2304; Sander 6665

PROVENANCE

"M. Sebastiani Gleyss ex purgstall austriaci sum 1515", inscription on title, early marginalia (usually cropped); Christie's New York, 8 November, 1996, lot 37.

$ 5,000-8,000

6

ALBUMASAR

Flores Astrologiae. Venice: Johannes Baptista Sessa, [ca. 1503]

4to (206 x 153 mm). 7 woodcut diagrams and 72 woodcuts of the planets, constellations and signs of the zodiac; some light spotting mostly to margins and minor worming to rear end papers. Modern limp vellum.

The translator, John of Seville, introduced the work of many Arabic astrologers to Western readers. The present work describes "nature of a year (or month or day) as determined by the horoscope of its beginning" (DSB I, 37).

REFERENCES

BMC V, 482 (IA. 24575); BSB-Ink. A-229; CIBN I, p.45; Essling 437; Goff A-358; GW 839; HC 608*; Klebs 37.3

PROVENANCE

Lathrop Harper, cat. 239 no. 45; Helmut Friedlaender (bookplate and sale, Christie's New York, 23 April 2001, lot 129)

$ 5,000-8,000

7

STOEFFLER, JOHANN

Elucidatio fabricae ususque astrolabii... Oppenheim: Jacobus Koebel, 1513.

Folio (264 x 202mm). Title within woodcut border, woodcut initials, woodcut illustrations, including some full page and some with printed extension slips (B3v, C4v with 3, D3r with 2, D4r); some soiling and staining; minor worming in gutters, occasionally touching images or text; library stamps on front pastedown title. Contemporary stamped calf' rubbed and rebacked.

FIRST EDITION OF THE FIRST GERMAN BOOK ON ASTROLABES, AND THE MOST COMPREHENSIVE WORK ON THE SUBJECT AT THAT TIME. Produced on the first press established in Oppenheim, it is thought that Koebel himself may have designed the woodcuts. Stoeffler taught at the University of Tübingen, where Philip Melanchthon and Sebastian Münster were among his students; there is a laudatory verse by Melanchthon printed at the beginning of the book.

REFERENCES

Adams S-1886; Benzing, Köbel, 27; Crone Library 6; Houzeau & Lancaster 3256; Stillwell Science, 892; Tomash & Williams S197; USTC 649878; VD16 S9191; Wellcome 6099; Zinner 991

PROVENANCE

Sotheby's New York, 11 December, 1993, lot 779

$ 5,000-8,000

7

8

VENETUS, PAULUS

Primus liber incipit de compositione mundi. Summa philosophie naturalis clarissimi philosophi Pauli veneti una cum libro de compositione mundi qui astronomie... [Paris: Thomas Kees, 14 November 1513]

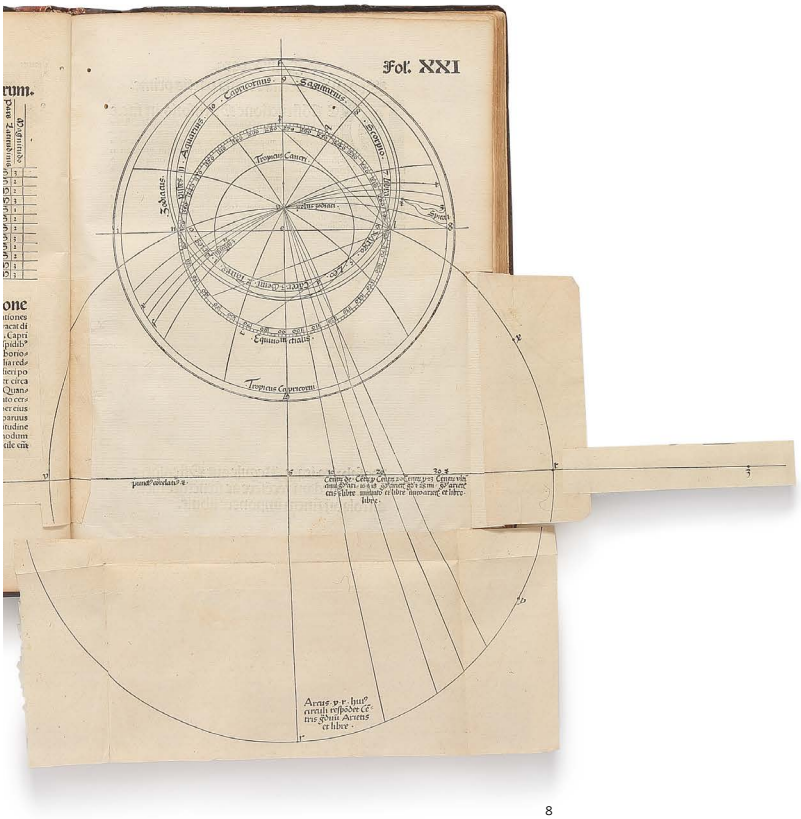
18 leaves (1270 x 195 mm). Gothic letter, title with printer's device and woodcut border, woodcut diagrams and signs of the zodiac; contemporary marginal annotations in sepia ink, minor marginal soiling, minor marginal repair to two corners of final two leaves. Modern limp brown paper covers.

The *De compositione mundi*, which includes sections on cosmography, astronomy, meteorology, geology, tides, springs and rivers, relies heavily on Ristoro's work *Composizione del mondo* (written in 1282). Paulus Venetus was a Roman Catholic philosopher, theologian, realist logician, and metaphysician. His writings demonstrated a broad understanding of the scientific matters and questions of his time.

REFERENCES

cf. Houzeau & Lancaster 2272; Moreau 1510/163

$ 10,000-15,000



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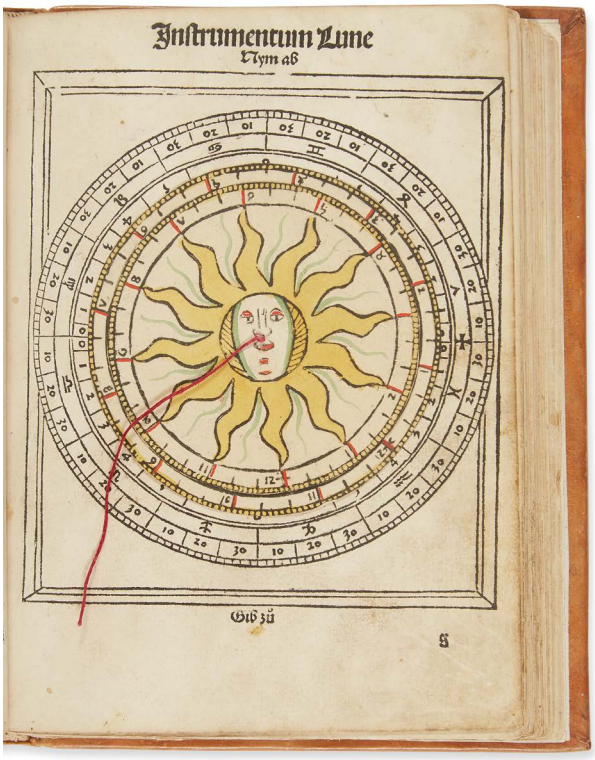

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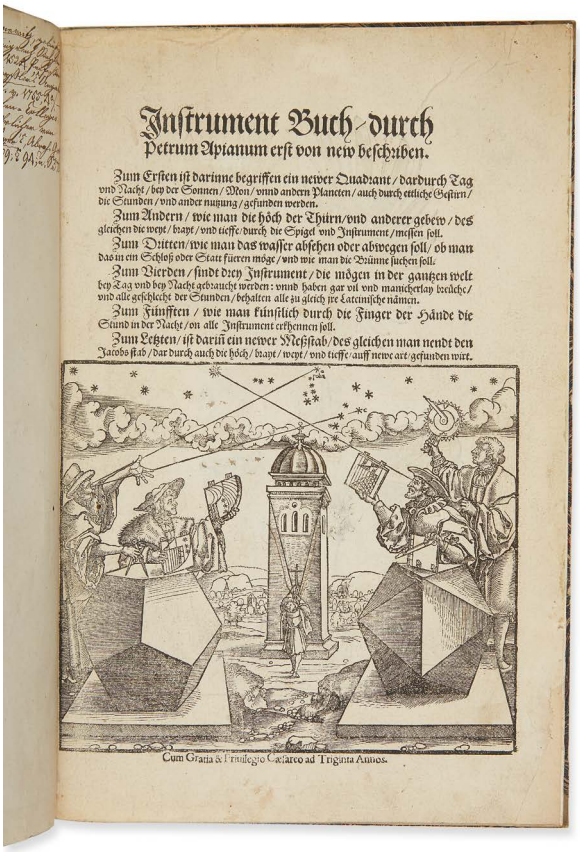

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9

REGIOMONTANUS, JOHANNES

Kalendarius Teütsch. Augsburg: [J. Sittich], January 1514

4to (180 x 140 mm). Title within four-part woodcut border printed in red and black, 87 woodcuts, including 1 full page hand colored lunar figure with volvelles; minor rubbing. Modern blind-stamped calf.

A RARE ILLUSTRATED CALENDAR FROM THE AUGSBURG RENAISSANCE, with only one copy listed on ABPC.

REFERENCES

Not in Adams; BMC 18.7.267; VD16 M6540.

$ 5,000-8,000

10

APIANUS, PETRUS

Instrument Buch. . .erst von new beschriben. Ingolstadt: [Peter & Georg Apian], 1533

Folio (310 x 200 mm). Woodcut of astronomers on title and cut of arms on verso; numerous text woodcuts of mathematical instruments and their use; lacks plates at end, repair to lower corner of title, light dampstain to upper and lower margins of a few signatures not affecting text, small wormhole. 19th century vellum-backed boards.

FIRST EDITION OF ONE OF THE EARLIEST TECHNICAL BOOKS TO BE PRINTED IN THE VERNACULAR. Apianus chose German, because his work was intended for practitioners in the field, rather than scholars. “Indeed, in the introduction to the work, Apian calls upon other authors to publish in German so as to encourage the broader dissemination of technical information.” (Tomash & Williams).

REFERENCES

Crone Library 18; Tomash & Williams A83; USTC 669172 (this variant, most often seen with title in black and red); USTC 669173; VD16 A3111; cf. VD16 ZV 659

$ 2,000-3,000

11

SCHOENER, JOHANN

Opera Mathematica. *Nuremberg: J. Montanus and U. Neuber, 1551.*

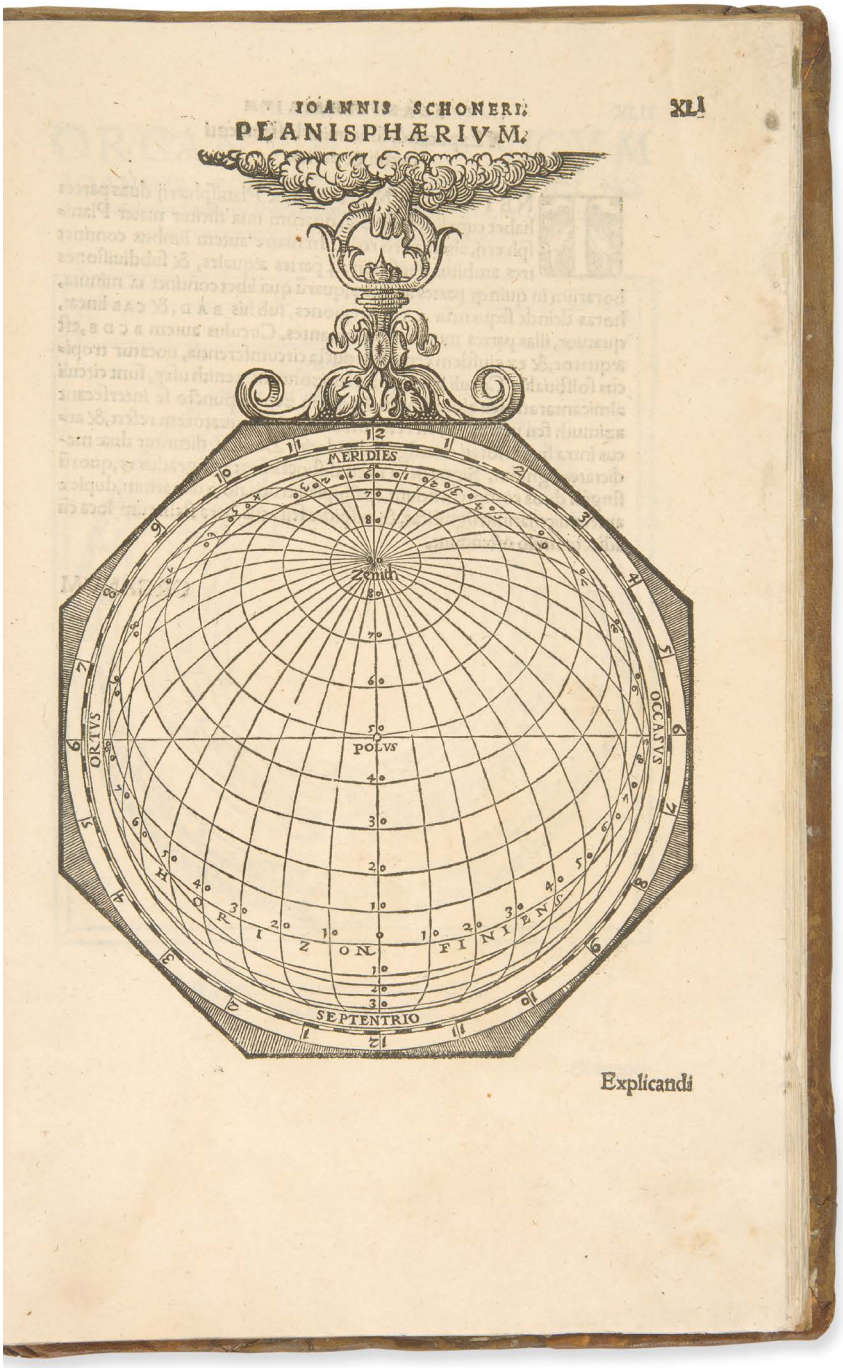
3 parts in one volume. Folio (12 x 7¾ in.; 310 x 190 mm). Title printed in red and black with woodcut ornaments, woodcut portrait of author on last page of preliminaries, numerous large and small woodcuts and diagrams, including a full-page cut of Schoener's terrestial globe, woodcut printer's device at end and with 10 leaves of uncut volvelles; final four signatures with minor repairs or reinforcements to outer margins, lower right corners of same and a few others with light dampstain. Contemporary gilt-ruled armorial calf; minor restoration to extremities.

First collected edition of Schoener's mathematical works (including astrology, astronomy and geography). Schoener started out as a Catholic priest in Bamberg, where he set up a printing press in his house and where he also produced the first printed globe to name America. From 1526 Schoener, now a Lutheran, taught mathematics at the Melanchthon Gymnasium in Nuremberg. He continued to print many works on astronomy and astrology, including several first editions of Regiomontanus's treatises. His own works had all been placed on the Index *Librorum Prohibitorum.*

REFERENCES

Adams S678 & 685 ;Sabin 77805; Zinner 2033; Houzeau & Lancaster 2388

$ 50,000-80,000



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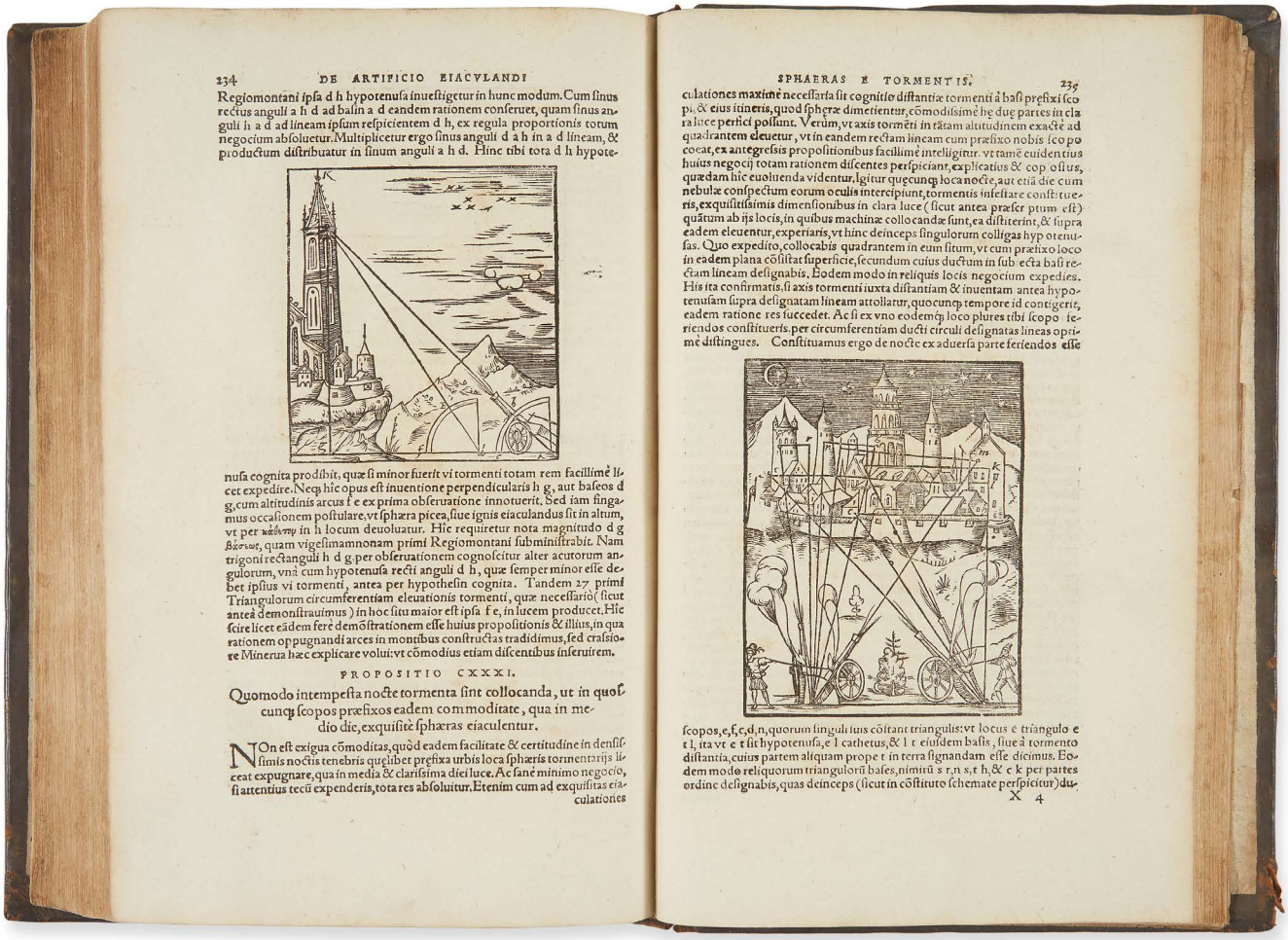


234 DE ARTIFICIO EIACVLANDI

Regiomontani ipsa d h hypotenusa inuestigetur in hunc modum. Cum sinus rectus anguli a h d ad basin a d eandem rationem conseruet, quam sinus anguli h a d ad lineam ipsum respicientem d h, ex regula proportionis totum negocium absoluetur. Multiplicetur ergo sinus anguli d a h in a d lineam, & productum distribuatur in sinum anguli a h d. Hinc tibi tota d h hypote-

nusa cognita prodibit, quæ si minor fuerit vi tormenti totam rem facillimè li-cet expedire. Neq; hic opus est inuentione perpendicularis h g, aut baseos d g, cum altitudinis arcus f e ex prima obseruatione innotuerit. Sed iam finga-mus occasionem postulare, vt sphæra picea, siue ignis eiaculandus sit in altum, vt per κάθετον in h locum deuoluatur. Hic requiretur nota magnitudo d g βάσεως, quam vigesimamnonam primi Regiomontani subministrabit. Nam trigoni rectanguli h d g per obseruationem cognoscitur alter acutorum an-gulorum, vna cum hypotenusa recti anguli d h, quæ semper minor esse de-bet ipsius vi tormenti, antea per hypothesin cognita. Tandem 27 primi Triangulorum circumferentiam eleuationis tormenti, quæ necessariò (sicut anteà demonstrauimus) in hoc situ maior est ipsa f e, in lucem producet. Hic scire licet eãdem ferè demõstrationem esse huius propositionis & illius, in qua rationem oppugnandi arces in montibus constructas tradidimus, sed crassio-re Minerua hæc explicare voluimus: vt cõmodius etiam discentibus inseruirem.

PROPOSITIO CXXXI.

Quomodo intempesta nocte tormenta sint collocanda, ut in quoscunq; scopos præfixos eadem commoditate, qua in me-dio die, exquisitè sphæras eiaculentur.

NOn est exigua cõmoditas, quòd eadem facilitate & certitudine in densis-simis noctis tenebris quælibet prefixa urbis loca sphæris tormentariis li-ceat expugnare, qua in media & clarissima diei luce. Ac sanè minimo negocio, si attentius tecũ expenderis, tota res absoluitur. Etenim cum ad exquisitas eia-culationes

SPHAERAS E TORMENTIS. 235

culationes maximè necessaria sit cognitio distantiæ tormenti à basi prefixi sco-pi, & eius itineris, quod sphæræ dimetientur, cõmodissimè hę duę partes in cla-ra luce perfici possunt. Verum, vt axis tormẽti in rãtam altitudinem exactè ad quadrantem eleuetur, vt in eandem rectam lineam cum præfixo nobis sco-po cocat, ex antegressis propositionibus facillimè intelligitur. vt tamẽ euidentius huius negocij totam rationem discentes perspiciant, explicatius & cop-osius, quædam hic euoluenda videntur. Igitur quęcunq; loca nocte, aut etiã die cum nebulæ conspectum eorum oculis intercipiunt, tormentis infestare constitue-ris, exquisitissimis dimensionibus in clara luce (sicut antea præfer-ptum est) quãtum ab ijs locis, in quibus machinæ collocandæ sunt, ea distiterint, & supra eadem eleuentur, experiaris, vt hinc deinceps singulorum colligas hypotenu-sas. Quo expedito, collocabis quadrantem in eum situm, vt cum præfixo loco in eadem plana cõsistat superficie, secundum cuius ductum in sub-ecta basi re-ctam lineam designabis. Eodem modo in reliquis locis negocium expedies. His ita confirmatis, si axis tormenti iuxta distantiam & inuentam antea hypo-tenusam supra designatam lineam attollatur, quo cunq; tempore id contigerit, eadem ratione res succeder. Ac si ex vno eodemq; loco plures tibi scopo fe-riendos constituerís, per circumferentiam ducti circuli designatas lineas opti-mè distingues. Constituamus ergo de nocte ex aduersa parte feriendos esse

scopos, e, f, c, d, n, quorum singuli suis cõstant triangulis: vt locus e triangulo e t l, ita vt e t sit hypotenusa, e l cathetus, & l t eiusdem basis, siue à tormento distantia, cuius partem aliquam prope t in terra signandam esse dicimus. Eo-dem modo reliquorum triangulorũ bases, nimirũ s r, n s, t h, & c k per partes ordine designabis, quas deinceps (sicut in cõstituto schemate perspicitur) du-

X 4

12

12

REGIOMONTANUS, JOHANNES

De triangulis planis et sphaericis libri quinque, una cum tabulis sinuum, in quibus tota ipsorum triangulorum scientia ex primis fundamentis Geometricarum apodeixewn absolutissime extructa continetur... in lucem edita... per Danielem Santbech. Basel: [Heinrich Petri and Pietro Perna, 1561]

2 volumes in one, folio (308 x 197mm). Woodcut initials and diagrams; occasional slight browning. Contemporary calf, spine with raised bands in six compartments with gilt filigree motifs, vellum manuscript fragments in binding; extremities rubbed, joints cracking.

THIRD EDITION. "Regiomontanus' monumental work on Triangles, the first publication of which was delayed until 12 August 1533, attracted many important readers and thereby exerted an enormous influence on the later development of trigonometry because it was the first printed systematization of that subject as a branch of mathematics independent of astronomy" (DSB XI, p.350).

REFERENCES

Houzeau & Lancaster 2500; Tomash & Williams R54, R61, P64, S13; VD16 M6571; Santbech: Zinner 2273

PROVENANCE

Earls of Macclesfield (Sotheby's London, 25 October 2005, Lot 1721)

$ 7,000-10,000

13

13

SCHILLER, JULIUS

Coelum stellatum Christianum. *Augsburg: Andreas Aperger, 1627*

Oblong folio (12½ x 16¼ in.; 320 x 410 mm). Engraved title with a view of Christ in majesty seated with saints and biblical personages, 49 (misnumbered "LIV") engraved constellation maps and 2 engraved maps of the northern and southern skies, all by Lucas Kilian; closed tear to title and first leaf, marginal tear repaired to one chart. Contemporary spotted calf with single blind rule.

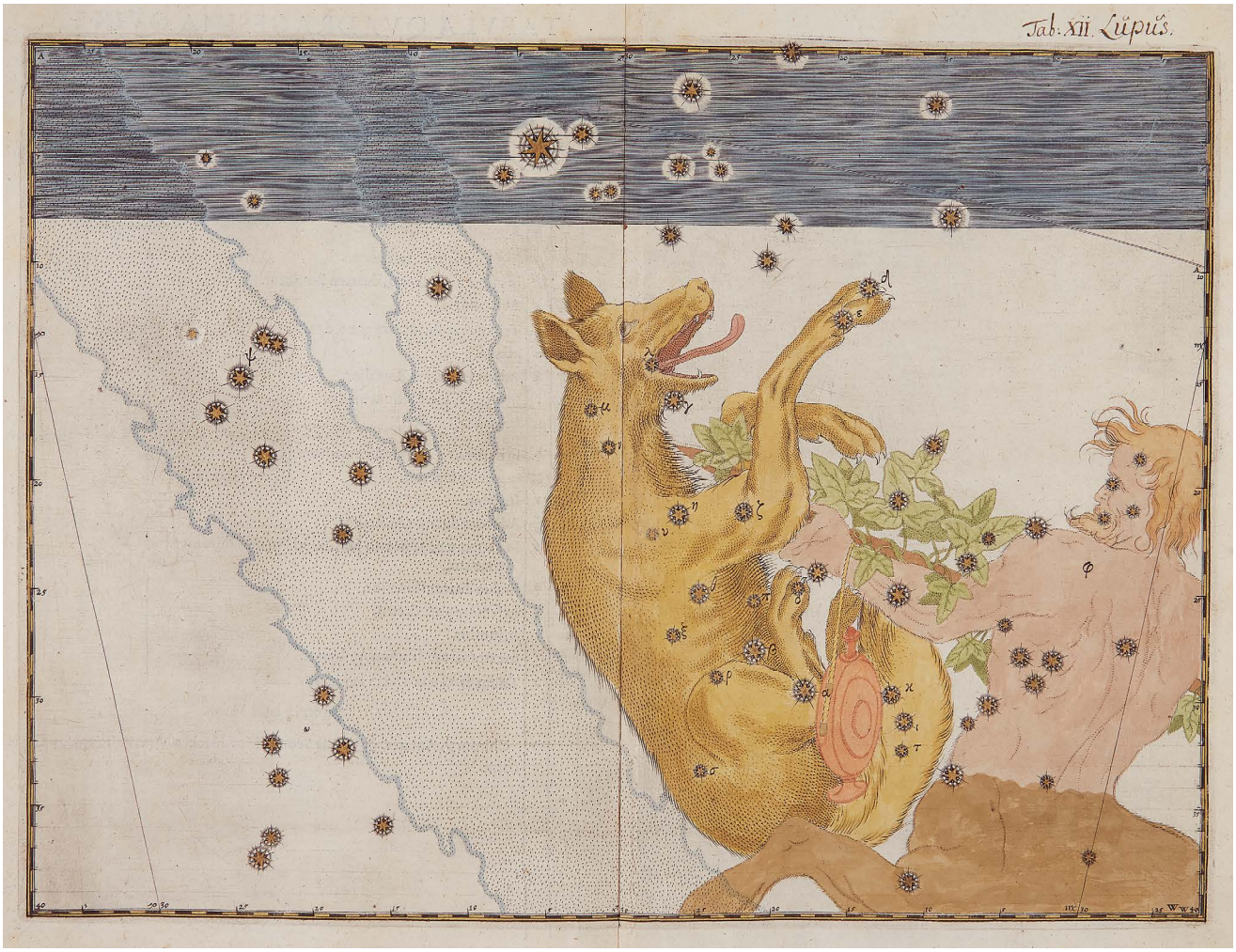
FIRST EDITION "An interesting and curious old work in which the stars appear as in the Uranometria [of Johann Bayer], but instead of the ancient figures and names of the constellations, numerous saints are enshrined amongst the stars. Biblical names are substituted instead of the so-called heathen ones . . . It is said that Judas or Julius Schiller revived the names given to the Zodiacal groups centuries before by the Venerable Bede, and completed the reformation with all the constellations . . . copies of this work are very rare" (Brown).

Several new objects appear on these charts, some of which have proved fictitious, but among the most important is the great nebula in Andromeda, now classified as M31.

REFERENCES

Brown, pp. 31-33; Warner, p. 229; Zinner 5078

$ 15,000-20,000



14

14

BAYER, JOHANNES

Uranometria, omnium asterismorum continens schemata, nova methodo delineata, aereis laminis expressa.
Augsburg: Christophorus Mangus, 1603

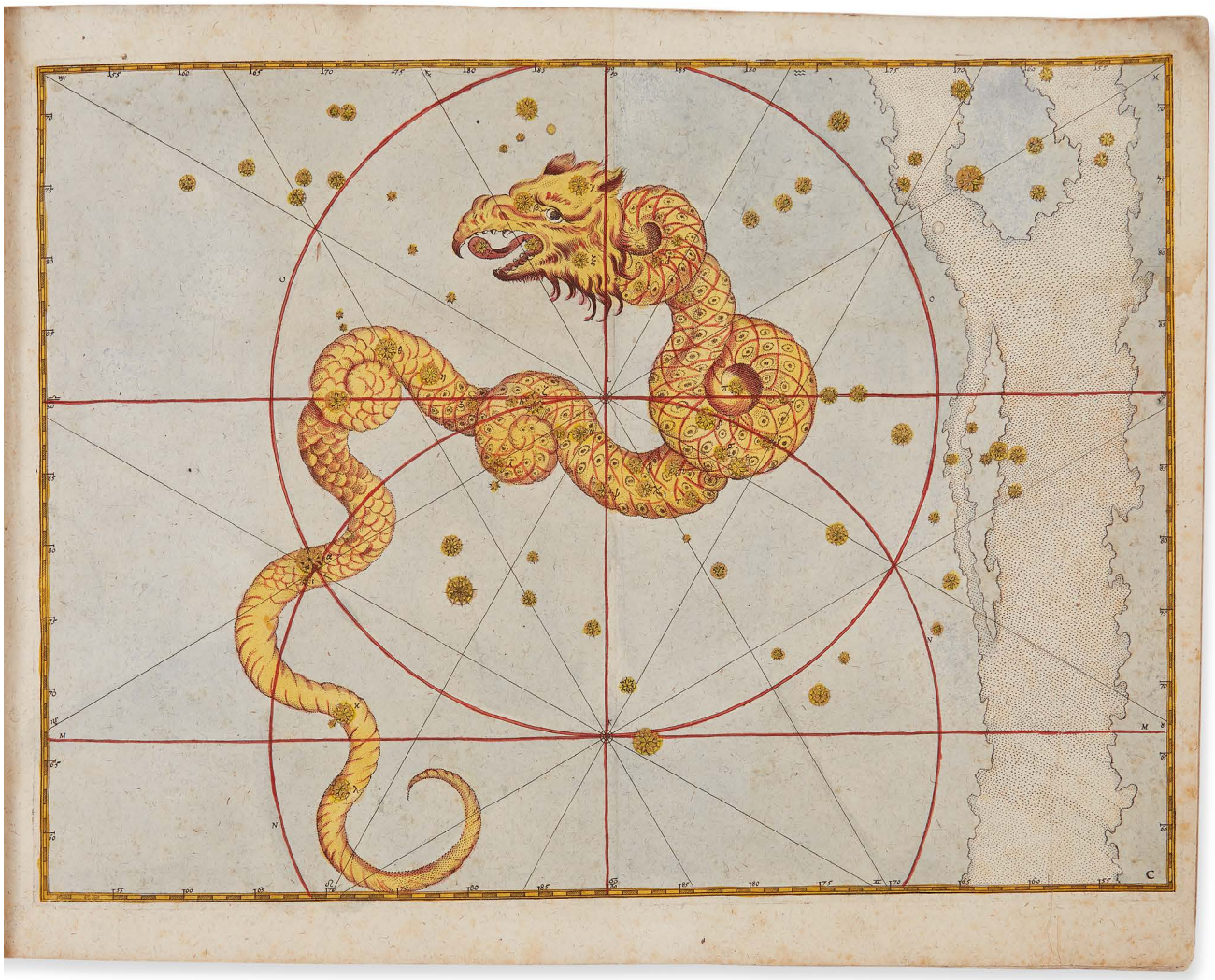
Folio (320 x 210 mm). Hand-colored architectural frontispiece, 51 double-page engraved star maps by Alexander Mair, hand-colored and heightened with gold,on guards throughout, letterpress descriptive text printed on rectos and versos of the maps, printer's woodcut device on colophon, bound with manuscript star catalogue; title creased with closed tears, primarily marginal worming to a few plates, minor toning and spotting, some spotting to manuscript catalogue. Full calf, spine with raised bands in six compartments, second gilt lettered, others with repeat gilt filigree motif, marbled endleaves, edges specked red; overall rubbed, corners bumped, joints starting.

FIRST EDITION OF THE FIRST ACCURATE STAR ATLAS

The first collection of star maps engraved on a grid so that star positions could be read off to fractions of a degree. It was also the first to use the modern system of identifying the stars within a constellation by the use of Greek letters for the brighter stars and Roman letters for the fainter ones. Bayer's main sources for star positions were the recent observations of Tycho Brahe and of Pieter Dierkzoon Keyser (with regard to the southern hemisphere). The artist Alexander Mair clearly found some inspiration in the Jacobo De Gheyn engravings in the Aratea published by Hugo Grotius in 1600, but most of Bayer's constellation figures are quite different from De Gheyn's, and generally more attractive. Many have no known prototype.

REFERENCES
VD17 39:125032X; Warner, *The Sky Explored*, pp. 18-19; Zinner 3951

$ 7,000-10,000



15

15

BAYER, JOHANN

Uranometria. Ulm: Johannis Gorlini, 1661

Folio (323 x 210mm.) Engraved architectural title, hand colored, incorporating vignette view of Ulm, and 51 double-page engraved astronomical charts (by Alexander Mair), each with delicate hand coloring and the stars heightened in gold; title trimmed and mounted to front board and light, mostly marginal spotting. Later calf-backed limo card boards.

THE FIRST ACCURATE CELESTIAL ATLAS. Bayer was the first to use Greek letters to identify the more important stars in each constellation - a method still employed today as the Bayer Designation. Each sheet describes a single constellation or Zodiacal group.

$ 8,000-12,000

16

16

16

LUBIENIECKI, STANISLAUS

Theatrum cometicum, duabus partibus ... et Theatri cometici exitus, sive De significatione cometarum. Amsterdam: Daniele Baccamude, 1666-1668

3 volumes bound in 2, folio (15½ x 9¼ in.; 393 x 235 mm). 2 elaborately engraved allegorical titles by Sebastien Stopendaal after M. Scheits, both vividly hand-colored and heightened in gold, 1 half-title and 3 letterpress titles with decorative woodcut devices, 85 plates (vol. I: 57, vol. II: 26, vol. III: 2), all vividly hand-colored, woodcut initials and tailpieces, side-notes; title-page, frontispiece, and *2 of vol. I on tabs, title and frontis backed, repairs to both, minor worming, numerous primarily closed marginal tears, often repaired, minor foxing and toning, some dampstaining, plate 51 (vol. I) with large tear resulting in loss which has been restored. Modern full blue morocco, covers with double gilt rules, spine with raised bands in 7 compartments all with double gilt rules, gilt-lettered red morocco labels to second, marbled endpapers, all edges gilt; some rubbing to edges.

FIRST EDITION, FINISHED IN VIBRANT HANDCOLOR. ONE OF A FEW KNOWN HAND-COLORED COPIES. "CET OUVRAGE EST SI RARE, QUE BENTKOWSKI ... QUI N'A VU QUE LA 1RE PARTIE, DOUTE SI LA CONTINUATION AIT PARU" (Graesse).

Lubieniecki's encyclopedic treatise gathered together the observations of dozens of his contemporaries including Bayer and Hevelius, covering all known comets up to the year 1665. The fine engravings consist of celestial maps showing the paths of comets and the figures of the constellations traversed. "Since each map represents the observations of a different astronomer, taken together they illustrate the variety of cartographic traditions popular during the seventeenth century." (Warner, *The Sky Explored*, p. 164). The second part (offered here) provides a chronology of 415 comet sightings from the flood (the first report is dated to 2312 BC) to 1665, with commentaries, drawn from a range of historical sources. Rarely encountered in anything near a complete state. Only two complete copies of the first edition are recorded at auction since 1975 by ABPC: the Honeyman and Dunham copies. A third copy, with 3 additional titles and 81 plates, but lacking one of the 2 portraits, was sold in 1989. Of the three copies held by the British Library, two are substantially defective.

REFERENCES

Brunet III, 1194; Graesse IV, p 270: Honeyman 2052; Knijff & Jan Visser, *Bibligraphia Sociana* 2067; Poggendorff I, 1508; Thorndike, *History of Magic and Experimental Science* VIII, 336; Warner 164I; Not in Houzeau and Lancaster

$ 40,000-60,000

17

17

HEVELIUS, JOHANNIS

Prodromus Astronomiæ, exhibens... novas & correctiores tabulas solares... additus est catalogus stellarum fixarum. Gedani [Danzig]: Johannis-Zachariæ Stollii, 1690

Folio (381 x 232 mm). 2 double-page engraved frontispieces, engraved and woodcut initials and headpieces, engraved portrait of Hevelius, engraved plate following L2, woodcut and engraved diagrams, 56 double-page engraved plates, exquisite later hand coloring; repair to title, occasional spotting and browning, expert marginal repairs to preliminary frontispiece, repaired closed marginal tears (H4, O2), text amendment of 3 characters pasted to Y2, marginal repairs (Aa4, Ee4), primarily marginal closed tear to Ff4 just affecting two characters. Later full velum, covers and spine ruled in blind, with decorative cornerpieces and central filigree ornaments in blind, edges speckled red.

FIRST EDITION, published posthumously, with an introduction by Hevelius' widow Elisabeth. The manuscript of Prodromus astronomiae was one of the few items saved from the fire at Hevelius' house in 1679.

REFERENCES

Houzeau & Lancaster 12781; STC German XVIIc. H1022

$ 40,000-60,000

18

18

THOMAS, CORBINIANUS

Mercurii philosophici firmamentum firmianum descriptionem et usum globi artificialis coelestis. Frankfurt & Leipzig: n.p., 1730

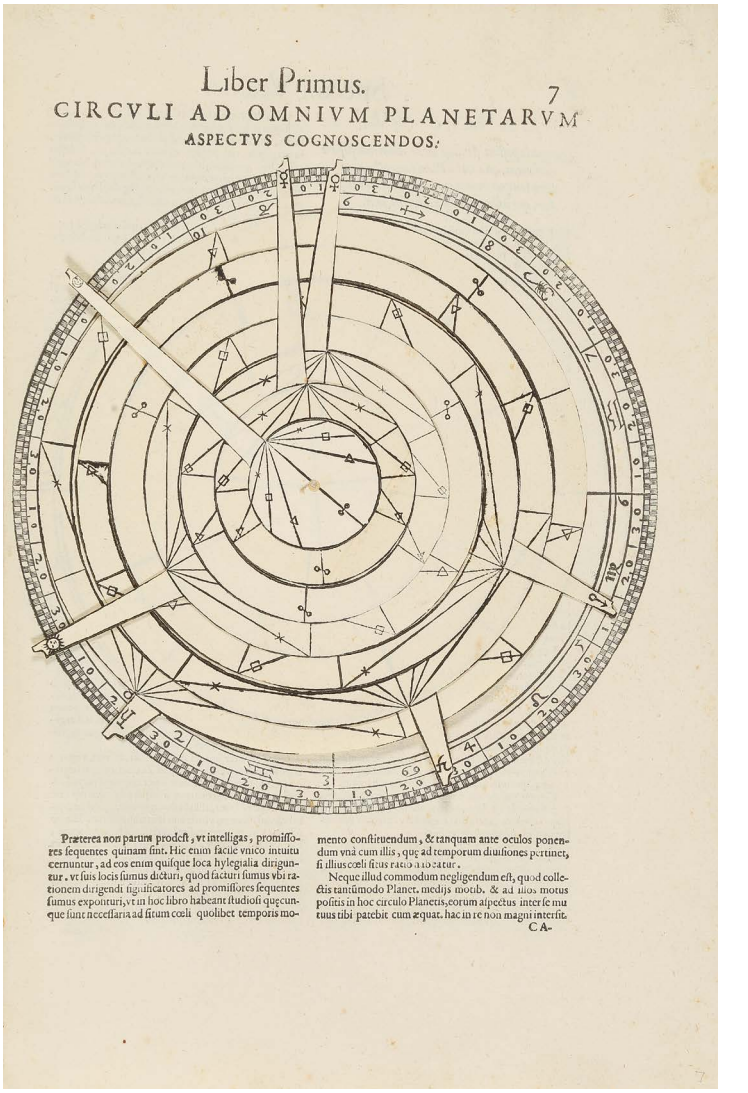
Oblong 4to (155 x 197 mm). Hand colored engraved frontispiece by A. G. Fleischmann, 71 (of 84) engraved plates with early hand coloring (many folding) of armillary spheres, globes and celestial maps, one engraved text diagram; light foxing and light occasional text browning, title with loss to outer margin and one leaf with lower corner torn away. Contemporary sheep-backed boards.

FIRST EDITION OF "ONE OF THE UNSUNG TREASURES OF CELESTIAL CARTOGRAPHY" (LINDA HALL) by one of the first celestial cartographers to dedicate a separate plate to Camelopardalis, which first appeared on globes about 1600, but which is usually represented together with Cepheus or Cassiopeia. Thomas was also the first cartographer to supply separate plates for some of the southern constellations such as Indus and Pavo. In honor of his patron, the Archbishop of Salzburg, Thomas fashioned a new constellation, the Corona Firmiana, but it was never used again.

REFERENCES

Honeyman sale VI:2975; Linda Hall, *Out of This World*, 24; Warner, *The Sky Explored,* pp. 251 and xii

$ 2,000-3,000



19

19

GALLUCCI, GIOVANNI PAOLO

Speculum Uranicum in quo vera loca octavae sphaerae ... Venice: Damianus Zenarus, 1593

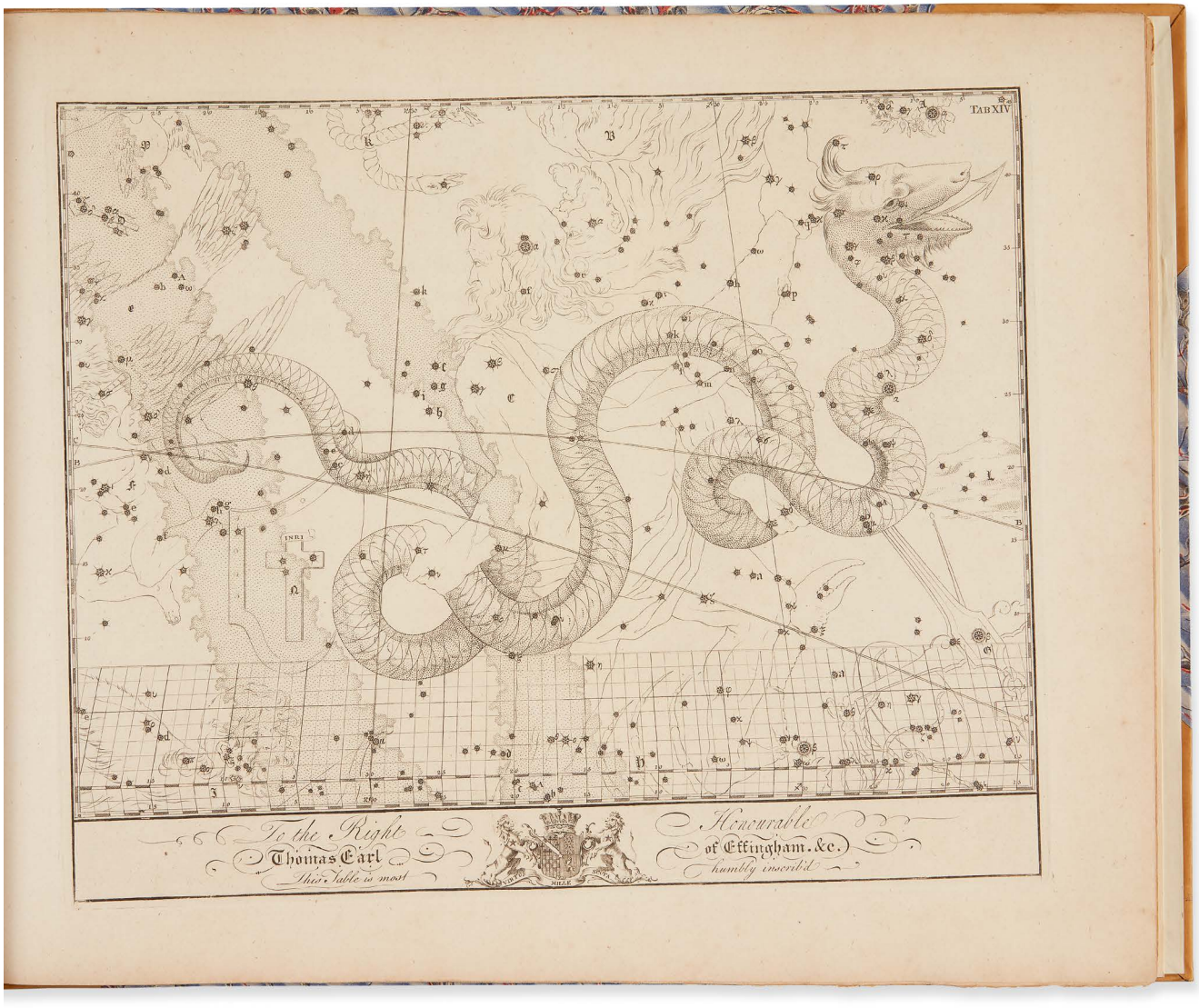
Folio (422 x 280 mm), title with engraved border by Giacomo Franco with the publisher's dragon device, 17 large circular woodcut diagrams with attached volvelles totaling 39 moving parts, woodcut headpieces, historiated and floral initials. Occasional scattered spotting, and foxing, title somewhat soiled with repair to lower margin just clipping imprint, 9 lines of numerical table entries canceled on A4v, 12 lines canceled on D4v, lacking the folding table "Canon Sexagenarius", and the four-leaf "De harum paginarum usu" found in some copies, (both of which were loosely inserted, and are therefore scarce). Contemporary limp vellum, worn and somewhat discolored, spine reinforced with repairs to a few losses, pastedowns wormed with some losses, reinforced with later paper.

FIRST EDITION, WITH ALL THE VOLVELLES IN A FINELY PRESERVED STATE.

REFERENCES

Houzeau & Lancaster 12742; Riccardi i 570

$ 10,000-15,000



20

20

BEVIS, JOHN

[Uranographia; or the Celestial Atlas. *London: ca. 1750*]

oblong folio (15 x 19¼ in.; 385 x 485 mm). Engraved frontispiece showing Frederick Prince of Wales dressed as Caesar accepting a copy of the atlas from Urania, 51 engraved star charts with printed arms of the dedicatees (either academic institution or nobleman) beneath each image; frontis edges a little ragged and generally rubbed, index leaf (often lacking) with some marginal reinforcement, no title page (only found in a few copies). Modern calf and marbled boards.

FIRST EDITION OF A TRULY RARE CELESTIAL

Bevis spent the years 1747-1749 working on the star charts and endeavoring to attract subscribers as the project was to be costly. He managed 5 subscribers who ordered 30 copies. Unfortunately only a few proofs or complimentary copies were issued, with Bevis going bankrupt in 1750 due in part to the high cost of the engravings. The plates passed to the creditors and were later probably used for the Atlas Celeste 1786, itself a very rare work.

A small number, perhaps 6 copies, were listed in Bevis' estate at the time of his death in 1771.

The *Uranograhia Britannica* was based on Bayer's *Uranometria* but includes about 5 times as many stars, with Bayer's positions corrected. The last two plates represent the northern and southern hemispheres.

REFERENCES

For Brevis's discovery of the Crab Nebula, see N. V. Mayall, The Story of the Crab Nebula Science, vol. 137, no. 3524, 1962, p. 91 seq. Brown, Astronomical Atlases, Maps & Charts pp. 51--52, 57--58.

$ 25,000-30,000

21 (DETAILS)

21

ARMILLARY SPHERE BY CASPAR VOPEL, COLOGNE, 1549.

Signed "*CASPAR VOPELI MATHEMA PROF COLONIAE AGRIPPINAE SPHAERAM HANC FACIEBAT 1549.*"

A 4 inch (98 mm) diameter brass armillary sphere with central globe in wood, globe marked with circles for the tropics, equator, and ecliptic. Sphere consisting of thin brass bands with stamped inscriptions, solstitial & equinoctial colures (labelled *COLVRVS SOLSTICIORVM* and *COLVRVS AEQUINOCTIORVM*) meeting at the poles, solsticial stamped *ZONA FRIGIDA* near each pole, *ZONA TEMPERATA* between the poles and near the tropics, and between the tropics *ZONA TORRIDA* (winter half) and *ANTOECI* (summer half), equinoctial colures stamped *CIRCVMVM PERISCII* near each pole, *HETEROSCII ALTERVM* between each pole and tropics, and *AMPH/ISCII* twice between the tropics. Five parallel bands running perpendicular to colures representing the Arctic and Antarctic circles (stamped *CIRCVLVS ARCTICVS* and *CIRCVLVS ANTARCTIVS),* the tropics of Cancer and Capricorn (stamped *TROPICVS CANCRI* and *TROPICVS CAPRICORNI*), and the equator (divided into 12 equal parts with the signs of the Zodiac named in Latin, and divided every 1°). Graduated ecliptic band tangential to the tropics (divided into 12 equal parts of 30° for each sign of the Zodiac, each section stamped with the Latin name and symbol of each sign, and embellished with stars and the figurative representation of each constellation, with three stars marked *SPICA, ANTARES,* and *VRNA*). Three rotating bands attached to the axis of the ecliptic, representing the orbit of Saturn (labelled *SATVRNI SPHAERA PHOENON CELI SIGNIFERUM PERAGIT IN ANNIS 29 DIEBUS 162 ET HORIS 12*……), the orbit of the Sun (labelled *SOLIS SPHAERA. HELIOS TOTVM PERAGRAT ZODIACVM IN 365 DIEBVS…*) and the orbit of the Moon (labelled *PRIMA DEVM TERRAS GLACIALI SYDERE CIRCVM LVNA MEAT…*)

VERY RARE 16TH CENTURY ARMILLARY SPHERE by Caspar Vopel, one of only ten recorded examples by him, with the earliest dating to 1541. All but two (including the present example) are in Museums. Vopel (1511-1529) was a professor of mathematics at the Montan Gymnasium in Cologne. His first recorded instrument was a painted celestial globe done in 1532, followed by a printed pair of globes (terrestrial and celestial) in 1536. While it seems that his favorite instrument was the armillary sphere, he also produced sundials, nocturnals, and an astrolabe. Several of Vopel's spheres, with the present examples included, are not mounted with a meridian or horizon ring, but rather, were designed to be hand-held and fixed with a handle.

REFERENCES

Kugel, Alexis. *Spheres. The Art of the Celestial Mechanic.* 2002, A3.

PROVENANCE

Exhibited: *La Mesure du Temps dans les Collections Belges* (Exhibition catalogue, Société Générale de Banque, Brussels, 1984), no. 3, p. 31

There are only 10 recorded examples of Vopel's armillary spheres; London, Science Museum (1541); Washington, D.C., Smithsonian Institution (1541); Private Collection (1542); Copenhagen, National Museum (1543); Greenwich, National Maritime Museum (1543); Washington, D.C., Library of Congress (1543); Salzburg, Städt Museum (1544); Munich, Deutsches Museum (1545) ; London, Science Museum (1552)

$ 80,000-120,000


CASPAR VOVELIVS
LEO
VIRGO
LIBRA
GEMINI
CANCER
LEO
VIRGO
CANCER
LEO

21

22

22

A DELICATE 16TH CENTURY MINIATURE ARMILLARY SPHERE

Unsigned, but attributed to Christoph Schissler of Augsburg, second half of the 16th century.

Gilt brass with traces of vermillion colouring in the stamping. 55 mm in diameter.

The rings for the arctic and antarctic circles, the equator and tropics of Cancer and Capricorn are named in Latin as are the solstitial and equinoctial colures. The ecpliptic/zodiac circle is divided on both sides in degrees for each sign. Two minor repairs, mounted on a later brass stand.

This delicate miniature armillary sphere likely began its life as part of a astronomical clock or other large instrument. Christoph Schissler was one of the most renowned instrument makers of his day, and was known for the beauty and precision of his instruments. His oeuvre included the highest quality armillary spheres, astrolabes, quadrants, sundials, astronomical compendia, and celestial & terrestrial globes. Only 100 or so instruments signed or attributed to him are still known exist.

REFERENCES

The Clockwork of the Heavens. An Exhibition of Astronomical Clocks, Watches, and Allied Scientific Instruments. London, 1973. Item 16.

$ 7,000-10,000

23

GILT BRASS ASTRONOMICAL COMPENDIUM "VIATORIUM" (TRAVELER'S TIMEPIECE) BY MARCUS PURMAN, GERMANY, 1594.

Signed "*MARCVS PVRMAN MONACHY FACIEBAT VIATORIUM 1594.*"

Rectangular gilt brass box with hinged lid (54 x 40 x 12 mm), engraved on all faces. Underside engraved with tables of longitude and signs of the zodiac "*Tabula longitutinis die et in gressus solis in xii signa zodiacus",* lid with rotating disc divided in 24 equal parts for each hour of the day labelled "*Index Dierum Altatis Luna",* rotating to reveal the phases of the moon. Inner lid with Horary volvelle with central eight-point wind rose, surrounded by open border stamped with the maker's name at one end, and the name "*VIATORIUM"* and date of the instrument at the other end. Lower lid with diagram for a horizontal dial with half-our divided hour lines surrounding an inset compass. Plummet holder shaped and engraved as two monstrous fish, which also served as a support for the upper end of a strong gnomon (lacking here). Upper lid and edges decorated with engraved strapwork and stylised leaf decoration.

A very fine astronomical compendium, an ingenious instrument that contained numerous devices used to perform astronomical calculations and tell time. The name of this particular instrument, "V*iatorium"* means "Traveler's Timepiece", and indeed, small devices such as this were meant to aid the traveler in orienting themselves and telling the time while remaining lightweight and portable. The gilt decoration and elaborate engraving were intended to demonstrate social status of the owner, who in this case, was clearly a wealthy and important person.

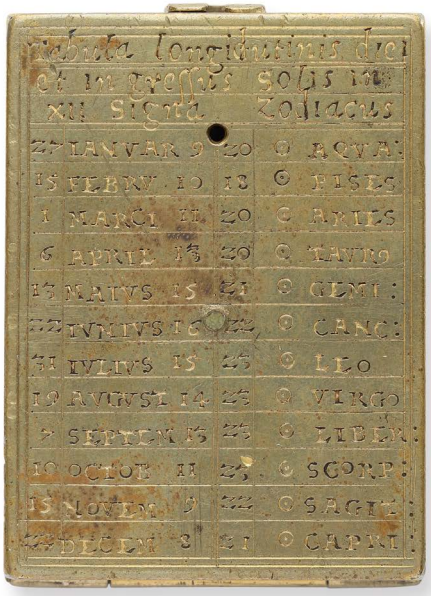
REFERENCES

See inventory No. 42672 "Astronomical Compendium by Marcus Purman, German, 1597" at the Oxford Museum of the History of Science.

$ 12,000-18,000

23 (DETAIL)

23 (DETAIL)



23 (DETAIL)

23

24

DUTCH MINIATURE PLANETARIUM, AFTER THE DISCOVERIES OF GIOVANNI DOMENICO CASSINI AND HIS GRANDSON CÉSAR-FRANÇOIS CASSINI DE THURY (CASSINI III), CA 1749

A gilt brass geared miniature folding planetarium with central gilt brass sun, and wooden planets Mercury, Venus, Earth (with printed paper gores) and its moon rotating around sun on a geared arm, Mars, Jupiter (with paper rings, on folding arm with 2 hinges, plus 4 separate arms for each of its satellites), and Saturn (with gilt brass rings, on folding arm with 4 hinges, plus separate arms for 5 satellites), hinged arms all engraved with information on the distances from the Sun, orbits, and the like. The whole mounted onto a metal base marked with the months and the signs of the zodiac in Dutch. Incorporating the 1675 observations on Saturn of Cassini I, but not the 1781 discovery of Uranus.

WITH: Autograph manuscript notebook in Dutch, 6 pp (70 x 91 mm), in original 18th century marbled wrappers, titled *"Corte verklaring van het Planetarium me de Stelling van Mr. Cassini. Uynekenaar van de Coninklijte Societijt te London van de accademie te Berlyn..."* Recording the planetary observations made by Cassini in 1749, with details on the dates on which each sign of the zodiac was observed, as well as the movements of the planets, and details on their orbits.

Planetarium and book housed together in round turned wood box.

A DELIGHTFUL MINIATURE FOLDING PLANETARIUM BASED UPON THE OBSERVATIONS OF GIAN DOMENICO CASSINI AND HIS GRANDSON CÉSAR-FRANÇOIS CASSINI DE THURY (CASSINI III).

Gian Domenico Cassini (1625-1712) was the first in a line of great astronomers who settled in France. Amongst his many discoveries, were the 2nd, 3rd, 4th, and 5th satellites of Saturn (Tethys, Dione, Rhea, and Iapetus) between the years 1671-1684 (after Huygens' discovery of the 1st, Titan, in 1655), as well as the division of the rings of Saturn in 1675, now known as *Cassini's Division.* These observations are reflected in the present planetarium. His Grandson, César-François (Cassini III) was a member of the French *Académie des Sciences* and a foreign member of the Berlin Academy. His astronomical work consisted primarily of observations of lunar and solar eclipses, occultations of stars and planets, and the like, some of which are recorded in the accompanying manuscript.

REFERENCES

see "The Cassinis" IN: *Dictionary of Scientific Biography,* vol III

PROVENANCE

Christie's 4 October 1995 (attributed to being after Giovanni Maria Cassini)

$ 12,000-18,000

24

25 (ALTERNATE VIEW)

25

25

BRASS MECHANICAL UNIVERSAL SUNDIAL BY GASPARD, GERMAN LORRAINE, CA 1750

Signed *"GASPARD A LUNEVILLE."*

A 7 x 5½ x 5 in (when folded for travel) complex mechanical universal sundial in brass and silvered brass with decorative piercing and turning of the brass, and finely shaped finials and sights. 5½ inch diameter ring gear, inset compass, target arm, minute hand (which operates a pinion gear against the ring gear) hinged plumb bob staff, thumb screws, and hinged leg which locks over latitude arc to raise the dial.

A WONDERFUL AND VERY RARE COMPLEX MECHANICAL UNIVERSAL SUNDIAL, ONE OF ONLY THREE KNOWN EXAMPLES BY THE MAKER GASPARD. To operate the dial, one sets the inclination for the proper latitude, orients it using the inset compass, levels the dial using the plumb bob and thumb screws, tilts the target arm for the proper solar declination (as indicated by the slit shadow), and rotates the minute hand until sunlight falls through the slit directly onto the target line. The time is then indicated by the chapter ring readout window and the minute hand.

Lunéville was an important city of Lorraine, and home to a flourishing interest in science during the 18th century thanks to Duke Leopold and Stanislaus I (1677-1766), the former King of Poland and founder of the Academia Stanislai in Lunéville.

PROVENANCE

Tesseract Catalogue 55, 1996/1997, item 18

$ 8,000-12,000

MAGNIFICENT 18TH-CENTURY PLANETARIUM BY JOHN HANDSFORD, BRISTOL, CA 1780

SIGNED ON THE ENGRAVED SILVERED DRUM PLATE *"MADE FOR RICH.D ALDRIDGE, ESQ. BY JOHN HANDSFORD, BRISTOL."*

A very rare 18th century planetarium, silvered drum plate engraved with *"Principal Affectations of the Planets",* tables of the planets Mercury, Venus, Earth, Mars, Jupiter, and Saturn, and their details such as distance from the sun, periods, etc., as well as tables for the satellites of Saturn and Jupiter, and finely engraved zodiac calendar scale at border; plate mounted onto drum with geared mechanism, the whole turned by a manual hand-crank with ivory handle. Central coppered brass sun with silvered engraving of sun's face, five planetary arms with ivory planets and satellites, 1½ inch terrestrial globe with 12 hand-colored engraved paper gores, the earth and moon rotating on separate geared mechanism with 2 rotating discs, showing the phases of the moon, the moon's path, and the time of day. With a multitude of accessories including a high and low watermark tide plate, an illuminating lamp, a reflecting mirror, a horizon plate, and more. The whole mounted onto a gilded brass tripod stand with cabriole legs terminating in scroll feet, together measuring 15¾ inches in height. Housed in the original oak carrying case (18 x 19 x 18½ in) with original accessory tray (plush lining worn), and brass carrying handles.

A MAGNIFICENT AND FINELY DETAILED PLANETARIUM, CUSTOM MADE FOR ITS ORIGINAL OWNER.

Little is know about Richard Aldridge, for whom this instrument was made, other than the fact that he was a banker in Bristol, and that his name appears on the subscriber lists of several books written during the period, including Benjamin Donne's *An Essay on Mechanical Geometry, Chiefly Explanatory of a set of Schemes and Models,* 1796 and Collinson's *The History and Antiquities of the County of Somerset,* 1791.

PROVENANCE

Christie's South Kensington, 1997, lot 24

◉ $ 40,000-60,000

26

TELLURIUM & LUNARIUM BY BENJAMIN MARTIN, LONDON, CA 1767

Signed "*MADE BY B. MARTIN, LONDON*" on side of drum.

Gilt-brass drum containing double-cone gear-work for operating both the tellurium and lunarium, top plate of drum engraved with central sun motif surrounded by zodiac degree and calendar scales. Circumference of drum cut with 274 teeth, the mechanism operated by two ivory handled hand-cranks mounted onto side of drum. The whole mounted onto a 14½ inch tall turned brass column with folding tripod base; lunarium with small geared earth and moon in ivory, each rotating above with separate rings representing the daily rotation of the earth, and phases of the moon; tellurium with 3-inch terrestrial globe signed in cartouche "*A New Globe of the Earth. By James Ferguson,*" mounted with silver meridian, mounted above geared mechanism with pointer and plate indicating the hour of the day; complete with small and large brass spheres representing the sun, as well as original oil lamp that can be used in place of the sun spheres, pointer extending from sun to globe indicating the direction of the sun's rays. Housed in the original locking mahogany case.

A VERY RARE AND EXCELLENT EXAMPLE OF BENJAMIN MARTIN'S FAMOUS TELLURIUM & LUNARIUM.

Benjamin Martin (c. 1705-1782) was one of the leading sellers of scientific instruments in the 18th century. A very successful businessman, he took over the globe-making business of James Ferguson (maker of the globe in the tellurium portion of the present instrument) in the 1750s. Martin was renowned for his excellent planetary models, and in the 1760s he introduced two special models; the tellurian, which shows the annual motion of the Earth around the sun, and the lunarium, which shows the motions of the moon around the earth, as well as of the moon and earth around the sun. The present instrument is an excellent example of this innovative instrument. Martin's work was world renowned, so much so that he was commissioned by Harvard University to produce a suite of instruments for their collections.

REFERENCES

A Measure of Time. 25th Anniversary. Trevor Philip & Sons, p. 30; *Instruments of Science: an Historical Encyclopedia,* p 467

◉ $ 40,000-60,000

27 (DETAIL)

27

28

NEW PORTABLE ORRERY BY W.S. JONES, LONDON, 1794

A Table of the Principle Affections of the Planets, Jan^{y} 1st 1794. Published as the Act Directs by W. & S. Jones. Designed for the New Portable Orreries by W. Jones, and Made and Sold by W.& S. Jones, 30 Holburn, London. London, 1794.

An 8 inch diameter portable tabletop orrery, with hand-colored engraved paper dial with zodiacal and calendrical scales, showing the months of the year, signs of the zodiac, details on the movements of the planets as well as on the satellites of Saturn and Jupiter, the movement of a comet, as well as the predicted appearance of the ring of Saturn from 1796-1810. Central gilt-brass sun, mounted onto multi-geared mechanism around which rotates the planets Mercury & Venus (in ivory), and the Earth (plaster globe with engraved hand-colored paper gores, signed "*Jones London*" cancel slip laid down on cartouche) & ivory moon. Earth & moon rotating above two rings, showing the phases of the moon and the signs of the zodiac. The whole operated by a hand-crank with turned-bone handle. Some repaired cracks to base.

AN EXCELLENT 18TH CENTURY ENGLISH PORTABLE ORRERY BY THE LONDON INSTRUMENT MAKER W. JONES.

◉ $ 8,000-12,000

28

29

29

CLOCK-TOP ORRERY WITH ETCHED GLASS GLOBE, CIRCA 1800

A heliocentric clock-top orrery with orbiting Earth and six other planets, the whole orrery enclosed within a later 9.87 inch diameter glass globe etched with constellations. The whole mounted onto a mahogany base. Orrery driven by a manual hand-crank found at side of base.

A beautiful example of a clock-top orrery, originally from a very fine Directoire While Marble, Bronze, and Ormolu Skeletonised Orrery Clock. The drive to the orrery was originally taken directly from the second wheel pinion of the clock via a vertical arbor.

REFERENCES

Tardy, *La Pendule Française,* Vol II, colour pl. XL, p. 204

PROVENANCE

S.H. Hole; Christie's 2 June 1980 for £7500 & 2 July 1997 for £28,750 (as part of a Directoire White Marble, Bronze and Ormolu Skeletonized Orrery Clock)

$ 20,000-30,000

30

EARLY 19TH CENTURY FRENCH ARMILLARY SPHERE

A 17½ inch diameter wooden and engraved paper armillary sphere, ecliptic ring with months and signs of the zodiac, horizon ring with months, signs of the zodiac, and directions, solsticial colure labeled "*Colure des Solstices et Étoiles Fixes",* equinoctial colure *labeled "Colure des Équinoxes et Étoiles Fixes*." Central gilt sun, surrounded by 9 discs rotating on brass arms, representing different planets or astronomical bodies, each printed with an image of the object and accompanying text: the asteroid Pallas (discovered by Olbers in 1802); the asteroid Juno (discovered by Harding in 1804); Saturn; the comet Herschel; Jupiter; Mars; the dwarf planet Ceres (discovered by Piazzi in 1801); Mercury; and Venus; plus, terrestrial globe with meridian ring, and orbited by lunar disc on brass arm, together orbiting the sun with a pulley system,¾ ring surrounding the sun representing the orbit of the earth. The whole on ebonized wood stand with 5 turned legs. Housed in the original wooden case (25 x 19½ x 19½ inches).

A wonderful, early 19th century French armillary sphere, ca 1804-1805 as the latest discovery included dates to 1804.

$ 12,000-18,000

30

31

A SPECTACULAR THOMAS, HARRIS & SON BRASS PLANETARIUM WITH TELLURIUM AND LUNARIUM ATTACHMENTS, LONDON, CA 1800

Signed "*Tho[ma]s Harris, & Son. Opposite the British Museum. London*" on the brass drum.

8 inch diameter brass drum supported on tapered pillar with folding splayed legs, outer edge of drum engraved with calendar scale, surrounding zodiacal calendar, central column mounted by gilt brass sun, and surrounded by nine rings, 1 for each planet, and each mounted with ivory and blackened ivory spheres for the planets; engraved and geared lunarium with ivory and black sphere for the moon (Earth sphere replaced), with 4 engraved rotating rings showing the Lunar Apogee and Perigee, the days of the month, the signs of the zodiac, and the phases of the moon, pointer wanting; engraved and geared tellurium mounted with 2½ inch diameter terrestrial globe with hand-painted engraved gores, signed within cartouche "*A New Terrestrial Globe by J. Newton, 1800,*" globe with engraved meridian and equinoctial arc. Original fitted mahogany accessory tray with 10 brass arms for the planets, plus 1 arm to demonstrate the retrograde of Venus, the Earth arm with attached moon, and the Jupiter, Saturn and Uranus arms with multiple attached moons, Saturn (ring replaced). Housed in locking mahogany box with brass handles.

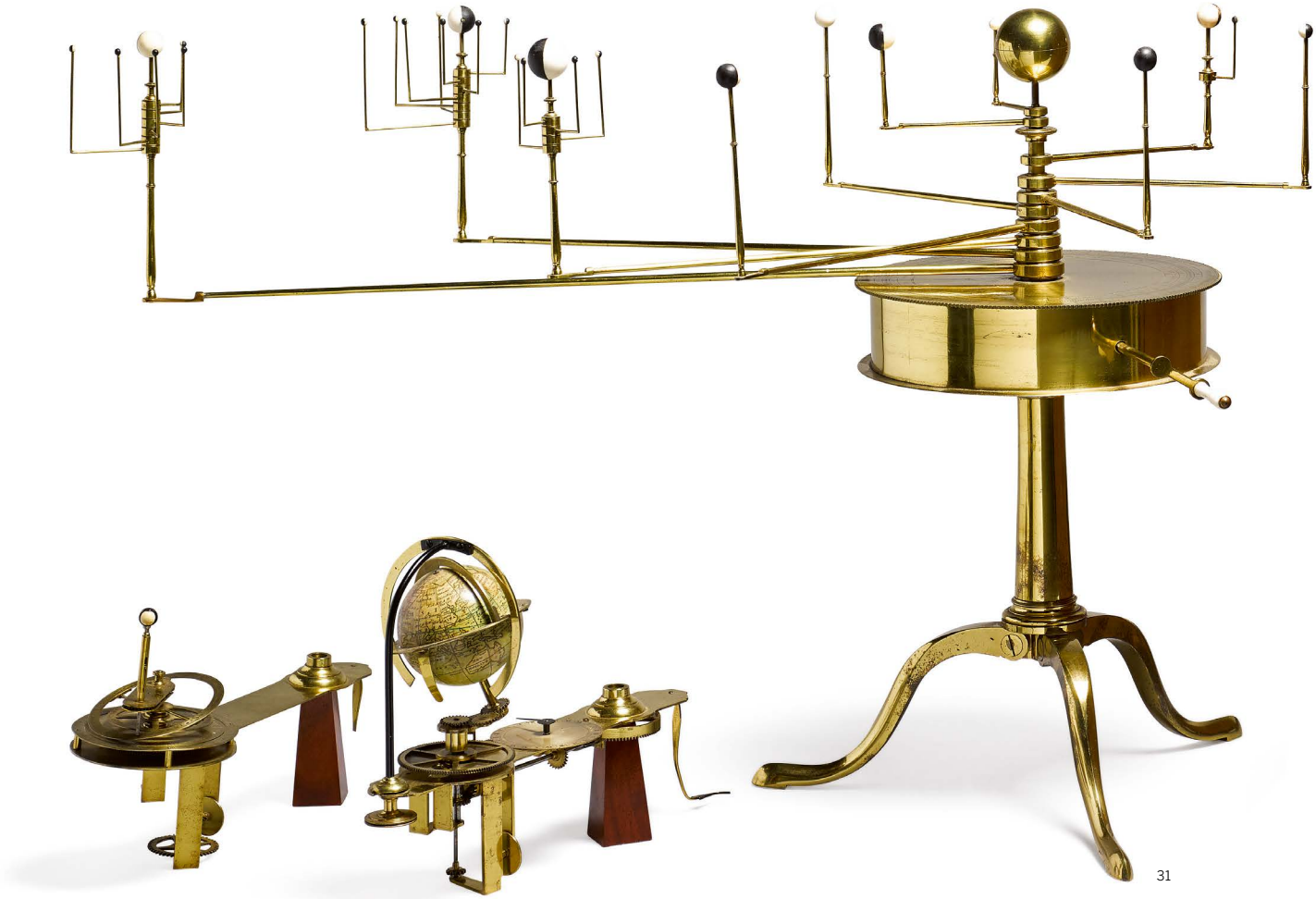
A MAGNIFICENT PLANETARIUM, COMPLETE WITH LUNARIUM AND TELLURIUM ATTACHMENTS. Thomas Harris & Son was one of the most prestigious London firms to produce globes, mathematical instruments, planetaria, telescopes, and other fine instruments in the early half of the 19th century. This Planetarium is an example of the some of their finest work.

PROVENANCE

Sotheby's Olympia, October 2002, lot 132 (cover lot)

◉ $ 50,000-80,000

31 (DETAIL)



31

32

SWISS GILT BRONZE CLOCK-TOP ORRERY BY FRANÇOIS DUCOMMUN, CA 1810

SIGNED "*FRANÇOIS DUCOMMUN*"

A gilt bronze heliocentric clock-top orrery with central sun, orbited by Mercury and Venus, and with orbiting Earth and moon, rotating year calendar with coloured enamel plaques depicting the signs of the zodiac, with removable bell-jar cover (12 inches tall with jar); the whole mounted on a 8¼ inch diameter wooden base. Orrery driven by and ivory hand-crank found at side of base. Come chips to edge of bell jar.

A very rare and beautiful clock-top orrery by the eminent Swiss clockmaker François Ducommun ca 1810. François Ducommun was a member of a large family of clockmakers at La Chaux-de-Fonds. Ducommun was evidently very proud of this orrery, which he had originally conceived as part of a clock, as in a portrait painted of him in 1839, he appears pointing at the orrery clock. An example of this very rare orrery clock has been preserved at the Civici Musei, Castello Sforzesco in Milan.

REFERENCES

see King, Henry C. *Geared to the Stars. The Evolution of Planetariums, Orreries, and Astronomical Clocks,* pp. 306-307

• $ 15,000-20,000

32

33

A POCKET PLANETARIUM IN POCKET CELESTIAL GLOBE [JOHN] NEWTON, [LONDON, CA 1830].

Pocket planetarium housed within a *Newton's Improved Pocket Celestial Globe* case. [London: Newton, Son, & Berry, ca 1830].

Central gilt-brass sun, surrounded by planets Mercury, Venus, Earth & Moon, Mars, Saturn, Jupiter, Saturn and Uranus in ivory, all mounted onto wires rotating around the sun. Housed in a 3-inch fishskin covered wood pocket globe case, with 2 brass hook-and-eye clasps, interior lined with 12 hand-colored engraved celestial gores depicting the Northern and Southern hemispheres, and with the allegorical representations of the signs of the zodiac, all in Latin. Signed *"Newton's Improved Pocket Celestial Globe."*

A VERY RARE POCKET PLANETARIUM BY ONE OF THE MOST IMPORTANT GLOBE MAKING FIRMS IN ENGLAND IN THE 19TH CENTURY. We can only find one other example of this instrument, located at Snowshill Manor and Garden, in Gloucestershire, as part of the National Trust.

"The Newton family were one of the most important globe making firms in England in the early 19th century. The founder, John Newton (1759-1844) was apprenticed to Thomas Bateman (fl. 1754-1781), who in turn, had been a pupil of Nathaniel Hill..."(*Globes and the Mechanical Universe,* p. 59)

PROVENANCE

Alain Brieux, 1964; Skinner, May 2005, lot 1563

◉ $ 12,000-18,000

33

33 (DETAIL)

34

ITALIAN PTOLEMAIC ARMILLARY SPHERE

Italian brass armillary sphere, likely early 19th century, 22 inch tall, 11 inch diameter. Unsigned. Horizon ring labeled "*CIRCVLVS PARALLELVS*" and engraved with the names of the winds at the points of the directions "*LEVANTE*", "*SCIRROCO*", "*MEZZOGIORNIO*", "*LIBECCIO*", "*PONENTE*", "*MAESTRO*", "*TRAMONTANO*", "*GRECO*". Ecliptic ring with the names and signs of the Zodiac; meridian ring labeled "*CIRCVLVS MERIDIANVS*" and divided every ten degrees; arctic circle labeled "*CIRCVLVS ARTICVS*", antarctic circle, colures, and tropic rings unlabeled. Some repairs to arctic ring, antarctic ring detached but present.

An unusual Ptolemaic Italian armillary sphere.

$ 3,000-5,000

34

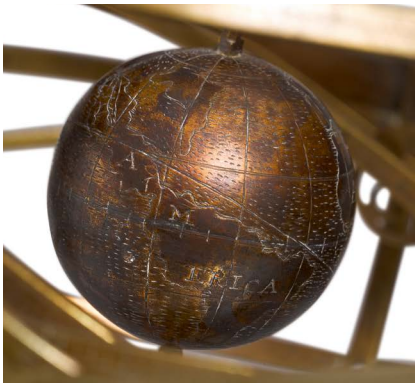
35

PTOLEMAIC GILT BRONZE ARMILLARY SPHERE WITH EARLY, POSSIBLY 16TH CENTURY, ENGRAVED GLOBE

16 inch tall, 9½ inch diameter gilt bronze armillary sphere on turned wood stand, ca 1780. Horizon ring engraved with the names and signs of the zodiac in Latin, ecliptic ring divided into 12 equal parts with the signs of the Zodiac named in Latin alongside the figurative representation of each constellation and divided every 1 degree. Inside the primary sphere are two movable systems of rings fixed perpendicular to each other, representing the orbits of the Sun and the Moon. At center of sphere is a finely engraved 1½ inch early bronze globe, depicting Antarctica as "*NOVA GUINEA*" and with a very elongated and narrow North American continent.

A lovely Ptolemaic armillary sphere, complete with central finely engraved early globe of the Earth, and eight point sun & crescent moon, each rotating around the Earth on their own rings. The central early terrestrial globe is particularly fine.

$ 4,000-6,000



35 (DETAIL, GLOBE)

35

36

COLLECTION OF 10 ASTRONOMICAL MAGIC LANTERN SLIDES IN ORIGINAL BOX BY H. HUGHES, LONDON, CA 1840

Box with original engraved paper label to interior of lid reading *"H. HUGHES, OPTICAL, NAUTICAL & MATHEMATICAL INSTRUMENT MAKER, 59, FENCHURCH STREET, LONDON"*, lid of box with original label reading "*H. HUGHES, OPTICIAN. 59 FENCHURCH ST. LONDON."*

Together 10 mechanically-driven wood and hand-painted glass magic lantern slides, each slide geared, and driven by a hand-crank. Slides 1-9 with the original descriptive printed paper labels. Housed in the original wooden box.

A WONDERFUL COMPLETE COLLECTION OF MECHANICAL MAGIC LANTERN SLIDES DEMONSTRATING VARIOUS ASTRONOMICAL PHENOMENA, including the Solar System and the revolution of the planets & their satellites around the Sun. Rare to find a complete set in the original box. The slides include depictions of the annual motion of the Earth around the Sun; the cause of of the tides and the phases of the moon; the apparent direct and retrograde motion of Venus or Mercury; the eccentric revolution of a comet around the Sun; the various eclipses of the Sun and the transit of Venus ' and the phases and eclipses of the Moon amongst others.

$ 5,000-8,000

36

37

[CELESTIAL ATLAS CARDS]

Set of 28 black etched French celestial plates/cards with punch-out stars, ca. 1780

4to (9 1 /2 x 7½ in.; 240 x 185 mm). Black etched cards with pinholes for star locations in constellations, the surrounding figures mythological or biblical, printed pink card mounts. Loose in contemporary card portfolio with silk ties; spine of portfolio partially perished, some minor rubbing.

With instructions on the verso of surrounding mounts providing instructions for what time of year to use each card, the present is practical celestial atlas - also far more affordable than the large, colored folios. Rare.

$ 4,000-6,000

37

PROPERTY OF VARIOUS OWNERS:

LOTS 38- 66

38

38

PROPERTY OF A PROMINENT NEW ENGLAND PHYSICIAN

VERY RARE GEORGE III MAHOGANY AND ENGRAVED BRASS ORRERY

Signed "*Made by Ed. Beavess, London, 1760,"* likely made for him by the workshop of Benjamin Cole of London.

An 11 inch-diameter brass orrery on mahogany base, ecliptic ring engraved with the months of the year, the signs of the zodiac, and with the months divided into 30 or 31 days, "Arctick Circle", and Tropick of Cancer"(one section repaired), equinoctial colure divided into 360 sections, by degrees of 10, central gilt-brass sun, orbited by Mercury, Venus, Earth & Moon, all in bovine horn, the Earth & moon on separate geared rotating disc painted in dark blue with gold stars, the whole mounted onto a larger dark blue disc, painted with gold rays emanating from the sun. The whole operated by a manual hand-crank at side, and driven by a geared mechanism. Crack to mahogany base, one some wear to blue paint.

This type of geared model of the solar system, known as a tellurium, finds its origins in an instrument conceived by Thomas Tompion and George Graham in 1712. As was common at the time, this instrument was then copied and improved by John Rowley, a master of mechanics to George I. Rowley also made a number of instruments for Charles Boyle, the 4th Earl of Orrery. It is from this type of tellurium that similar geared models have garnered the name 'orrery". Rowley's apprentice Thomas Wright (d. 1767) succeeded Rowley, and an orrery very similar to the present example was depicted on his trade card. Wright was in turn succeeded by his apprentice, Benjamin Cole (I) (d. 1766) and his son, Benjamin Cole (II), who was active from 1766-1782.

The Coles would become the some of the most important retailers of mathematical instruments in 18th century London, and their trade card was engraved with a magnificent "Grand Orrery." As Turner points out in *Early Scientific Instruments: Europe 1400-1800,* at the time in London, the highly specialized trade in scientific instruments was made up of a network of "chamber masters," with each of these masters producing a single type of instrument, coordinating both the manufacture and retail sales for their makers. This is supported by the observation of distinct similarities between those orreries by Rowley, Wright, and Cole.

Little is know about the maker of the present orrery, Edward Beavess. He is only known from a 1759 newspaper advertisement which notes that he was established "two doors from the Brown Bear in Seacole Lane, Snow Hill, London." he was perhaps a retailer, and it is likely that the present orrery was manufactured for him in the Cole workshops.

REFERENCES

Calvert, H.R. *Scientific Trade Cards in the Science Museum Collection.* London: H.M.S.O., 1971; Clifton, Gloria. *Directory of British Scientific Instrument Makers, 1550-1851.* London: National Maritime Museum, 1995; Turner, *Early Scientific Instruments Europe 1400-1800.* London: Sotheby's Publications, 1987

$ 40,000-60,000

39

UNIVERSAL EQUINOCTIAL RING DIAL BY BENJAMIN COLE, LONDON, CA 1850.

SIGNED "*COLE, LONDON.*"

A 4-inch diameter universal equinoctial ring dial in brass, with suspension ring, sliding pinhole gnomon with calendrical scale to one side, and zodiacal scale to the other; upper scale engraved with latitudes for both Northern and Southern latitudes; chapter ring engraved with 24 hours (I-XII, and I-XII); equinoctial ring with declination scale to one side and degree scale to other (90°-0°-90°).

A WONDERFUL MID-18TH CENTURY UNIVERSAL EQUINOCTIAL DIAL. Also known as a "Traveler's sundial", these clever instruments would be suspended from a cord, with the suspension point on the meridian ring set to the local latitude. The center bar is then set until a ray of light passes through a small hole, and falls on the equatorial ring, indicating the time of day.

$ 6,000-8,000

39

THE FIRST ELECTRIC SOUND SYNTHESIZER

A Helmholtz Sound Synthesizer, manufactured in Chemnitz by Max Kohl after the design by Hermann von Helmholtz, ca 1905.

Wood, brass and steel sound synthesizer, signed "*Max Kohl, Chemnitz, 1/8*", 39½ x 29", mahogany base fitted with 11 steel tuning forks signed MK, each fork stamped with corresponding note and frequency in vs (vibrations per second, i.e. hertz). Forks 1-10 fixed between pairs of electromagnets and mounted vertically onto wooden platforms (numbered 1-10) along with brass Helmholtz resonators, each pair ranging in size according to their graduating frequencies, each platform with "Aus/Ein" [on/off] switch. For full description, please visit www.sothebys.com

A MAGNIFICENT EXAMPLE OF HERMANN VON HELMHOLTZ'S SOUND SYNTHESIZER, AN ELECTRONICALLY DRIVEN DEVICE USED FOR ARTIFICIALLY CREATING MUSICAL SOUNDS OF DIFFERENT TIMBRE, AND THE VOWELS OF THE HUMAN VOICE.

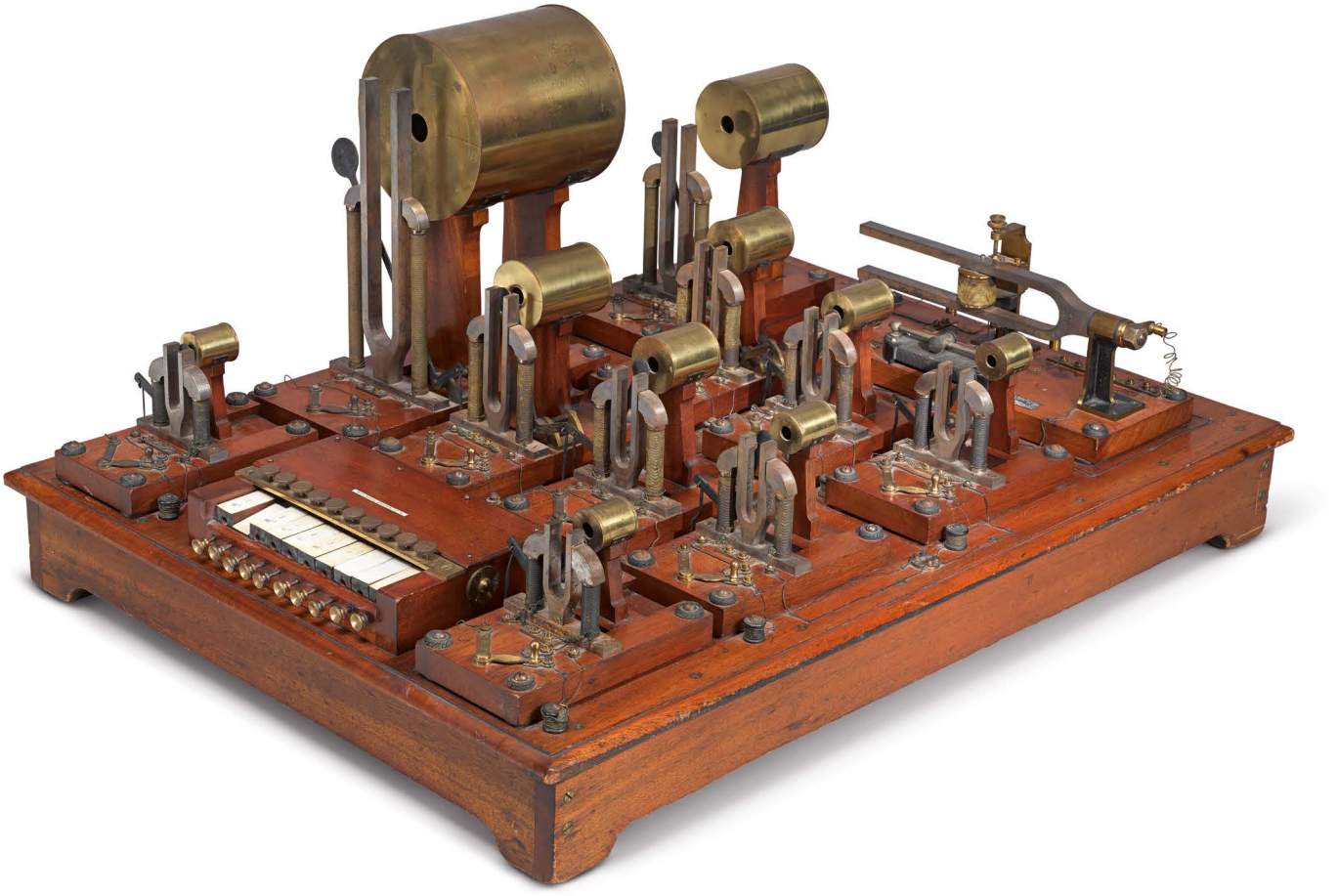
◉ $ 25,000-35,000

The Helmholtz Sound or Vowel Synthesizer was used to combine timbres of 10 harmonics to form the vowel sounds A, E, I, O, and U. Driven by an intermittent electrical current, the tuning forks were made to vibrate using electromagnets. The forks would generate a fundamental frequency and overtones which could then be combined. The keyboard controlled a series of round shutters which covered the aperture of each resonator. When one pressed a key, that shutter would move, allowing the waves from the tuning fork to enter the resonator and produce a tone; the intensity could be adjusted by sliding the resonator closer to or farther from the fork.

With this device, Helmholtz showed that musical notes are composed of many different tones, and that the timbre of vowel sounds and musical notes is a result of their complexity. The device clearly demonstrated that the musical note not only contains "a simple 'fundamental' vibration... but also a 'harmonic series' of whole number multiples of this frequency called 'overtones'. Helmholtz proved, using this synthesizer, that it is the combination of overtones at varying levels of intensity that give musical tones, and vowel sounds, their particular sounds quality, or timbre." (Rees) Specimens of this device are extremely rare, with only one similar but smaller apparatus located in a US institution that we know of — we have not seen any others as large or finely made as this one. Max Kohl of Chemnitz is perhaps one of the most famous scientific instrument makers of the late 19th and 20th centuries. His work was distinguished by its exacting craftsmanship, and high quality materials.

REFERENCES

For a detailed description of how to operate this apparatus, and detailed references please go to www.sothebys.com



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41

ENIGMA I

A Fully Operational Three-Roter Enima I Cipher Machine. Erfurt, Germany: Olympia Büromaschinenwerke AG for Heimsoeth und Rinke, 1944

3-rotor Enigma I cipher machine, serial number A01259 / bac / 44E, with 3 aluminum rotors, each rotor with 26 positions labeled with numbers, housed in the original oak case (13¼ x 11 x 6½ in.) with leather handle, case with hinged front panel stamped "*ENIGMA*" and "*Klappe Schleissen*" opening to reveal *Steckerbrett*. Control panel with standard raised "QWERTZ" keyboard of 26 glass and metal keys with white on black backgrounds, light panel with letters A-Z and hinged rotor cover lifting to reveal 26 light bulbs, reflector & rotor compartment, and battery compartment, ebonite *Steckerbrett* (plug-board) and 12 patch-cables (10 plugged into Steckerbrett and 2 spares stored in lid of case), lid with 10 spare bulbs, green contrast filter, spare patch-cables, and instructions printed on metal plate ("*Zur Beachtung*!"). Instruction plate, power source indicator plate, and green contrast filter replaced; *Stecker* cables with original plugs and newer cables. WITH: A circa 1934 German Baumuster Type T1 Telegraph key, and 2 facsimile Enigma operating manuals.

A VERY FINE, FULLY OPERATIONAL 3-ROTOR ENIGMA I CIPHER MACHINE. The Enigma I, often called the "*Heeres*" Enigma, was used by the German *Heer* (Army), the *Luftwaffe* (Air Force), and later, by the *Kriegsmarine* (Navy) before the introduction of the "M4" 4-rotor machine. The serial number A01259 / bac / 44E of the present machine indicates that it was manufactured for Heimsoeth und Rinke in 1944 by Olympia Büromaschinenwerke AG. Olympia Büromaschinenwerke AG is commonly known as the Olympia Typewriter Company and was founded in 1903. It produced a number of items for Germany during the war, including M4 Enigma machines. The company survived the war but went out of business in 1992 as computers replaced the need for typewriters.

Patented in 1918 by Arthur Scherbius, the Enigma machine uses three electromechanical cipher wheels, each with 26 contacts at either side. The three rotors would be placed in pre-arranged positions, and the user would then type in a plain text message using the keyboard. The machine would encipher the message, and each corresponding encoded letter would light up on the light panel. The enciphered message would then be sent to the receiving party, usually via Morse code. The receiving party would then decipher the message, using another Enigma machine with the rotors set to the same position as the first. The rotors of all Enigmas were interchangeable, and indeed, rotors were swapped out very frequently.

41

The Enigma machine set a challenge that was answered by the remarkable team at Bletchley Park, whose achievements provide one of the most compelling stories of World War II. Breaking Enigma was the work of many, including Polish cryptographers who had already begun to decipher Enigma traffic before the war; naval forces who risked their lives capturing Enigma machines and code books; Alan Turing and other mathematicians with their revolutionary models for deciphering; Tommy Flowers and other mechanical geniuses who designed 'Colossus', the world's first programmable digital computer, at the GPO Research Centre at Dollis Hill in north west London; the hundreds of Wrens who operated the Bombes and, later, Colossus machines that made possible the daily decrypts. Their work saved countless lives and had an enormous impact on the submarine war in the Atlantic, the North African campaign, and the Normandy invasion; the work of Bletchley Park is often said to have shortened the war by two years. Furthermore, by coming to the understanding that to defeat Enigma it was necessary to mechanize much of the work of decryption, they helped to inaugurated the computer age.

$ 180,000-200,000

NEMA 45

A Fully Operational NEMA Model 45 Cipher Machine. Uster, Switzerland, Zellwager A.-G., 1948

Swiss NEMA Model 45 cipher machine, serial number 311, complete with 10 wheels consisting of: 1 rightmost red entry-wheel, or Eintrittzwalze (ETW), 1 leftmost reflector wheel, or Umkehrwalze (UKW), and 6 pairs of wheels (A16, B19, C20, and D21), each consisting of 1 electrically wired coding wheel and 1 stepping wheel, all 10 with 26 positions for each letter of the alphabet. "QWERTZ" keyboard with 31 white on black bakelite keys consisting of the 26 letters of the alphabet, "BU" and "ZL" keys to toggle between letters and numbers, carriage return "WR" key, and two blank keys, plus metal space bar; combined rotor cover and light panel with letters A-Z, metal manufacturer's label reading "Zellweger A.-G. Apparate- u. Maschinenfabriken. Uster. Type: T-D No.: 311", metal power source toggle switch, two nodes for connecting external 4-volt power source, counter re-set lever, panel lifting to reveal 26 light bulbs, rotor & reflector compartment, and battery compartment. In the original locking metal carrying case with leather handle (14¼ x 12¾ x 5¾ in.), case stenciled with "*TD311*," inside of lid fitted with 16 spare bulbs, external lamp panel for extra security, mains cable with Edison fitting. WITH: Original NEMA Instruction manual, printed in French & German, with "*ENTKLASSIFIZIERT DATUM: 9. Juli 1992*" printed on the front wrapper.

A RARE, FULLY OPERATIONAL SWISS NEMA CIPHER MACHINE, ONE OF THE FEW USED FOR TRAINING

$ 15,000-20,000

When the Swiss discovered that their Enigma traffic was being intercepted by both the Germans and the French, their they developed their own electromechanical wheel-based cipher machine known as the NEMA (Neue Machine). Between 1941-43, a team of mathematicians including Hugo Hadwiger, Heinrick Emil Weber, Paul Glu, and Captain Arthur Alder worked to develop the machine, with the first prototype being developed in 1944, and production starting in 1946, too late to assist the war efforts.

A total of 640 machines were built by the manufacturer, with numbers TD-100 to TD-199 being issued for use by the Foreign office, numbers TD-200 to TD-419 being used in training, and numbers TD-420 to TD-740 being Operational Machines reserved for use in war. The Operational Machines were slightly different in operation, with different notches on the stepping wheels, two extra wheels stored in the lid, and a paper label on the lid in French, German, and Italian indicating that they were only to be used in the event of war. The Swiss Army used the NEMA after WWII until it was replaced by other more advanced cipher machines, such as the Hagelin. The NEMA was officially declassified on July 9th, 1992.

42

43

43

FIALKA (RUSSIAN: ФИАЛКА) M-125-3M

RUSSIAN ELECTROMECHANICAL ROTOR-BASED CIPHER MACHINE, CA 1965

An electromechanical, wheel-based cipher machine in original gray metal case (13 x 8 x 10½ inches) with locking detachable lid, machine with 10 unique coding wheels, plus 10 spare coding wheels and 1 spare reflector stored in lid, serial number 98-70967 & 98-70248. With standard power supply unit in matching gray metal case (10 x 7 x 6 inches) with carrying handle, serial number 98-70230, and electrically powered telegraph key.

The M-125, codename **ФИАЛКА** (Fialka, meaning Violet) was first introduced in 1956 in the USSR, and was succeeded by the more complex M-125-3M in 1965. It was the favored machine of the Warsaw Pact and allied nations, including Cuba, and the design of the machine was based upon the German Enigma — leading it to often be referred to as the "Russian Enigma." Where the Enigma had a panel where the encoded letters would light up, the Fialka printed the message directly onto a strip of paper. Having learned from the flaws in the German design, the Russians made a number of improvements to the machines, including: Using 10 wheels instead of only 3 or 4; introducing more frequent wheel turn-overs; allowing a letter to be encoded onto itself (the great flaw of the German Enigma); replacement of the Steckerbrett with a punched card; the movement of adjacent wheels in opposite directions; and the ability to change the wiring of the wheels while in the field.

Most machines had the capability of using Latin or Cyrillic writing, and each country in the Warsaw Pact had its own customized version, with a different keyboard and print head designed for each country, as well as different wiring for the coding wheels.

$ 12,000-18,000

44

HAGELIN M-209-A

A HAGELIN M-209-A TACTICAL MECHANICAL CIPHER MACHINE, SYRACUSE, NY, LC SMITH & CORONA TYPEWRITERS INC, UNDER LICENSE FROM HAGELIN, CA 1942

Portable hand-operated pin & lug mechanical cipher machine with 6 coding wheels, in original green metal integral case (7 x 6 x 4 inches) with metal label to lid reading :*"SIGNAL CORPS. U.S. ARMY. CONVERTER. M-209-A. SERIAL NO. 13898. ORDER NO. 1499-PHILA-42. SUPPLIED BY HAGELIN CRYPTOGRAPH COMPANY. NEW MILFORD CONN." W*ith original military-grade canvas bag with short canvas strap. Inside of lid fitted with roll of paper tape, one tube for oil, and one tube for ink. With facsimile manual, and original decommission tag.

A lightweight and portable mechanical cipher machine, the Hagelin M-209-A was developed in Sweden for the US Army. Using 6 mechanically driven coding wheels, text was entered one letter at a time, and the encoded letters were printed on a paper tape using a built-in printer. Unlike the Enigma line of encoding machines, this required no electricity to operate, and this, coupled with it's light weight, made it a much more versatile machine.

$ 6,000-9,000

45

HAGELIN CD-57

A Pair of Functional Hagelin CD-57 Pocket Cipher Devices. Switzerland, Crypto AG. Zug, 1957

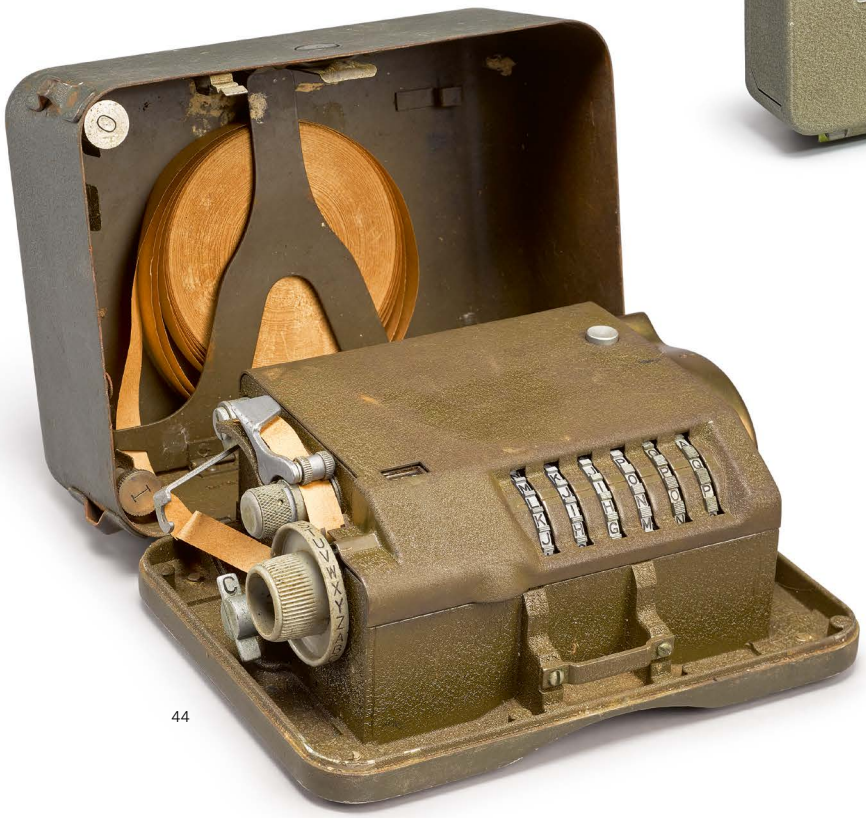
Two mechanically operated pocket cipher machines, serial numbers 3001895 and 3001858, each housed in two-part military case variant (5½ x 3 in.) of drab-green die-cast aluminum, complete with 6 coding wheels (29, 31, 37, 41, 43, & 47) and rewinding crank housed in case lid. Hinged top lid with case lock, white on black input/output letter disk, crank insertion hole, and window revealing letter counter, case bottom with cipher tape holder, operating lever, and locking lever, the whole opening to reveal keying mechanism with input/output disc, and stack of 6 coding wheels on axle with drum locking lever. Each cipher machine accompanied by its original grey carton box. Some minor wear, commensurate with age and use.

TWO FULLY FUNCTIONAL HAGELIN CD-57 POCKET CIPHER DEVICES.

Developed by Boris Hagelin in 1957, the eponymous Hagelin CD-57 was a mechanically operated, pin-and-lug pocket cipher machine that remained in service until the mid 1970s. By secret arrangement with the United States National Security Agency, two primary versions of this device were made; the CD-57, made for use by NATO and NATO-friendly countries, and the CD-55, made for use by non-NATO countries. The two appeared identical, however the CD-55 was much easier to break; the CD-57, basically a pocket-version of Hagelin's unbreakable CX-52 desktop cipher machine, featured a highly improved stepping mechanism and could quickly be converted to an unbreakable one-time tape (OTT) cipher machine by replacing the 6-wheel stack with the so-called RT/CD (Random Tape) option and fitting the bottom of the case with a key tape cassette.

Because of its easily concealable size, the CD-57 was popular with a number of intelligence agencies during the cold War, as well as with many European and other armies.

$ 3,000-5,000



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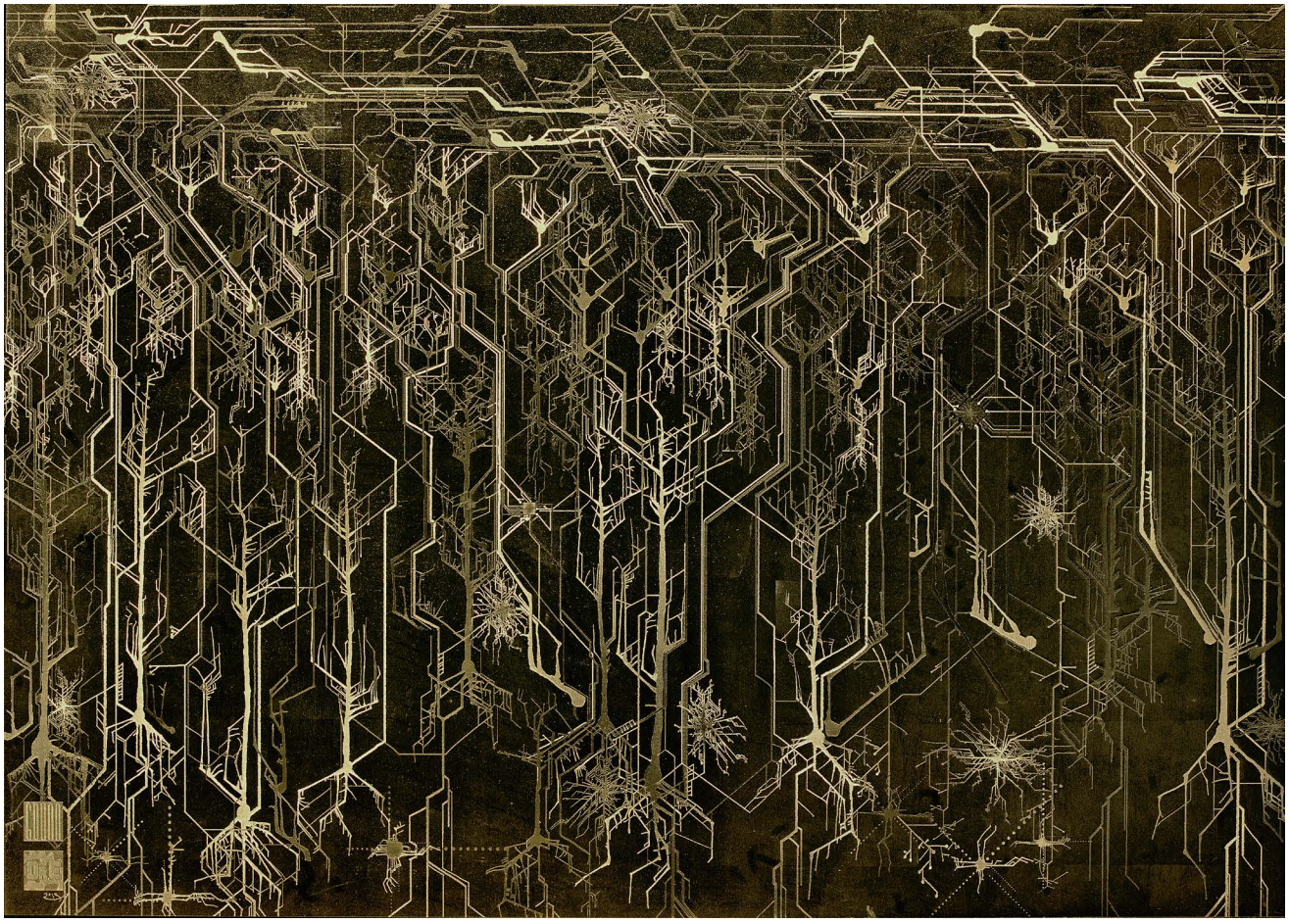


46

46

DR. GREG DUNN IN COLLABORATION WITH DR. BRIAN EDWARDS

Cortical Circuitboard, 2013

22k gilded microetching (32 x 24 inches). Number 6 of a limited edition of 15.

Cortical Circuitboard features a stylized array of cortical neurons that are arranged into the layered structure of the cerebral cortex. Incorporating aesthetic motifs drawn from circuitboard design into the neural landscape, it draws parallels between the chaos of a biological brain and the order of an electronic one.

This piece features the first example of Dr. Edwards' animation algorithm. Using visual information built into the design, Dr. Edwards wrote a program that calculates the precise angle necessary at any coordinate on the microetching to reflect light to the viewer standing at a given position. This allows light to reflect off of the surface in specific ways, giving the artists the ability to depict animations within each neuron. As the viewer walks past the microetching the neurons fire action potentials, creating a finished piece whose circuit dynamics represent the actual firing patterns found within the cerebral cortex.

$ 25,000-30,000

47

DR. GREG DUNN IN COLLABORATION WITH DR. BRIAN EDWARDS

Self Reflected, 2017.

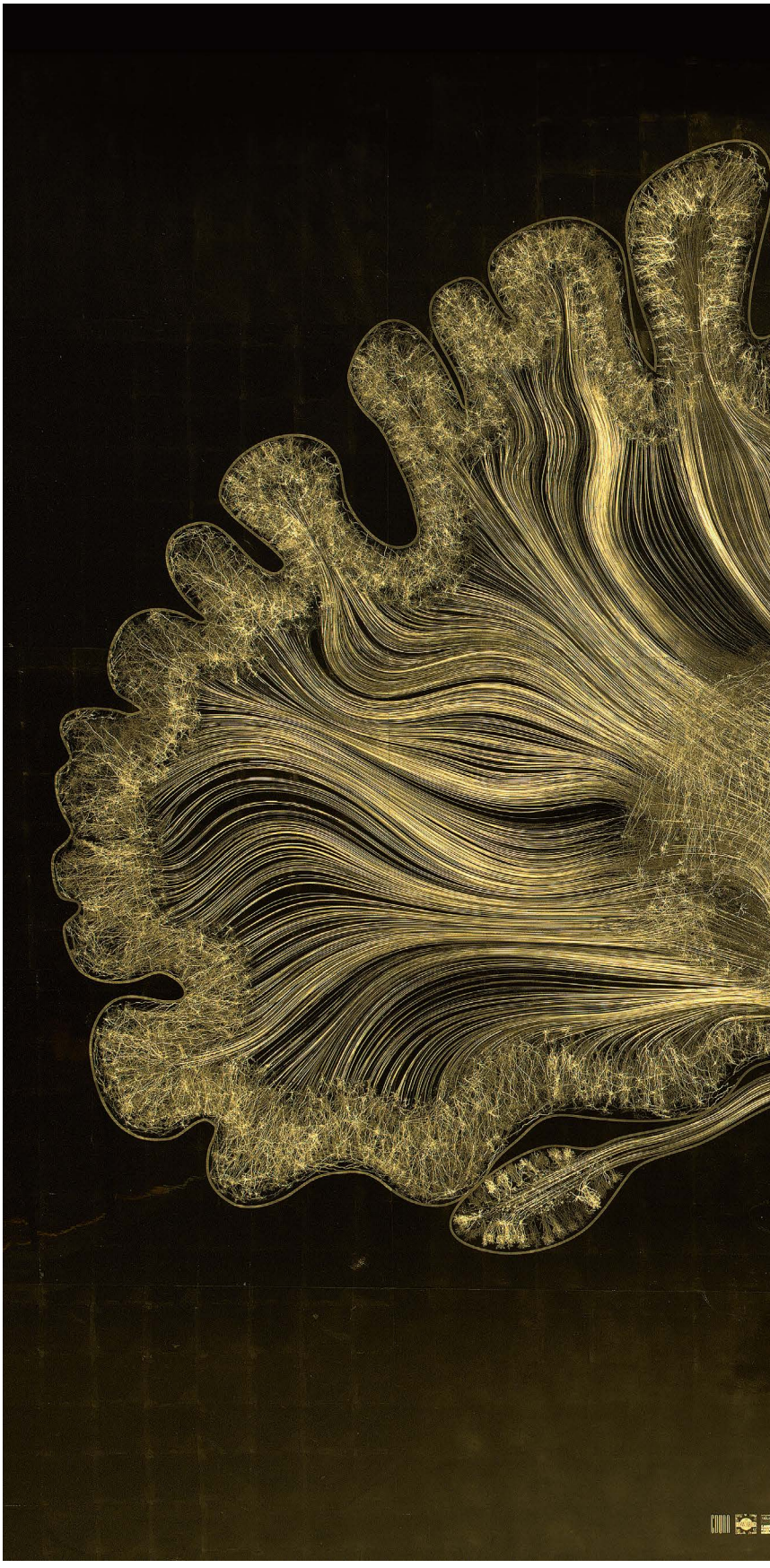
22k handmade gilded microetching (24 x 32 inches). Number 6 of a limited edition of 10.

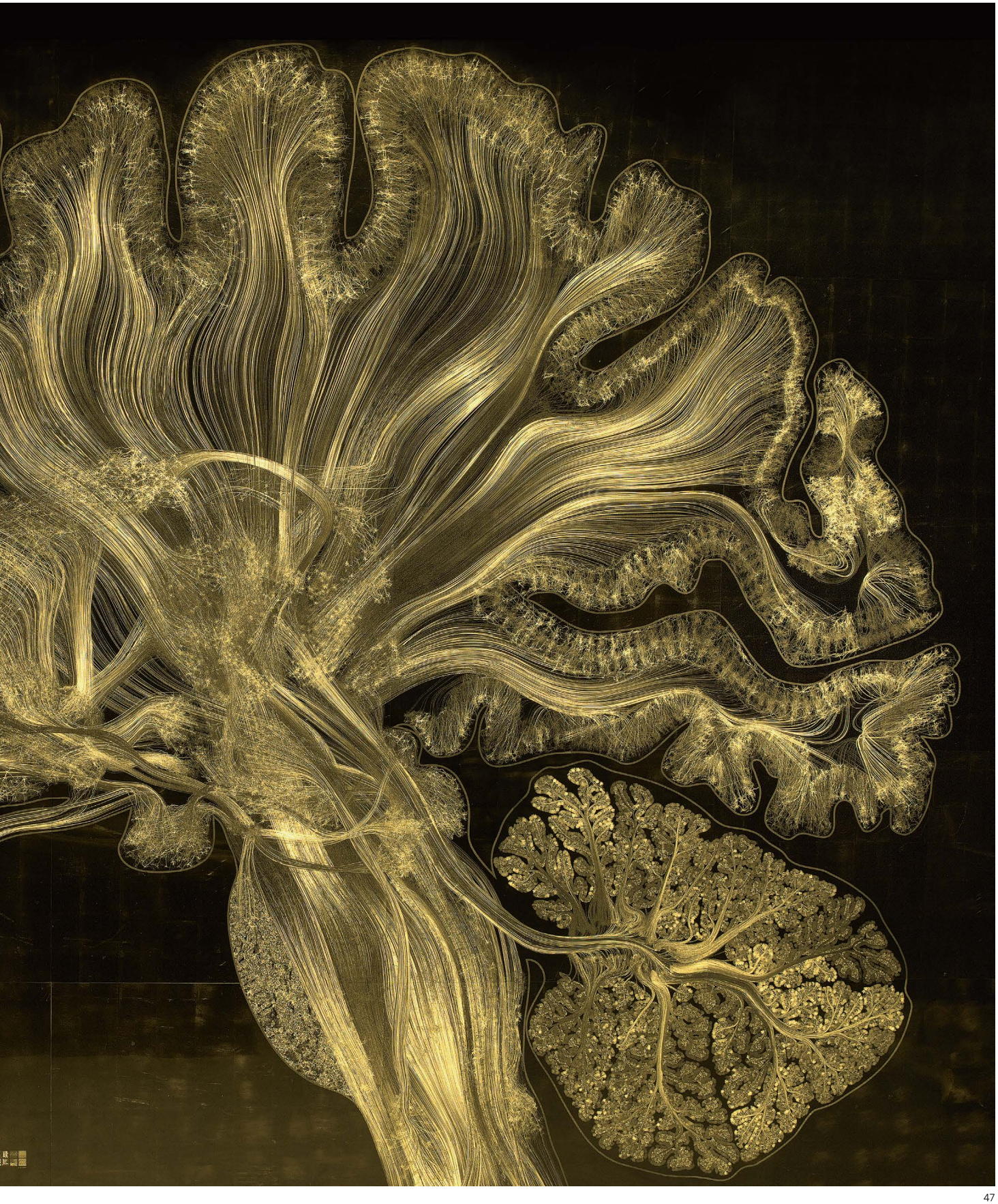
A REMARKABLE DEPICTION OF A SLICE OF THE HUMAN BRAIN AT 22X SCALE

Dr. Greg Dunn (artist and neuroscientist) and Dr. Brian Edwards (artist and applied physicist) created *Self Reflected* to elucidate the nature of human consciousness, bridging the connection between the mysterious three pound macroscopic brain and the microscopic behavior of neurons. *Self Reflected* offers an unprecedented insight of the brain into itself, revealing through a technique called reflective microetching the enormous scope of beautiful and delicately balanced neural choreographies designed to reflect what is occurring in our own minds as we observe this work of art. *Self Reflected* was created to remind us that the most marvelous machine in the known universe is at the core of our being and is the root of our shared humanity.

Self Reflected was made using an elaborate combination of hand drawing, algorithmically simulated neural circuitry, adapted neuroscientific data, photolithography, gilding, and strategic lighting. It is not a scan or a photograph of any kind. Microetchings are handmade lithographs that manipulate light on a microscopic scale to control the reflectivity of metallic surfaces in precise ways. These techniques were invented by Dr. Greg Dunn and his colleague Dr. Brian Edwards in order to change the way in which the viewer experiences a painting. PLEASE NOTE THAT THESE MICROETCHINGS ARE DESIGNED TO EVOLVE BASED ON THE MOVING PERSPECTIVE OF THE VIEWER AND ARE IMPOSSIBLE TO CAPTURE IN STILL IMAGES.

$ 25,000-30,000





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48

48

DR. GREG DUNN IN COLLABORATION WITH DR. BRIAN EDWARDS

Pranayama, 2015

22K handmade gilded microetching (24 x 32 inches). Number 5 of a limited edition of 10.

Pranayama, controlling the mind through the breath, has been practiced around the world for thousands of years. With continued practice comes a growing awareness of prana, a subtle energy in the body whose movement can be controlled through breath.

This dynamically reflective gilded microetching depicts the movement of prana in the body as the viewer walks around it. When walking from left to right, the "inhale" prana is withdrawn from the extremities, into the central channel, and upwards. When walking from right to left, the "exhale" prana moves back down the central channel and into the extremities. The microetching "breathes" as the viewer walks past it, providing a reminder to bring the mind back to a position of awareness.

$ 25,000-30,000

49

49

DR. GREG DUNN IN COLLABORATION WITH DR. BRIAN EDWARDS

Photosynthesis, 2018

22k handmade gilded microetching (24 x 32 inches). Number 4 of a limited edition of 10.

A stunning simulation of water and nutrient transport in leaf vasculature.

$ 30,000-35,000

50

50

BROWN, ROGAN

Magic Circle Variation, 2018

Hand and laser cut paper in custom shadow-box (37 x 37½ inches)

This work mixes hand and laser cutting to create an incredibly detailed and varied visual texture making multiple references: coral, bacteria, pathogens, diatoms, fungi etc... The circle of the title refers not only to the shape of the petri dish and microscope lens but also to the Buddhist mandala, as these pieces encourage meditation on the beauty and intricacy of the natural world as well as the artistic imagination that transforms it.

Magic Circle Variation and *X3/18* (lot 51) are companion pieces that explore different ways of approaching and representing nature or, more specifically in this case, of representing the Human Microbiome which is their common point of inspiration. *Magic Circle Variation* offers a holistic vision of a microbiological-bacterial colony coexisting in harmony, which is symbolized by the circle itself. On the other hand *Control X3/18*, using the same repertoire of motifs, presents the scientific vision of nature which works through the creation of taxonomies, separating and isolating individual elements of the colony for analysis through control experiments. The limitations of this approach are figured by the rupture of the Petri domes and the escape of the organisms they contain. This reflects the fact that scientists are unable to analyze the biome through such taxonomies because a) they are unable to successfully isolate and culture the bacteria in Petri dishes (most species of bacteria cannot be cultured in this way, E.coli is an exception) and b) the biome operates through an incredibly complex system of interaction and symbiosis and can only be fully understood through an analysis of these interrelations.

The excess of detail in these sculptures therefore acts as a visual metaphor for the excess of data in nature which constantly subverts and limits our attempts to fully comprehend it.

$ 6,000-8,000

51

51

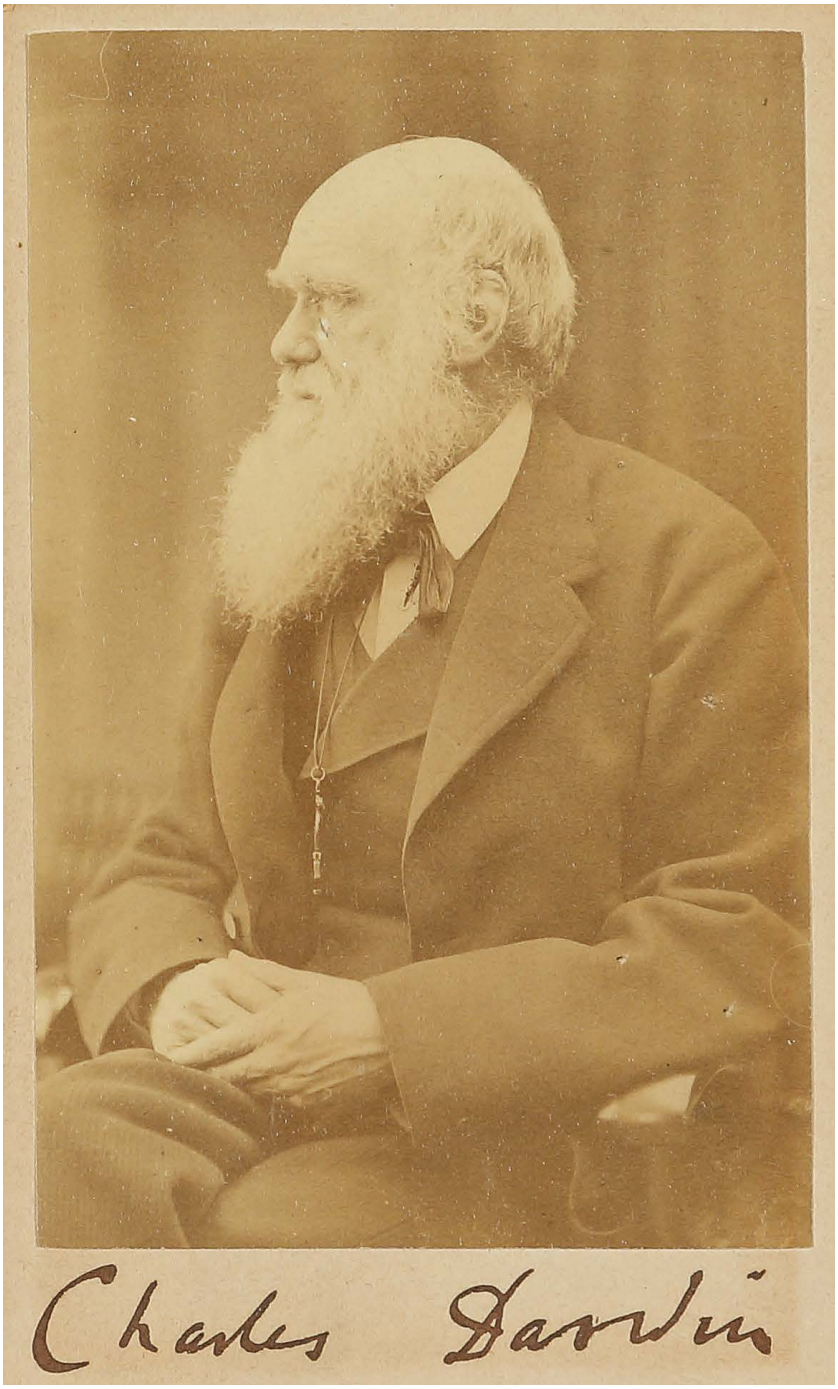
BROWN, ROGAN

Control X3/18, 2018

Hand and laser cut paper with plastic petri dishes, in a custom shadow box, (28 x 43½ inches).

Control X3/18 presents a variety of microbiological organisms separated and contained inside an array of transparent domes. One of the domes has been breached and from it spills a swirling mass of bacteria. On a simple level this sculpture plays with our fear of scientific research. Public attitudes to science are strikingly bipolar, on the one hand we see it as the motor of human progress potentially solving all our problems and advancing and enhancing us as a species; on the other we see the terrible effects that science can wreak upon our world: nuclear and biological weapons, pollution, climate change, environmental devastation.. This piece therefore contains a warning, that we have to beware our own hubris and perhaps accept that we can never be fully in control of nature, something always escapes us, exceeds us...

$ 5,000-7,000



52

52

DARWIN, CHARLES — OSCAR GUSTAVE REJLANDER [PHOTOGRAPHER]

Carte-de-visite, taken by a pioneering Victorian art photographer and collaborator of Charles Darwin's, circa 1871

1 carte-de-visite (image: 2¼ x 3 9/16 in.; 57 x 91 mm, mount: 2½ x 4⅛ in.; 64 x 105 mm), albumen photograph mounted on card, SIGNED by DARWIN on the mount; minor toning.

A REMARKABLE IMAGE OF DARWIN, SIGNED IN FULL "CHARLES DARWIN", TAKEN BY OSCAR GUSTAVE REJLANDER, THE FATHER OF ART PHOTOGRAPHY

The present photograph—showing Darwin seated half-length, with his hands clasped—was taken in 1871, while Darwin was working on *The Expression of the Emotions in Man and Animals* (1872) with Oscar Gustave Rejlander. Rejlander produced nineteen of the thirty photographs that featured throughout the text, posing in many of them himself. It was this collaboration that cemented Rejlander's place in the history of psychiatry and behavioural science.

Darwin was a photography enthusiast, and sat for many portraits over the course of his life. It was around 1869, however, that he began to grow weary of photographic studios soliciting him. Perhaps ironically it was also at this point that he began what would be his only his only large-scale photographic experiment. The theme of expression had long held interest for Darwin—indeed, he first started paying particular attention to the physical display of emotion through observing how his own children reacted to various stimuli. Over the course of several years, Darwin pursued and developed this preoccupation, employing his vast network of correspondents as he asked friends and colleagues to send images and descriptions of the representation of emotions. One of his correspondents was Oscar Rejlander, who, at the time, was already well-known in London. Over the course of their collaboration, Rejlander made some portraits of Darwin. Darwin then deemed these "The best photographs of me".

REFERENCES

Darwin Correspondence Project: "Darwin's Photographic Portraits," accessed on 14 October 2017, https://www.darwinproject.ac.uk/people/about-darwin/darwin-s-photographic-portraits

$ 15,000-20,000

53

BABBAGE, CHARLES; [FARADAY, MICHAEL]

Observations on the Temple of Serapis at Pozzuoli near Naples, with an attempt to explain the causes of the frequent elevation and depression of large portions of the earth's surface in remote periods, and to prove that those causes continue in action at the present time. With a supplement. Conjectures on the physical condition of the surface of the moon. London: Privately Printed [by Richard and John Taylor for the Author], 1847

8vo (222 x 135 mm), with 2 double-page lithographed plates (one hand-colored), and 4pp. advertisements at end. Original red cloth gilt; cloth somewhat soiled and discolored, corners bumped, front cover almost detached, but holding, losses to spine. First page of advertisements browned.

FIRST EDITION, PRESENTATION COPY, inscribed by Babbage to the British Scientist Michael Faraday: "To M. Faraday Esquire with the Author's regards". Michael Faraday and Charles Babbage enjoyed a long personal friendship, and were closely linked by their scientific interests and wide circle of friends.

Charles Babbage, often referred to as the "Father of Computing," is credited with inventing the first mechanical computer, as well as with originating the concept of a programmable digital computer. Conceived in 1821, his *Difference Engine No. 1,* based on the mathematical principle of finite differences, and designed to tabulate and calculate polynomial functions, was the first complete design for an automatic calculating engine. *His Analytical Engine*, conceived in 1834, was a much more ambitious general-purpose programmable computing engine.

REFERENCES

See: K. K. Schwarz. "Faraday and Babbage." *Notes and Records of the Royal Society of London*, Vol. 56, No. 3 (Sep., 2002), pp. 367-38

PROVENANCE

Robert Damon (English conchologist and geologist, bookplate)

$ 2,000-3,000

54

PASTEUR, LOUIS

"*Mr. Pasteur dans son Laboratoire*"

Albumen cabinet card by Adolphe Braun (164 x 108 mm), bearing the printed caption: "*A. Edelfelt | Mr. Pasteur dans son Laboratoire | No. 2767 | Ad. Braun et Cie.*" Verso printed: "*Le même sujet en grand et moyen format. Tir au charbon, procédé inaltérable. 15 et 6 francs.*" Some minor adhesive residue to verso.

INSCRIBED and SIGNED: "*A monsieur la député Siegfried ... tres sympathique souvenir, L. Pasteur.*"

Pasteur is shown here in his laboratory in the rue d'Ulm, in the midst of his experimental apparatus. He is holding a jar containing the spinal cord of a rabbit infected with rabies which he used to develop a vaccine against rabies. This photograph served as the basis for Albert Edelfelt's 1885 oil painting of Pasteur, which is held at the Musée d'Orsay.

$ 2,500-3,500

55

[THOMAS ALVA EDISON]

Thomas Alva Edison's Laboratory Compound Enshrined. One the Golden Anniversary of the Incandescent Lamp. *[Dearborn, Michigan]: Privately Printed for the Ford Museum, 21 October 1929*

Oblong album (9½ x 12 in.), 27 silver gelatin photographs (8 x 10 in.) mounted onto leaves with printed text captions facing each photograph, index at rear; brown morocco gilt with pink silk paste-downs. Some scattered foxing to a few photographs; binding somewhat rubbed.

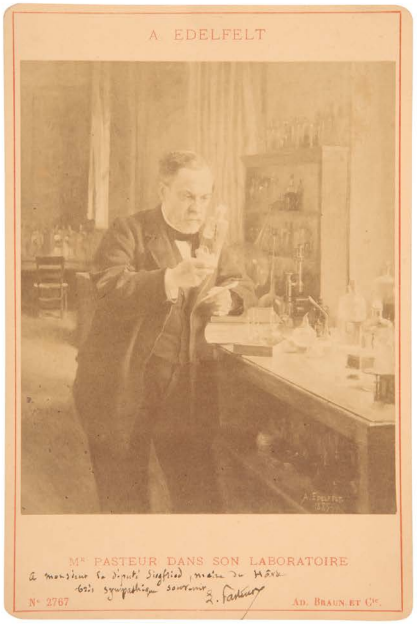
A PHOTO ALBUM COMMEMORATING "LIGHT'S GOLDEN JUBILEE" AT THE HENRY FORD INDUSTRIAL MUSEUM, FEATURING PHOTOGRAPHS OF THOMAS EDISON, HENRY FORD, AND HERBERT HOOVER

Light's Golden Jubilee was a celebration held in Dearborn, Michigan at the Henry Ford Museum to commemorate the the 50th anniversary of Thomas Edison's incandescent light bulb. The celebration was held on 21 October 1929, (just days before the stock market crash of 1929) and counted Thomas Edison, Henry Ford, Andrew Mellon, George Eastman, John D. Rockefeller, and President Herbert Hoover in attendance.

In addition to the Jubilee, the photographs included in this album show Edison's Menlo Park compound in its reconstituted form in Dearborn, Michigan (reconstructed under the auspices of Ford). Numerous photographs feature Ford and Francis Jehl, with a few appearances from President Herbert Hoover, and Thomas A. Edison himself.

$ 3,000-5,000

53



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56

[ALBERT EINSTEIN]

The Holy Bible. New York: Thomas Nelson & Sons, [circa 1930]

8vo. On India paper; some minor foxing to endleaves, SIGNED ("A. Einstein") and INSCRIBED in German BY EINSTEIN and his wife on front free endpaper, and dated February, 1932. Limp black leatherette, upper cover and spine gilt lettered, edges stained red; some foxing to fore-edge. House in half black morocco clamshell case, spine gilt lettered.

THE ONLY BIBLE SIGNED AND INSCRIBED BY EINSTEIN TO BE OFFERED AT AUCTION. ON FRONT FREE ENDPAPER, EINSTEIN HAS WRITTEN: *"DIES BUCH IST EINE [?]SCHÖNSFLICHE GUELLE DER LEBENSWEISHEIT UND DES TROSTES. LESEN SIE OFT DARINN UND GESCHENKEN SIE DABEI / IHREN / A. EINSTEIN."*

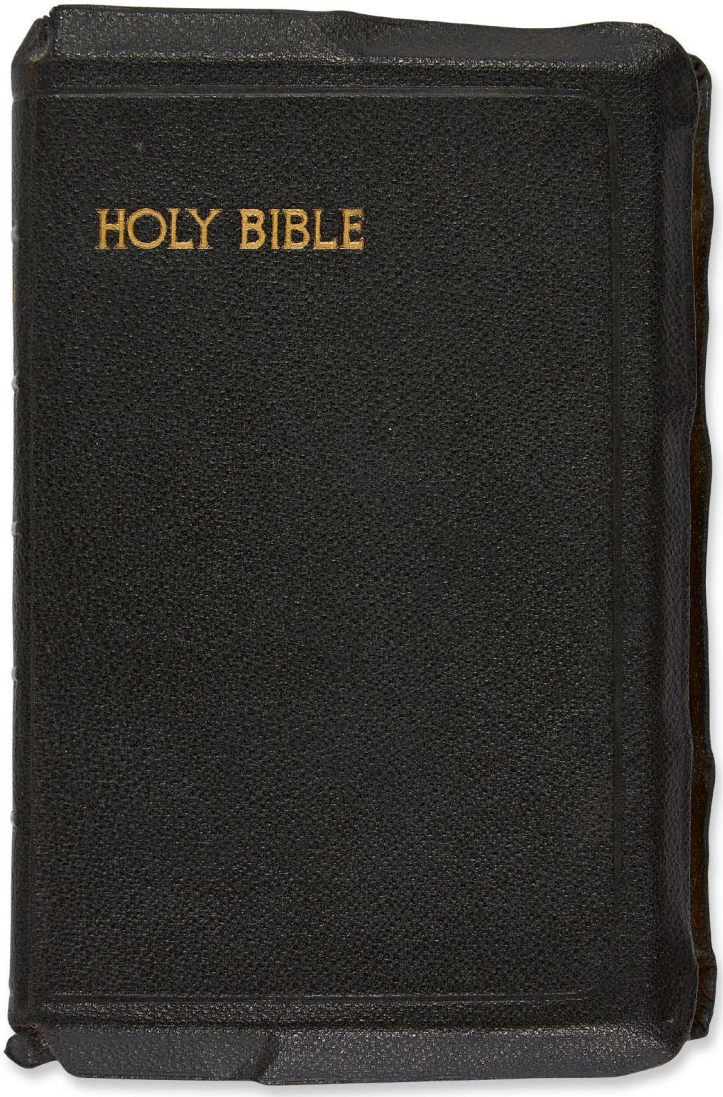
PROVENANCE

Harriet F. Hamilton (gift inscription) — Bonhams, New York (25-26 June 2013, lot 3171)

$ 200,000-300,000

"This book is an inexhaustible source of living wisdom and consolation. Read therein and think thereon."

A. Einstein



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As the world's most famous scientist, Einstein was often asked to make public pronouncements about God and religion. Prominently involved in the public debate about "Religion and Science" in the 1930s (and after), Einstein is known to have professed a "cosmic religion" and a disbelief in a personal God. But because Einstein would not publicly engage with sensitive religious questions that he felt were too highly charged, many of Einstein's most significant statements on god and religion were in fact made only in private circumstances – as here. On many important religious topics, therefore, Einstein's full position remains publicly unknown. This is very certainly the case with regard to his view of the Bible.

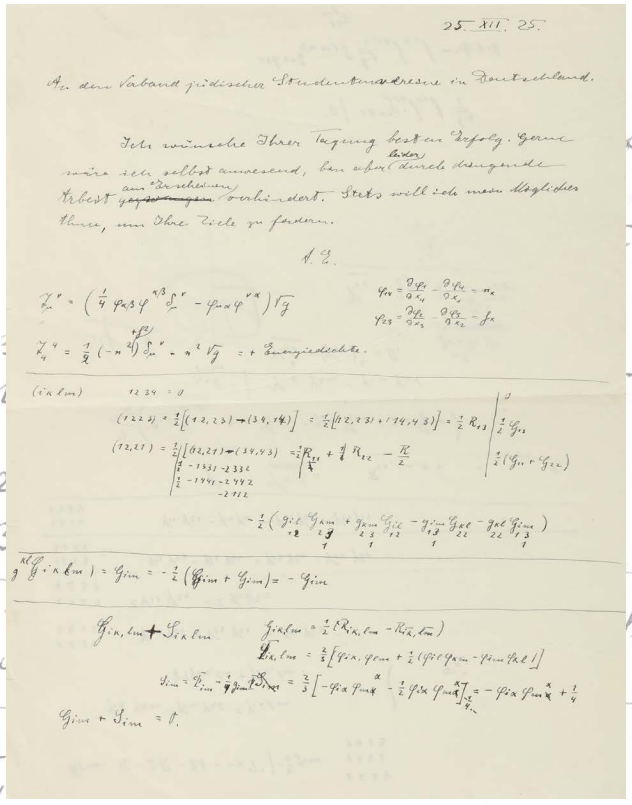
Einstein's inscription in this bible significantly alters our understanding of his view of the bible. The Bible was, in truth, one of Einstein's favorite book — he affirmed as much in a private 1926 letter to his sister Maja (in which he also cited *Don Quixote* as a beloved narrative). But because the public record of Einstein's view of the Bible is otherwise exceedingly slim, our understanding of his view has in large measure been shaped—or perhaps misshaped—by a single private statement Einstein made to author Eric (or Erik) Gutkind in a 1954 letter. Writing Gutkind about his recently published book on Judaism, *Choose Life* (1952), Einstein very candidly stated: "the Bible [is] a collection of honorable, but still primitive legends which are nevertheless pretty childish.... For me the Jewish religion like all other religions is an incarnation of the most childish superstitions." These remarks—which seemingly paint Einstein as man standing in opposition to the Bible—have been repeatedly offered as his definitive view of the text. By contrast, the present volume evidences Einstein's respect—and arguably even reverence—for the Bible. Rather than declaring the Bible to be a collection of childish and primitive legends, this statement presents it as a work of "inexhaustible" depth. The inscription present here offers a powerful counterpoint to the Gutkind letter, and opens new channels for thought and debate regarding Einstein's views OF the Bible, Judaism, and religion in general.

The present Bible was given to Harriet Hamilton by Einstein and his wife, Elsa, in 1932. The Einsteins visited Caltech during the winters in the early 1930s, and it would seem that during this period Hamilton temporarily served as Elsa's—and possibly Albert's—secretary. Given this, it is likely that the Bible, gifted to Hamilton in February 1932, was A gesture of appreciation, extended to an employee for whom the couple displayed an obvious fondness.

A REMARKABLE ASSOCIATION ITEM, AFFIRMATIVELY LINKING ONE OF HISTORY'S GREATEST PHYSICISTS WITH ONE OF ITS MOST REVERED TEXTS

Zum treuen
Gedenken
und mit Dank für
sch viel Liebes
Elsa Einstein
Neudorf Febr. 32

Dies Buch ist eine unerschöpfliche
Quelle der Lebensweisheit und
des Trostes. Lesen Sie oft darin
und gedenken Sie dabei
Ihres
A. Einstein.



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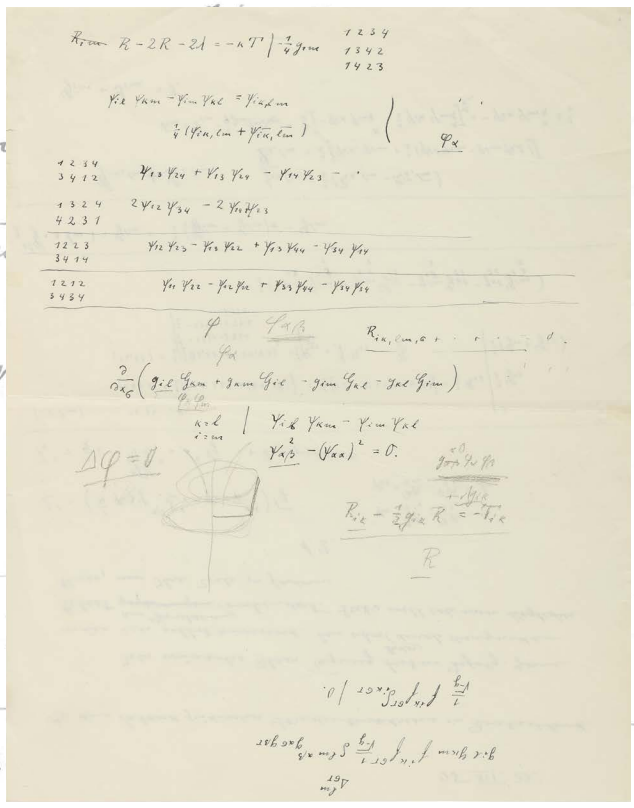

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57

EINSTEIN, ALBERT

Autograph manuscript signed, on General Relativity, [Berlin], 25 December 1925

2 pages (11 x 8⅝ in.), mathematical calculations, with a graphic representation of field lines and vectors written recto and verso on a single sheet, SIGNED "AE"; creases where previously folded.

AN EARLY WORK BY EINSTEIN ON GENERAL RELATIVITY

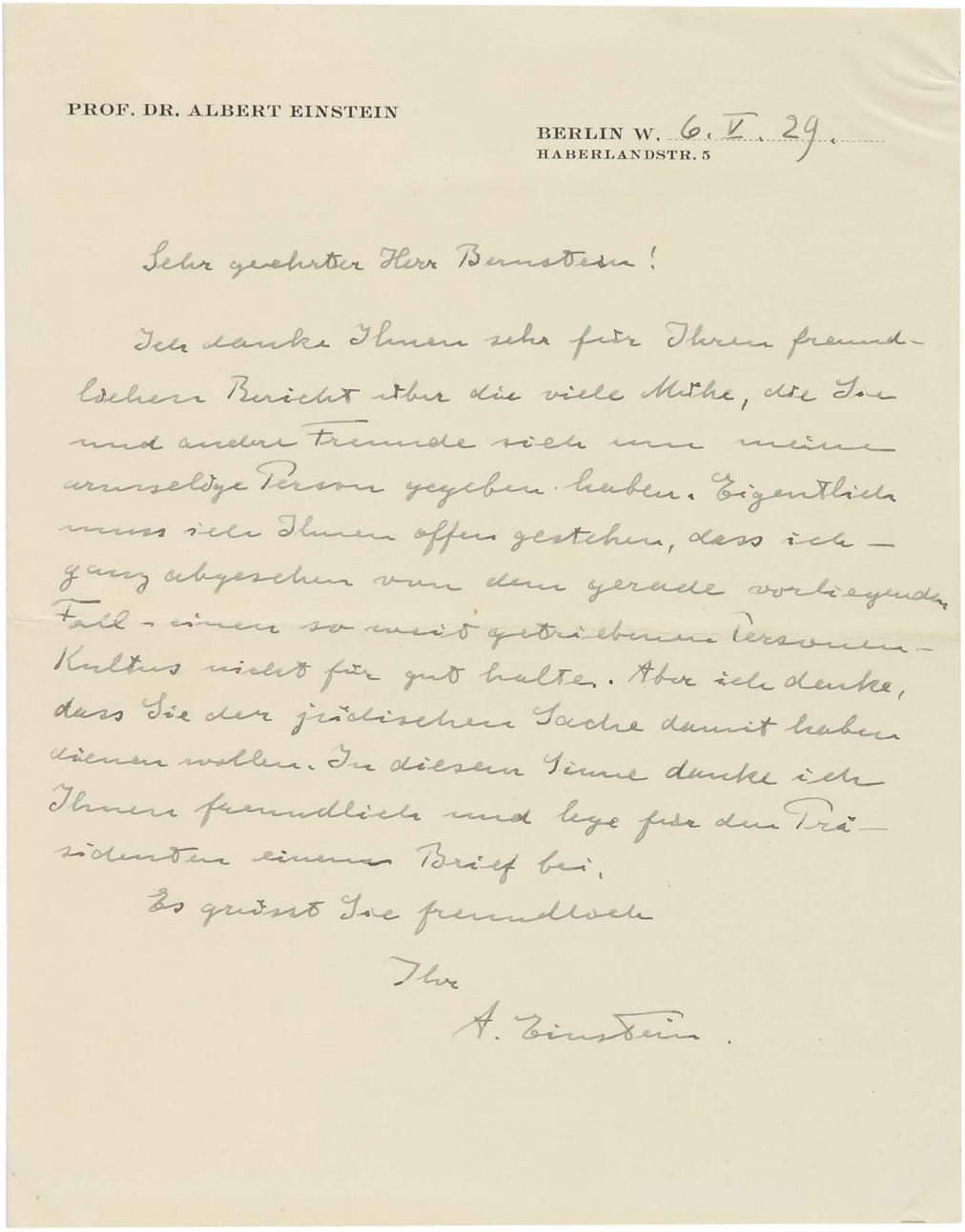
In 1925 Einstein was working on the problem of motion in General Relativity, and also in the early days of his work on unified field theory. Here, Einstein has used a mostly empty page for the purposes of recording his own research notes, which came to from the essence of his 1927 paper "Über die formale Beziehung des Riemannschen Krümmungstensors zu den Feldgleichungen der Gravitation" (*Mathematische Annalen*. 97, pp. 99-103). This paper appeared in a special issue of *Mathematische Annalen*, honoring the centenary of the birth of the mathematician Bernhard Riemann. Riemann's work was, of course, essential to the development of General Relativity, and the article discusses the role of the Riemann tensor in physics in determining the gravitational field.

The present notes were made in the same year as Einstein's pioneering "Einheitliche Feldtheorie von Gravitation und Elektrizitat"—his "first truly deep immersion" in unified field theory—was published. In the material offered here, Einstein utilizes the field equations of General Relativity and introduces a new tensor — *Rim - R/4gim* — which he considers of deeper significance for the law of gravitation. Einstein shows that the anti-symmetric component of the Riemannian curvature tensor will vanish when the tensor *Rim - R/4gim* vanishes. Einstein then proceeds to construct from the electromagnetic tensor a new energy tensor whose symmetry properties are the same as the Riemannian curvature tensor — thus producing an "electromagnetically enhanced curvature tensor" (in Einstein's words here).

Atop the recto of this manuscript, Einstein has composed a letter to the Union of Jewish Student Societies in Germany, in which he indicates: "I will always do whatever is possible in order to promote your goals." Einstein, however, excuses himself from attending their current conference in person due to "urgent work" (later rephrased to "urgent matters").

Sotheby's would like to thank Dan Kennefick and Diana K. Buchwald of Caltech for their assistance with cataloguing of this manuscript.

$ 60,000-90,000



PROF. DR. ALBERT EINSTEIN

BERLIN W. 6. V. 29.
HABERLANDSTR. 5

Sehr geehrter Herr Bernstein!

Ich danke Ihnen sehr für Ihren freundlichen Bericht über die viele Mühe, die Sie und andere Freunde sich um meine unselige Person gegeben haben. Eigentlich muss ich Ihnen offen gestehen, dass ich – ganz abgesehen von dem gerade vorliegenden Fall – einen so viel getriebenen Personen-Kultus nicht für gut halte. Aber ich denke, dass Sie der jüdischen Sache damit haben dienen wollen. In diesem Sinne danke ich Ihnen freundlich und lege für den Präsidenten einen Brief bei.

Es grüsst Sie freundlich

Ihr

A. Einstein.

58

58

EINSTEIN, ALBERT

Autograph letter signed to Herman Bernstein, Berlin, Germany, 6 May 1929

1 page (5⅞ x 7⅜ in.), signed "A. Einstein," in German, on personal stationary, printed with the address of Einstein's study, Haberlandstrasse 5, in Berlin.

An important letter, in which Einstein states his disapproval of the "cult of personality" built up around him.

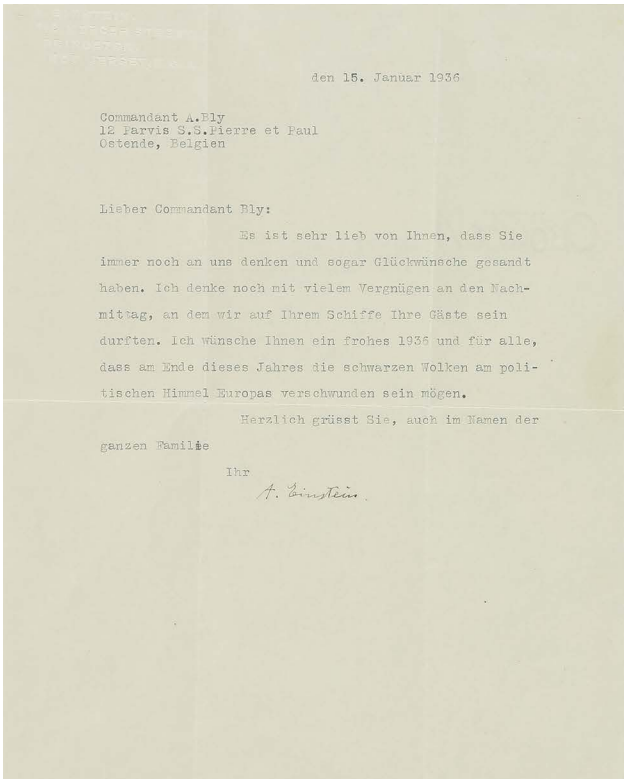
Einstein's 50th birthday was celebrated worldwide in 1929 with great fanfare. In the US, an event was held at the Metropolitan Opera House on April 16, 1929, where many celebratory pronouncements were made by dignitaries from all fields. Herman Bernstein was the chairman of the U.S. celebration of Einstein's 50th birthday.

In historical perspective, 1929 seems to mark the highpoint of Einstein's public fame. Recognized internationally for his scientific genius, Einstein was arguably the world's most famous man in 1929. It is in such a context of fame that Einstein's 50th birthday celebration was planned and that the present letter was written.

Despite his great fame, Einstein remained a modest and private man. In this important letter written at the height of Einstein's fame, Einstein here asserts that he does not approve of the "cult of personality" built up around him. But Einstein nonetheless condones it in the given circumstance, as the intention was to do honor to the Jewish people.

A HANDSOMELY WRITTEN LETTER. NOT FORMALLY PUBLISHED.

$ 30,000-40,000



den 15. Januar 1936

Commandant A.Bly
12 Parvis S.S.Pierre et Paul
Ostende, Belgien

Lieber Commandant Bly:

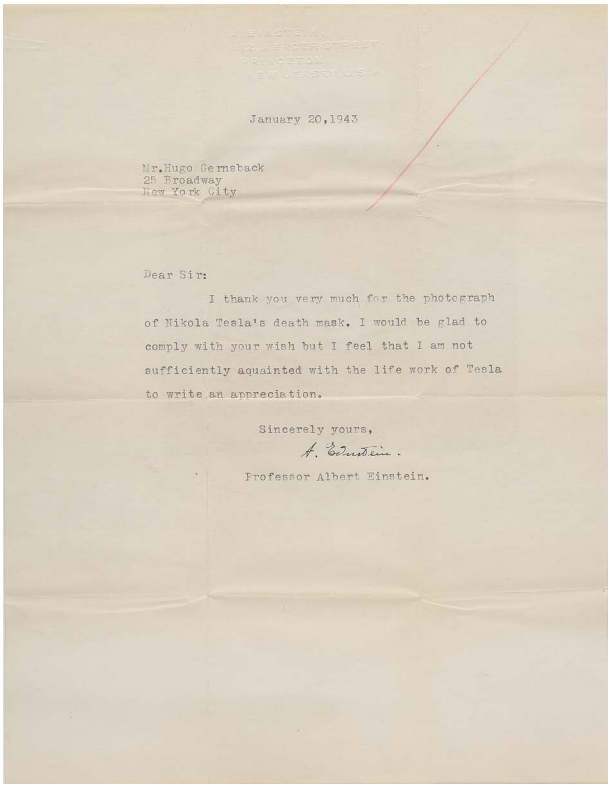
Es ist sehr lieb von Ihnen, dass Sie immer noch an uns denken und sogar Glückwünsche gesandt haben. Ich denke noch mit vielem Vergnügen an den Nachmittag, an dem wir auf Ihrem Schiffe Ihre Gäste sein durften. Ich wünsche Ihnen ein frohes 1936 und für alle, dass am Ende dieses Jahres die schwarzen Wolken am politischen Himmel Europas verschwunden sein mögen.

Herzlich grüsst Sie, auch im Namen der ganzen Familie

Ihr

A. Einstein

59



January 20,1943

Mr.Hugo Gernsback
25 Broadway
New York City

Dear Sir:

I thank you very much for the photograph of Nikola Tesla's death mask. I would be glad to comply with your wish but I feel that I am not sufficiently aquainted with the life work of Tesla to write an appreciation.

Sincerely yours,

A. Einstein.

Professor Albert Einstein.

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EINSTEIN, ALBERT

Typed letter signed to Commandant A. Bly, Princeton, New Jersey, January 15, 1936

1 page (approximately 11 x 8½ in.) signed "A. Einstein" in German, on blindstamped letterhead stationery; old folds. With black and white photograph (approximately 6⅜ x 4½ in.). Letter and photograph matted, framed, and glazed together.

"IT IS VERY KIND THAT YOU STILL THINK OF US AND EVEN SEND CONGRATULATIONS. I RECALL WITH PLEASURE THE AFTERNOON WHEN WE WERE ALLOWED TO BE YOUR GUESTS ON YOUR SHIP. I WISH FOR YOU A HAPPY 1936 AND FOR EVERYBODY, THAT BY THE END OF THIS YEAR, THE DARK CLOUDS IN THE POLITICAL SKY OF EUROPE MAY DISAPPEAR."

Einstein was visiting the United States when Hitler rose to power in 1933, and did not return to Germany, where he held the post of professor at the Berlin Academy of Sciences. He instead took up the position at the Institute of Advanced Studies in Princeton, New Jersey, where Einstein would remain for the rest of his life.

$ 4,000-6,000

60

EINSTEIN, ALBERT

Typed letter signed to Hugo Gernsback, publisher of the first science fiction magazine, January 20, 1943

1 page (10¾ x 8⅜ in.) signed "A. Einstein in English, on personal stationary blind-stamped with Einstein's home address on Mercer Street, Princeton, NJ; creasing where previously folded, some toning to edges, ink mark in upper margin, not affecting text.

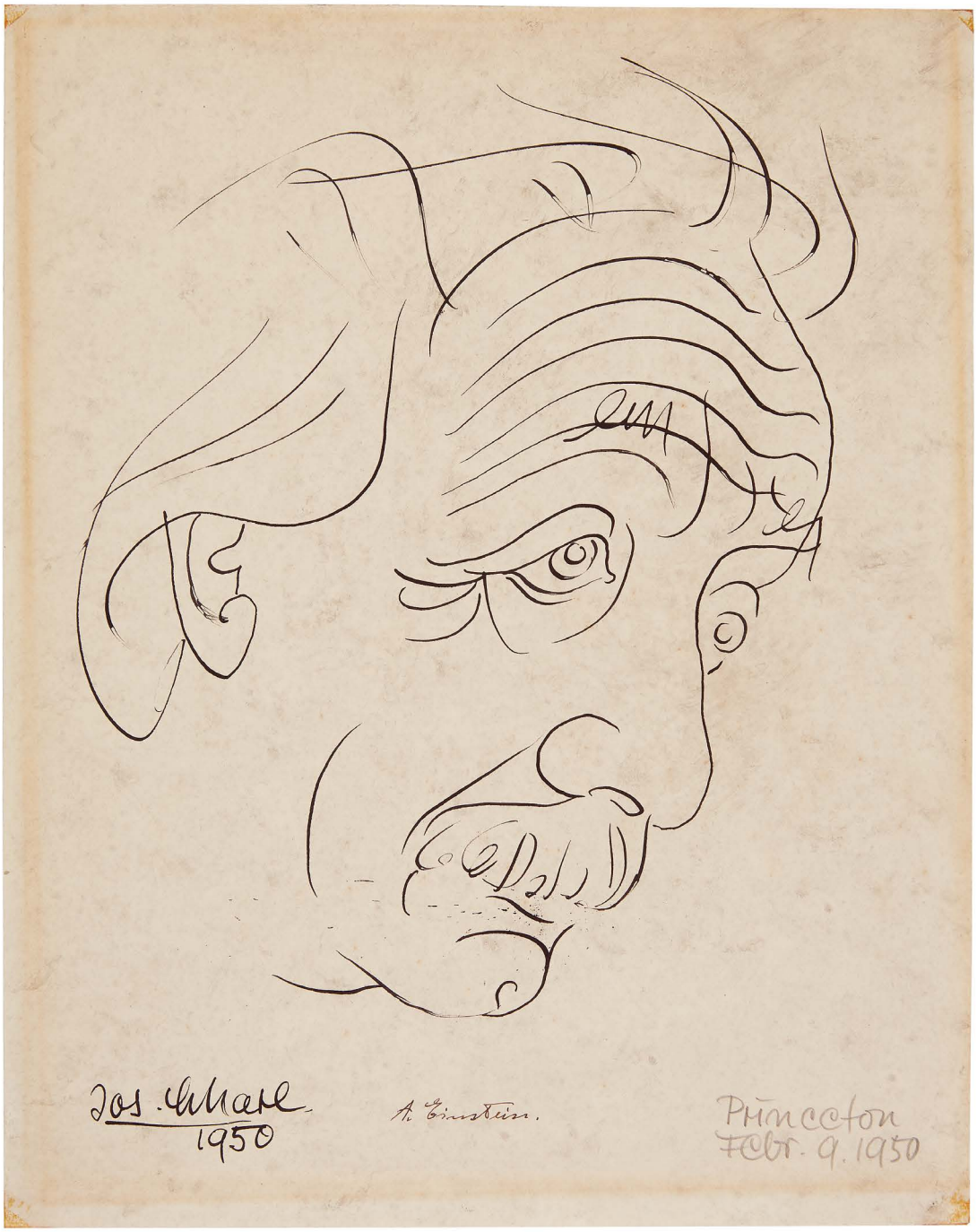
EINSTEIN REPLYING TO A REQUEST OF GERNSBACK'S REGARDING NIKOLA TESLA. Gernsback wrote a series of articles related to Tesla and his inventions. The present letter, dated January 21, 1943, was written less than two weeks after Tesla's death on January 7, 1943, in response to a request of Gernsback's. The letter reads in full:

"Dear Sir:

I thank you very much for the photograph of Nikola Tesla's death mask. I would be glad to comply with your wish But I feel that I am not sufficiently acquainted with the life work of Tesla to write an appreciation."

Tesla's autobiography, *My Inventions* (1919), first appeared as a six-part series in the *Electrical Experimenter*, a magazine published by Hugo Gernsback. The publisher contributed an introduction to the autobiography, and it would seem that his interest in the inventor persisted over the decades.

$ 10,000-15,000



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[EINSTEIN, ALBERT] — JOSEF SCHARL [ILLUSTRATOR]

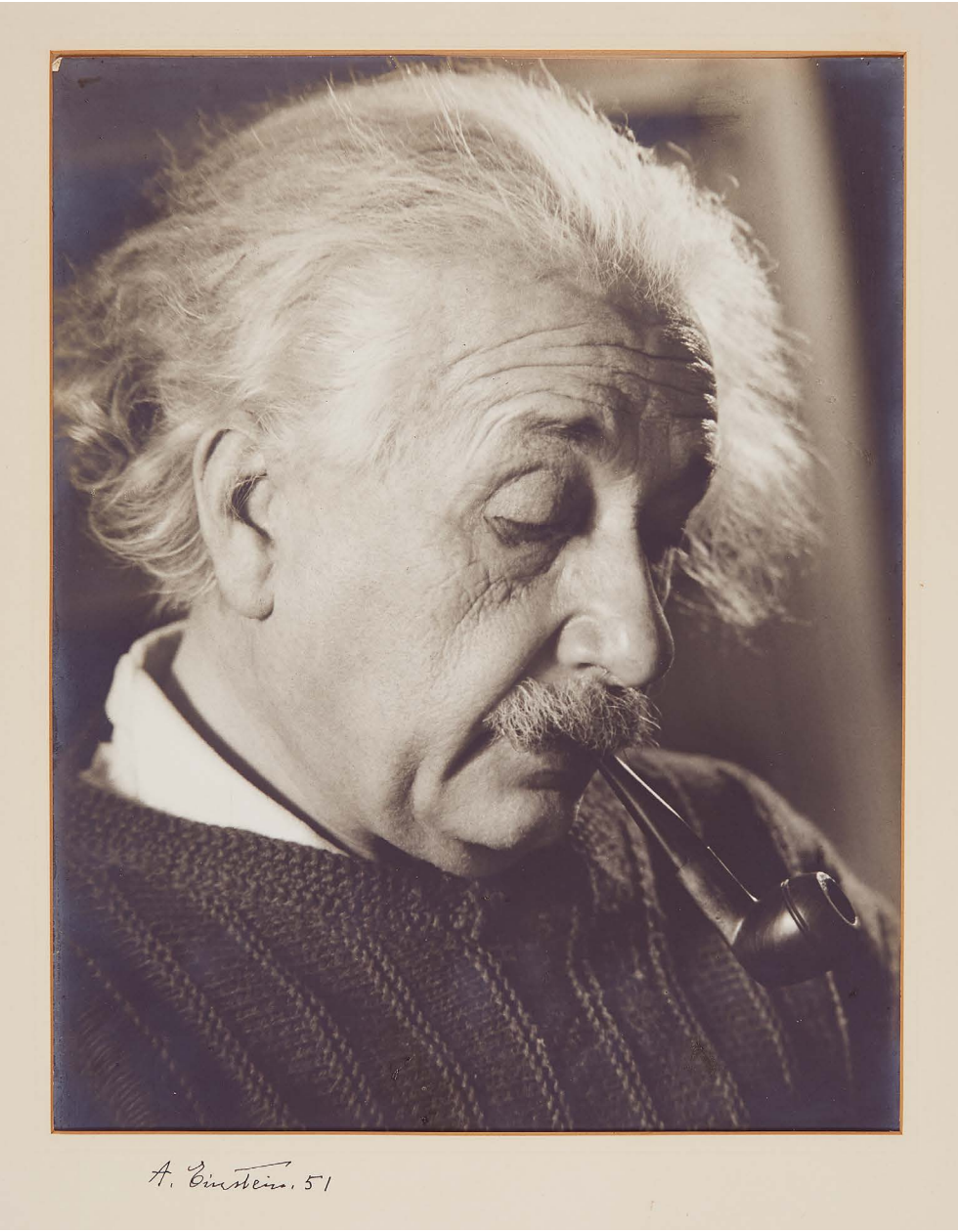
Pen and ink drawing, signed by Einstein and School, Princeton, New Jersey, 9 February 1950

Pen and ink on paper (11½ x 14½ in.; 292 x 368 mm). SIGNED by EINSTEIN ("A. Einstein") and JOSEF SCHARL ("Jos. Scharl 1950") in black ink in the lower margin, matted; some spotting and toning.

A UNIQUE WORK OF ART, SYMPATHETICALLY AND EXPRESSIVELY CAPTURING EINSTEIN'S CHARACTER, SKETCHED BY ONE OF EINSTEIN'S CLOSE AND LONG-TIME FRIENDS.

Einstein and Scharl's friendship stretched back to 1920s Berlin, and when Scharl sought to emigrate to the US after the rise of the Nazi party, Einstein served as his guarantor. Scharl painted and sketched Einstein on a number of occasions, and in 1944 and again in 1946, Einstein sat for Scharl, serving as subject for the latter's oil paintings. In 1950 Scharl made several different pen-and-ink portraits of Einstein, the present image being from that period. In 1966 one of Scharl's portraits of Einstein was used by the US Postal Service for an Einstein commemorative stamp.

$ 15,000-25,000



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[EINSTEIN, ALBERT] — ROMAN VISHNIAC [PHOTOGRAPHER]

Black and white photographic portrait, signed by Einstein on mat

Black and white silver print photograph (photo: 11 x 13¾ in.; 280 x 350 mm, with mat: 16 x 20 in.; 406 x 508 mm). Mounted on board, matted, SIGNED by EINSTEIN ("A. Einstein. 51") in black ink in the lower margin of the mat; one or two small chips to mat, minor toning to edges of photo.

A photographic masterwork — a superb and striking portrait of Einstein deep in thought. Apparently a unique large format copy.

Taken at a 1942 photo session, the present image offers a detailed view of Einstein in semi profile. The 1942 session was a causal affair undertaken at Einstein's Princeton home, where Vishniac discreetly took candid photos of the physicist. This image was originally taken within a fuller context (to include a more prominent background and greater view of Einstein's body), but Vishniac has here masterfully edited it to show ONLY EINSTEIN'S face in more immediate perspective. It is almost certainly the unique copy of this edited image.

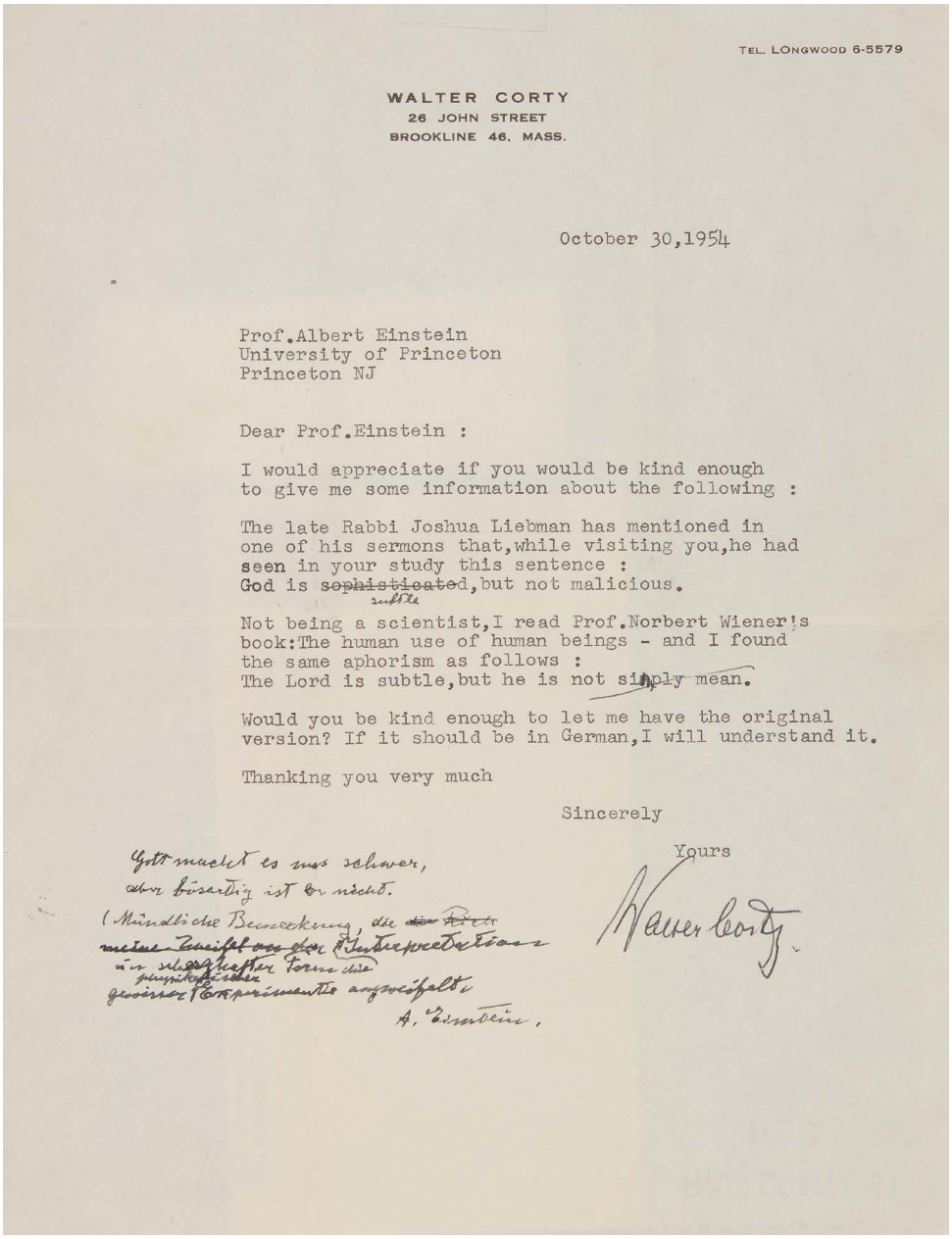
Later in life Vishniac released a portfolio of some seven images from this 1942 session—entitled "Einstein at Work"—which were printed and sold privately by Vishniac himself. An unedited copy of the same image was among the photos included in Vishniac's 1970-80s portfolio "Einstein at Work." The prints in this portfolio measured 10-1/4" x 13-1/4" (image size), and the present photograph is accordingly of an especially large and unique format.

ONE OF THE FINEST PHOTOGRAPHIC PORTRAITS OF EINSTEIN EVER TAKEN – HERE MASTERFULLY EDITED AND PRINTED IN A RARE LARGE FORMAT -- WITH EINSTEIN SIGNATURE PRESENT

$ 40,000-60,000

"Subtle is the Lord,
but malicious
he is not."

Albert Einstein



TEL. LONGWOOD 6-5579

WALTER CORTY
26 JOHN STREET
BROOKLINE 46, MASS.

October 30,1954

Prof.Albert Einstein
University of Princeton
Princeton NJ

Dear Prof.Einstein :

I would appreciate if you would be kind enough
to give me some information about the following :

The late Rabbi Joshua Liebman has mentioned in
one of his sermons that,while visiting you,he had
seen in your study this sentence :
God is ~~sophisticated~~ subtle,but not malicious.

Not being a scientist,I read Prof.Norbert Wiener!s
book:The human use of human beings - and I found
the same aphorism as follows :
The Lord is subtle,but he is not simply mean.

Would you be kind enough to let me have the original
version? If it should be in German,I will understand it.

Thanking you very much

Sincerely

Yours

Walter Corty

Gott macht es was schwer,
aber bösartig ist er nicht.
(Mündliche Bemerkung, die in scherzhafter
meine Zweifel an der Interpretation
in ulkiger Form die
gewisser Experimente anzweifelt
A. Einstein.

63

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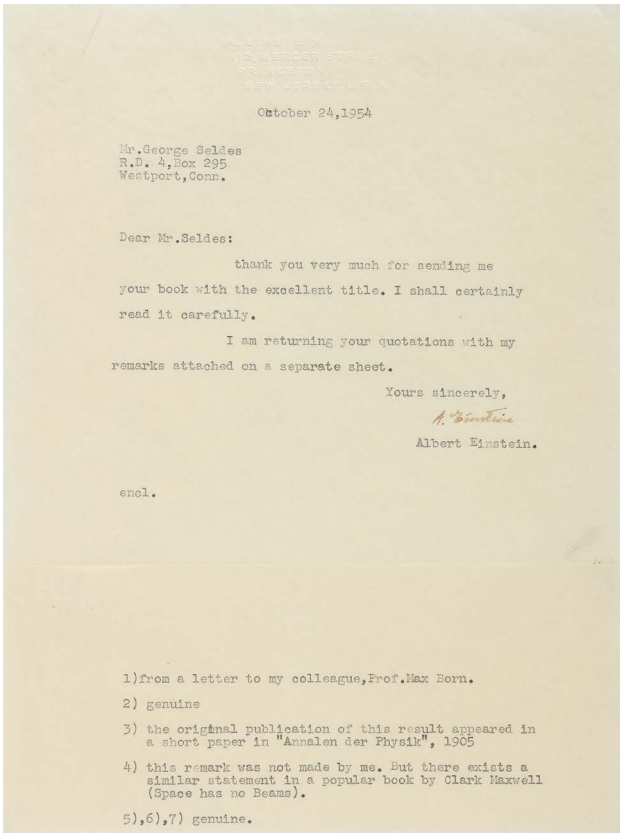
EINSTEIN, ALBERT

Autograph manuscript signed ("A. Einstein"), 1 pp, (8½ x 11 in) in black ink, written on a typed letter signed from Walter Corty to Einstein, in response to Corty's letter, dated October 30, 1954. Together with original cover. Creases where previously folded.

EINSTEIN CONFIRMS THE TRUE FORM OF ONE OF HIS BEST KNOWN AHORISMS, "SUBTLE IS THE LORD, BUT MALICIOUS HE IS NOT. ("Raffini ert ist der Herr Gott, aber boshaft ist er nicht")

Einstein writes in response to a Mr. Walter Corty seeking clarification on the original version of Einstein's famous aphorism, which Einstein said while on a visit to Princeton in 1921. Corty had heard two different versions, "God is sophisticated, but not malicious", and "The Lord is subtle, but he is not simply mean". Einstein immediately pens his response directly onto Corty's letter, additionally crossing out the "sophisticated" in Corty's letter and replacing with "subtle", as well as the "simply" in "simply mean". Einstein's response in German in part: "*Gott macht es was schwer, aber bösartig ist er nicht.*" [God makes it somewhat difficult, but he is not malicious]. He continues "*Mündliche Bemerkung, die in scherzhafter Form die Interpretation gewisser physikalischen Experimente anzweifelt.-A. Einstein*" [Trans: Here's an aside about that saying – In a funny way it questions the interpretation of certain physical experiments.]

$ 10,000-15,000



October 24,1954

Mr.George Seldes
R.D. 4,Box 295
Westport,Conn.

Dear Mr.Seldes:

thank you very much for sending me your book with the excellent title. I shall certainly read it carefully.

I am returning your quotations with my remarks attached on a separate sheet.

Yours sincerely,

A. Einstein

Albert Einstein.

encl.

1)from a letter to my colleague,Prof.Max Born.

2) genuine

3) the original publication of this result appeared in a short paper in "Annalen der Physik", 1905

4) this remark was not made by me. But there exists a similar statement in a popular book by Clark Maxwell (Space has no Beams).

5),6),7) genuine.

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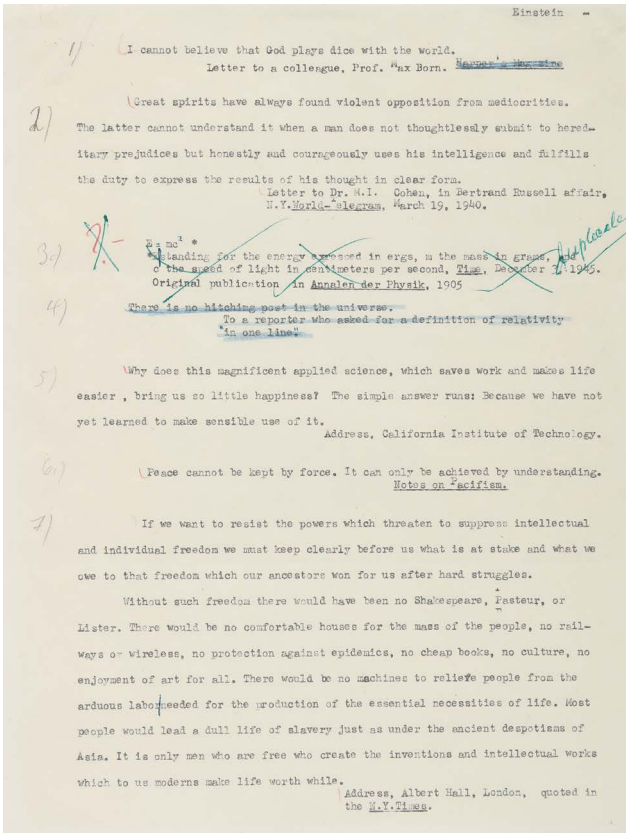

Einstein –

1) I cannot believe that God plays dice with the world.
Letter to a colleague, Prof. Max Born.

2) Great spirits have always found violent opposition from mediocrities. The latter cannot understand it when a man does not thoughtlessly submit to hereditary prejudices but honestly and courageously uses his intelligence and fulfills the duty to express the results of his thought in clear form.
Letter to Dr. M.I. Cohen, in Bertrand Russell affair, N.Y.World-Telegram, March 19, 1940.

3) $E = mc^2$ *
*standing for the energy expressed in ergs, m the mass in grams, and c the speed of light in centimeters per second, Time, December 1, 1945.
Original publication in Annalen der Physik, 1905

4) There is no hitching post in the universe.
To a reporter who asked for a definition of relativity "in one line".

5) Why does this magnificent applied science, which saves work and makes life easier, bring us so little happiness? The simple answer runs: Because we have not yet learned to make sensible use of it.
Address, California Institute of Technology.

6) Peace cannot be kept by force. It can only be achieved by understanding.
Notes on Pacifism.

7) If we want to resist the powers which threaten to suppress intellectual and individual freedom we must keep clearly before us what is at stake and what we owe to that freedom which our ancestors won for us after hard struggles.

Without such freedom there would have been no Shakespeare, Pasteur, or Lister. There would be no comfortable houses for the mass of the people, no railways or wireless, no protection against epidemics, no cheap books, no culture, no enjoyment of art for all. There would be no machines to relieve people from the arduous labor needed for the production of the essential necessities of life. Most people would lead a dull life of slavery just as under the ancient despotisms of Asia. It is only men who are free who create the inventions and intellectual works which to us moderns make life worth while.
Address, Albert Hall, London, quoted in the N.Y.Times.

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"I cannot believe that God plays dice with the world."

Albert Einstein

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EINSTEIN, ALBERT

Typed letter signed to George Seldes, Princeton, New Jersey, 24 October 1954.

1 page (11 x 8 1\2 in.), signed "A. Einstein," in English, on personal stationery blind-stamped with Einstein's home address on Mercer Street, Princeton, NJ; creases where previously folded, some toning. [With]: Additional original typed sheet of content (subsequently pasted by Seldes to the lower blank margin of Einstein's letter), and an annotated carbon which Einstein is returning to the sender; staple holes to second sheet, minor toning.

AN EXCELLENT AND IMPORTANT LETTER DEFINITIVELY AUTHENTICATING SOME OF EINSTEIN'S MOST WELL-KNOWN STATEMENTS.

"Dear Mr. Seldes:" Einstein beings. "thank you very much for sending me your book with the excellent title. I shall certainly read it carefully," he notes, likely referring to Seldes's *Tell the Truth and Run* (1953). "I am returning your quotations with my remarks attached on a separate sheet."

Einstein here writes the noted journalist and author George Seldes, who had contacted him for the purpose of incorporating some of Einstein's statements into his forthcoming book *The Great Quotations* (ultimately published in 1960). In contacting Einstein, Seldes sent along a page of seven statements, the authenticity of which he wished to confirm, including some of Einstein's most famous, including "$E = mc^2$", "I cannot believe that God plays dice with the world", and "Great spirits have always found violent opposition from mediocrities." The other statements concern peace, freedom, applied science, and a specious remark about relativity (which Einstein here denies he ever made—though he suggests James Clerk Maxwell might have made a somewhat similar remark).

In responding to Seldes' queries, Einstein reviewed and marked up the carbon containing the quotes to be authenticated, and then had his answers formally typed on a separate sheet of paper—agreeing to or denying their authenticity, and in some instances Einstein indicates the statement's source. Seldes subsequently trimmed down this typed sheet of responses and pasted it onto the bottom of Einstein's letter.

Seldes' book ultimately contained a good many more Einstein quotations than the seven present here. It therefore would appear that Seldes inquired about seven particular quotations for which he was unfamiliar with the published original source. Seldes acknowledges his correspondence with Einstein in his book.

Written at the end of Einstein's life—he died a few months later—this letter authoritatively validates the great scientist's words for all time.

$ 20,000-30,000

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[HOLOGRAPHY]

Four Holograms: "That's Life," "Marching Band," "New Dimensions in Jet Travel," and "Slalom Skier." St. Charles, Missouri: McDonnell Douglas Electronics Company, 1970-1973

Four image-plane reflection holograms, silver halide emulsion on film (4 x 5 in.), each mounted on cardstock with three identifying labels. Some minor scratches to emulsion, and scattered light discoloration to cardstock.

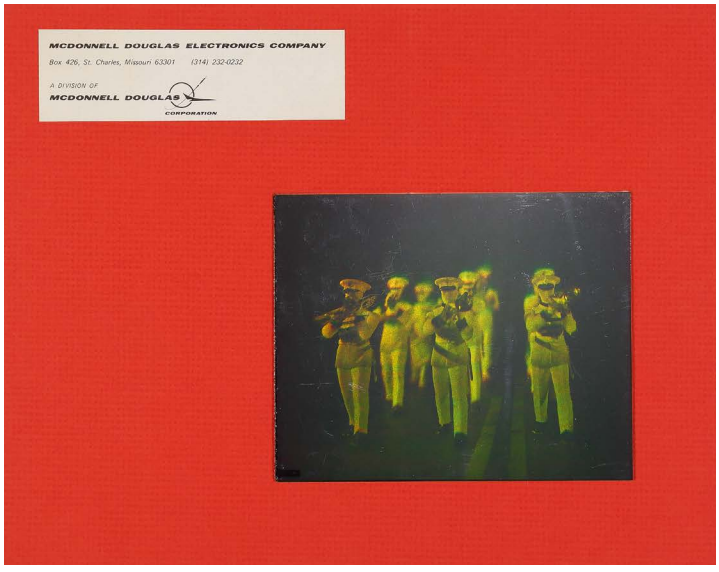
A hologram is a photographic recording of a light field, used to display and view a fully three-dimensional image under diffuse ambient light without the aid of any intermediate optics.

McDonnell Douglas was a major aerospace manufacturing and defense contractor that provided air and spacecraft simulators for the Mercury and Gemini manned space programs. Its subsidiary, McDonnell Douglas Electronics Company, housed a pulsed-laser holography laboratory until 1973, when when the corporation decided that the market for holograms was proving too elusive to pursue any further.

REFERENCES

Holographic Visions: A History of New Science, pp. 161-168, 352.

$ 2,000-4,000



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FEYNMAN, RICHARD

QED: The Strange Theory of Light and Matter. [Preface by Ralph Leighton]. Princeton: Princeton University Press, 1985.

8vo. 158 pp. Publisher's black cloth, with laid endpapers and spine lettered in violet; in a later dust-jacket. A fine copy. INSCRIBED AND SIGNED ON FLY-LEAF "*TO JIM COMPEAU, / WITH GRATITUDE AND BEST WISHES / RALPH / RICHARD.*"

FIRST EDITION, FIRST PRINTING, PRESENTATION COPY, SIGNED BY BOTH FEYNMAN AND LEIGHTON, of Feynman's last book, a vivid exposition of quantum electrodynamics by its greatest master. This was the heart of Feynman's work, and precisely the field in which he'd won his Nobel Prize — that is, for his "fundamental work in quantum electrodynamics, with deep-ploughing consequences for the physics of elementary particles". Distilled from a series of lectures at UCLA in 1983, this book was Feynman's only non-technical account of the subject: Gleick calls it a model of science writing.

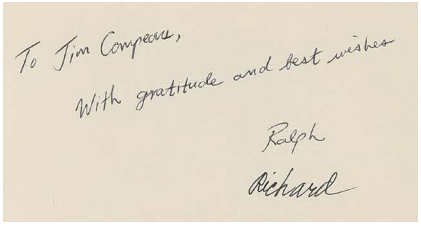
Signed familiarly "*Ralph*" and "*Richard*" — that is, Ralph Leighton and Richard Feynman. First-name signatures of Feynman are excessively rare, this being the only such signed copy on the market in twenty years or more; signed scientific books, rather than copies of his popular memoirs, are themselves excessively rare, this being one of only three examples seen on the market in decades. The recipient was James Lee Compeau (*b.* 1937), the brilliant and original teacher to whom the Feynmans had entrusted their own son.

Jim Compeau was the leading light and "folk hero" of Pasadena's Alternative School — and not unlike Feynman himself, Compeau too was celebrated for "his antagonism toward bureaucracy, his disregard for genteel language, his . . . irreverent political pronouncements, his . . . ridicule of most schooling practice, his tolerance of any behavior from others, his . . . subversiveness within an institutional framework, and his utter unconventionality".

REFERENCES

James Gleick *Genius: The life and science of Richard Feynman* (1992), page 13; P. H. DeTurk *PS 2001: The story of the Pasadena Alternative School* (1974), chapter 9 passim; NB: Leighton's contribution to this book was such that Feynman granted him 23% of his royalties

$ 10,000-15,000



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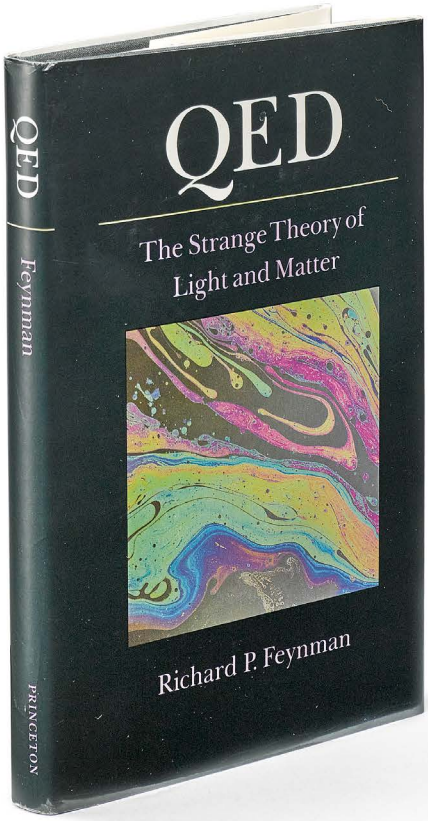

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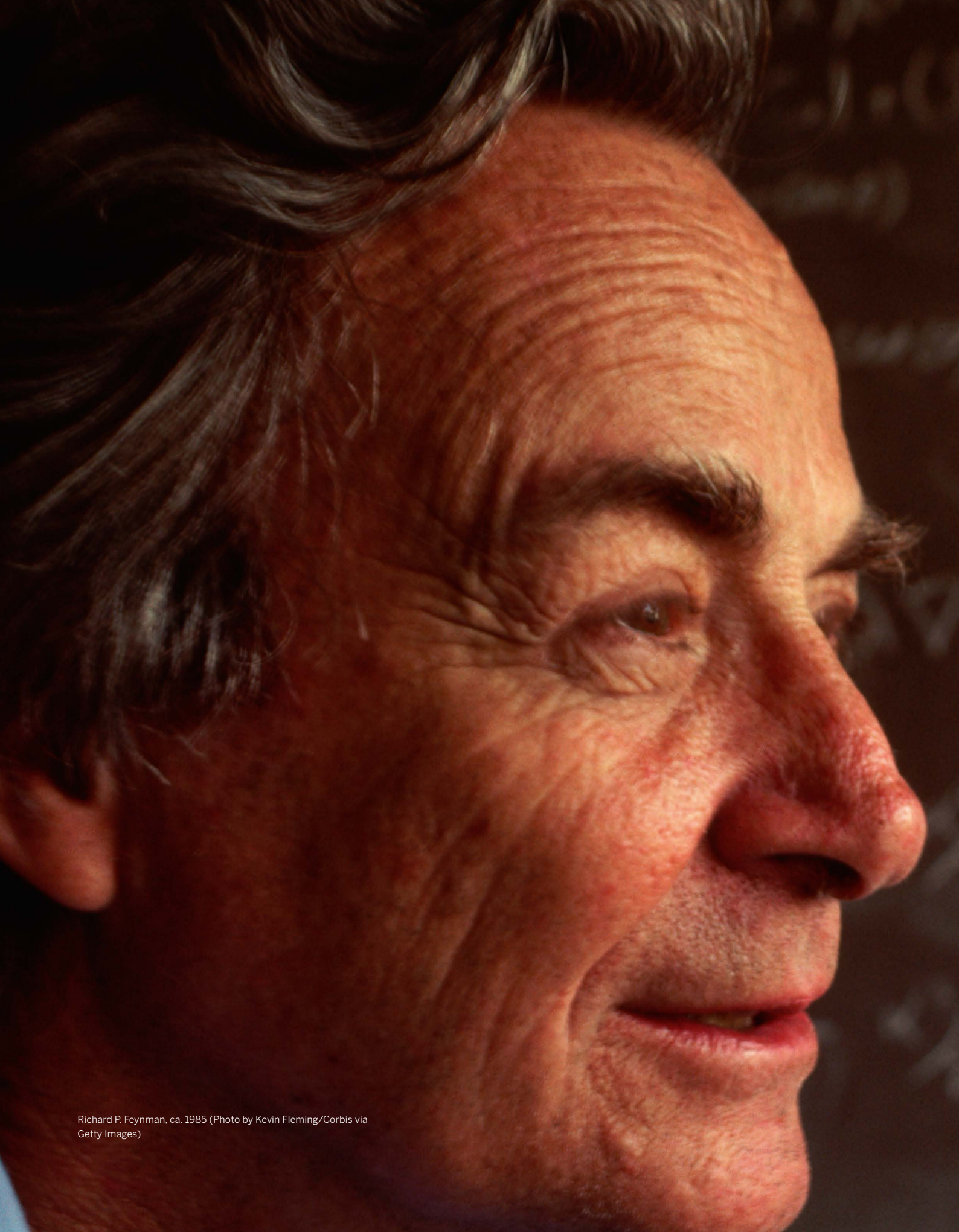
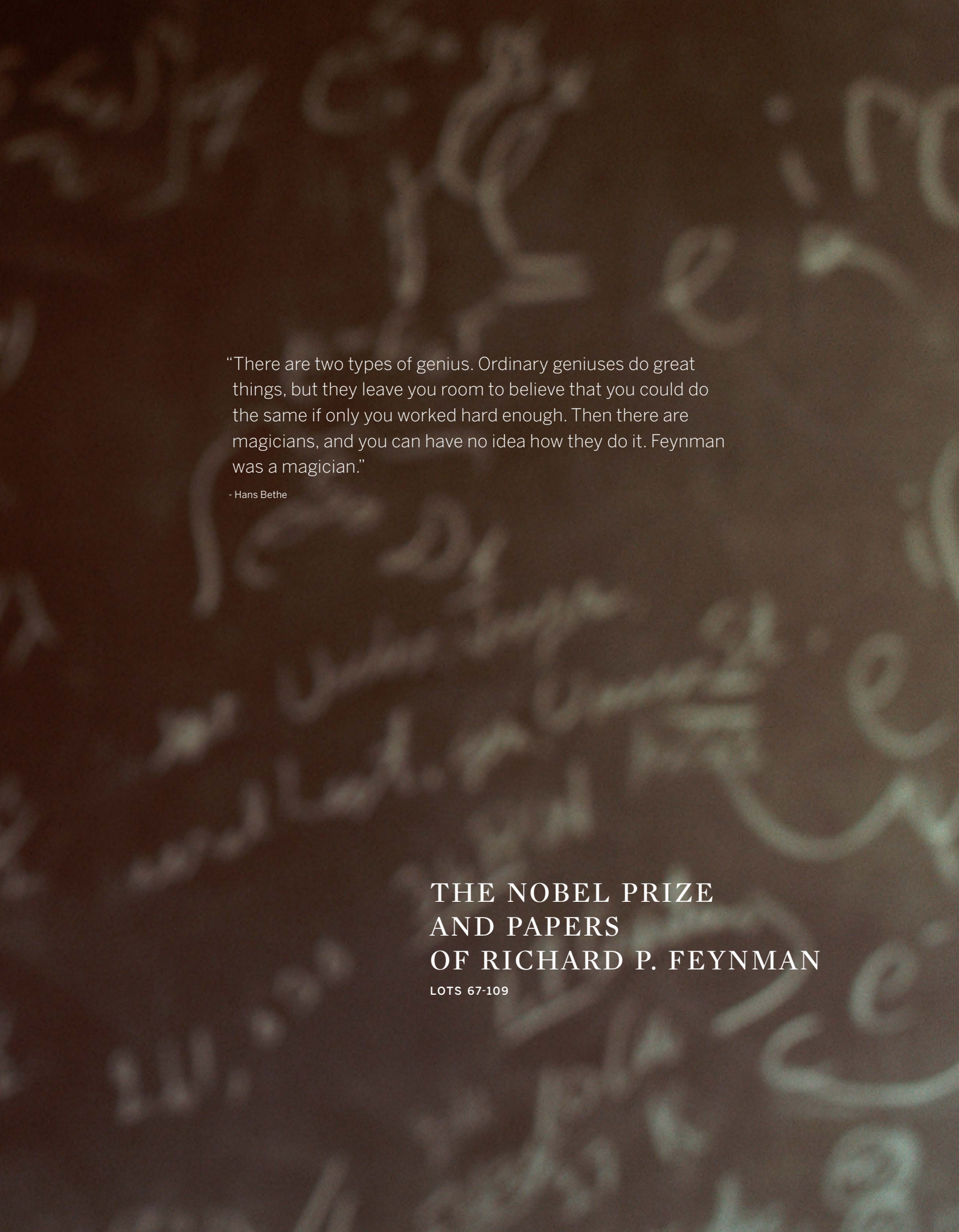


Richard P. Feynman, ca. 1985 (Photo by Kevin Fleming/Corbis via Getty Images)

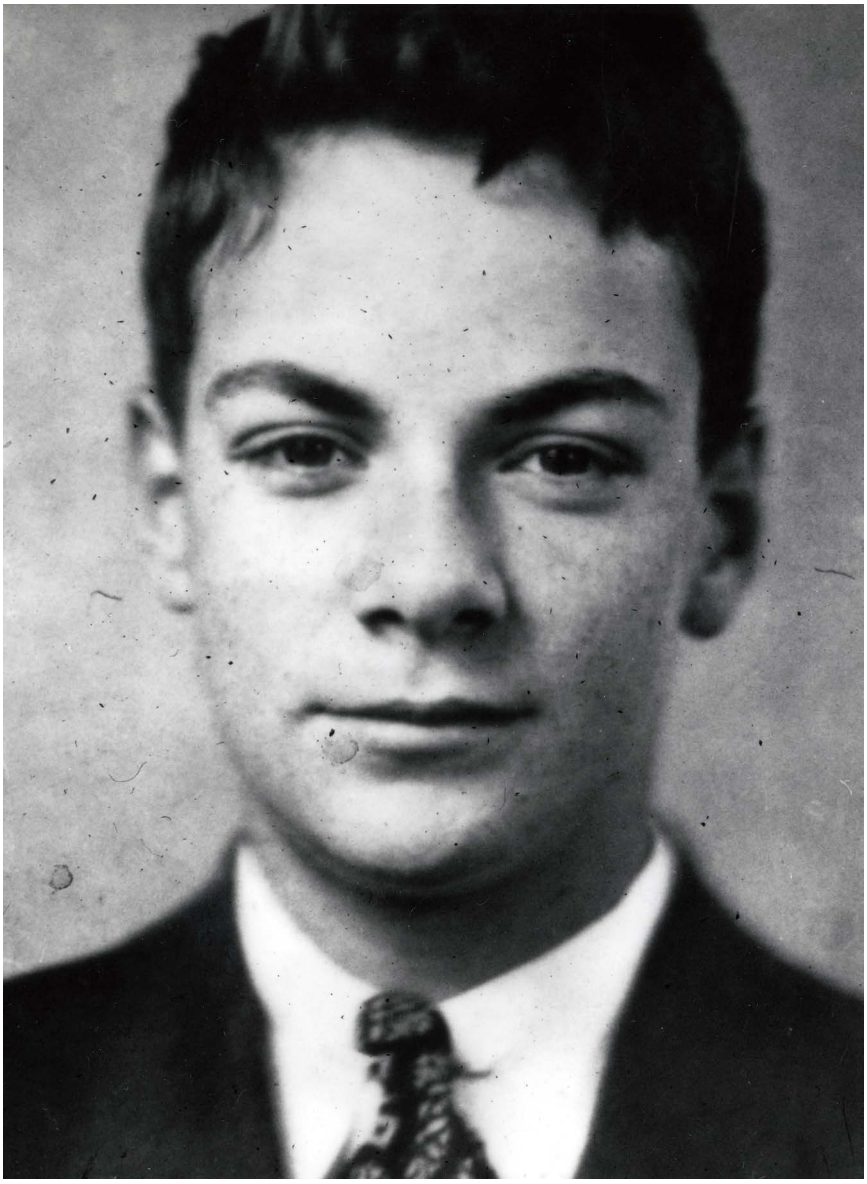


"There are two types of genius. Ordinary geniuses do great things, but they leave you room to believe that you could do the same if only you worked hard enough. Then there are magicians, and you can have no idea how they do it. Feynman was a magician."

- Hans Bethe

THE NOBEL PRIZE AND PAPERS OF RICHARD P. FEYNMAN

LOTS 67-109



Richard P. Feynman in his early years. (Courtesy of the Archives, California Institute of Technology)

BACKSTAGE WITH THE MAGICIAN

TIM HALPIN-HEALY

As with many physicists of my generation, I came to know of Richard Feynman best when, as an advanced undergraduate at Princeton in my first course in quantum field theory, I learned the essentials of quantum electrodynamics (QED) and, following in his and Hans Bethe's tracks, took a stab at the elusive & mysterious Lamb Shift myself. The Princeton Physics Department had long since vacated Fine Hall, where Feynman did his WWII PhD work with Wheeler, but aware that ghosts are slow to leave, I found myself often wandering its halls looking for inspiration, as well as the requisite empty classroom with fresh chalk & a clean blackboard to work through my calculations. The book for this QFT course— a "hot off the press" comprehensive tome on the subject— was way beyond me, much as Dirac's classic *Quantum Mechanics* had been for Feynman as he finished up MIT 40 years earlier. Nonetheless, bolstered by my senior thesis advisor David Gross, as well as courses in elementary particle physics and mathematical methods taught by Frank Wilczek, I came to master the techniques, tools, and grammar of Feynman diagrams. Gross and Wilczek were eventual Nobel Prize winners themselves; indeed, Wilczek

Richard P. Feynman talking to Paul Dirac at Relativity Conference in Warsaw, July 1962. (Courtesy of the Archives, California Institute of Technology)

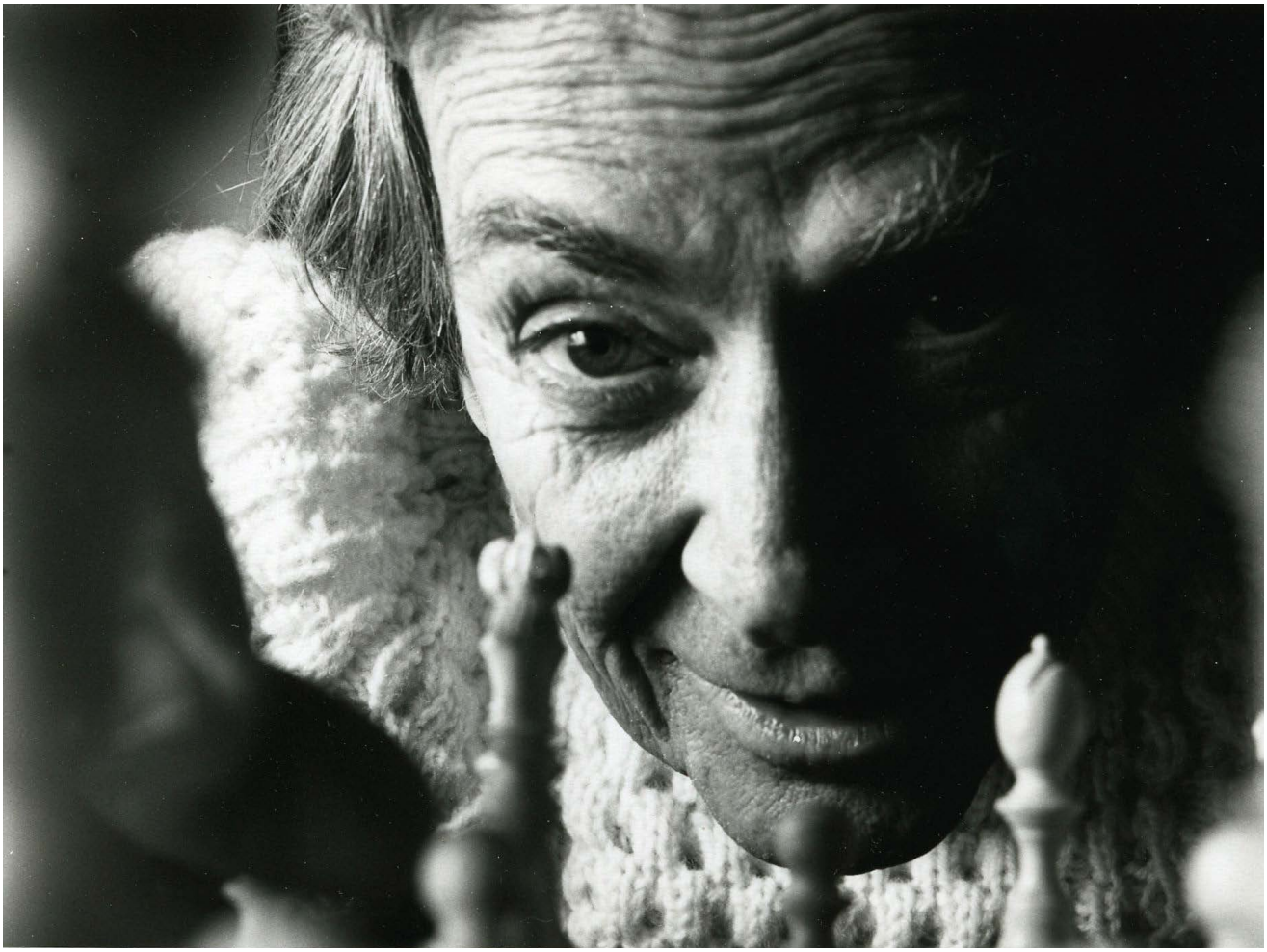
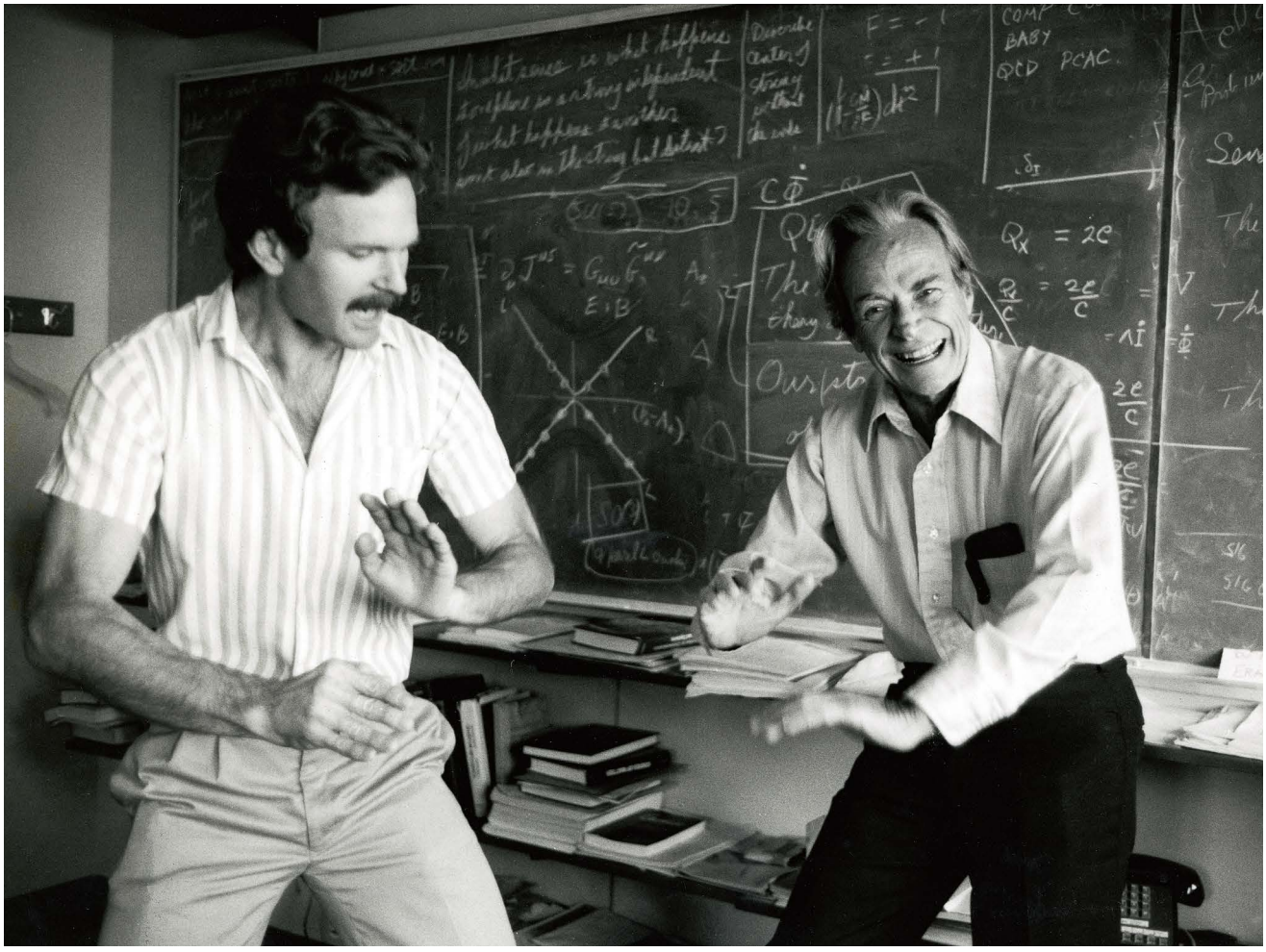


Photo by Michelle Feynman, courtesy of Michelle Feynman

became the second Physics Nobelist from the greater borough of Queens, NYC— Feynman was the first. They were "Legend" of the Princeton of my day, having deciphered the enigmatic particle accelerator experiments of the late 1960s (showing "Bjorken scaling," which played a role in Feynman's own "parton" description of quarks), and emerged with the declaration that non-Abelian gauge field theories were "asymptotically free"; i.e., the strong nuclear forces in play between quarks and gluons, binding the quarks together at low energies, would surprisingly simplify at the very highest energies. This 1970s work in quantum chromodynamics (QCD) was a glorious extrapolation, both spiritually and technically, of Feynman's diagrammatica, which had its own critical gestation 25 years earlier as RPF, along with his fellow QED Nobelist Julian Schwinger, another NYC school kid, sought to transcend the Dirac equation and unravel the Gordian knot that was the Lamb Shift, recently announced at the famous 1947 Shelter Island Conference.

Feynman the man became uber-"Legend," both to the public at large, on account of his popular books—the phenomenal best-seller "*Surely You're Joking, Mr. Feynman!*", as well as his participation in the investigation of the 1986 Challenger tragedy, but also to the much smaller, intimate, and insular physics community proper. Of course, for the latter, its tribal membership well-attuned to the manner and means of the craft, its small abundance of génie ever-present amidst its ranks, and its naturally critical objective gaze, the difficult task of separating the man from the folklore remains a delicate, rather personal bit of business. For one physicist, however,



Richard P. Feynman and Ralph Leighton, ca. 1985 (Courtesy of the Archives, California Institute of Technology)

sifting through Feynman's papers—here running the gamut from advanced quantum mechanics, solid-state and low-temperature physics, QED, QCD and elementary particle theory, biochemistry, nanotechnology, cryptography and coding—allowed an extraordinary glimpse into the man, far beyond the legend.

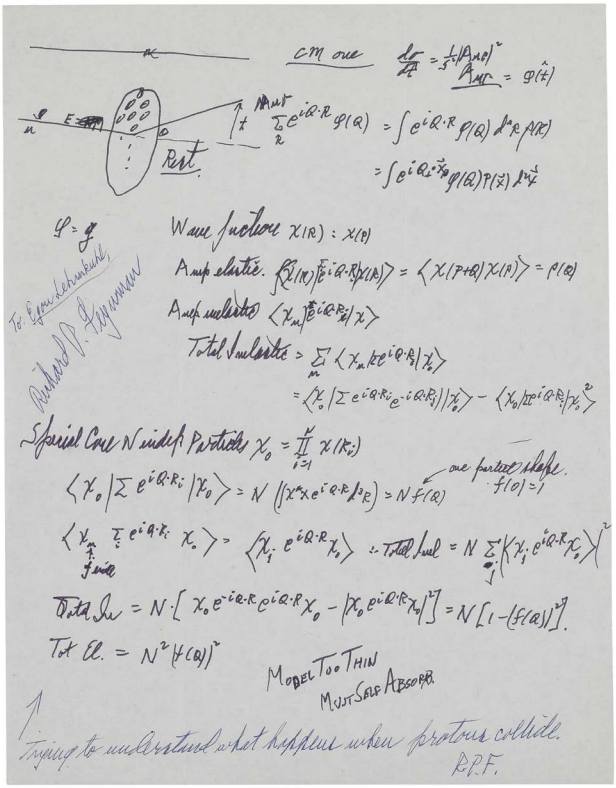
Nevertheless, truth be told, I had actually come in search of Feynman the boy—the young kid from Far Rockaway, Queens, who, with the blessing of his gifted High School teacher Mr. Bader, found his way to MIT and began to ascend his own Everest with Dirac's *Quantum Mechanics* well in hand, though not well understood, and reached the summit a mere decade later, having dispatched the Lamb Shift, along with other Herculean calculational tasks of QED, and revolutionized physics with his creative path integral formulation of quantum mechanics. He had taught us to sum over all possible histories, but his own made a singular, extremal contribution. Yet, as is clear from the manuscripts and his wonderful books herein, the boy remained forever in the man. As one who had revered Feynman in his youth, but accidentally came to consult on this special auction sale, I suddenly found myself backstage, sitting quietly with the young wizard who had become a great magician.*

-Tim Halpin-Healy, Physics Dept, Barnard College, Columbia University.

**To see it all in plain view, grab a cup of coffee, & settle in to the first 3 minutes of RPF's BBC interview from the 70's- www.tinyurl.com/RPFBBC. Best to watch from the start, though. Chhh, Chhh... Caltech notwithstanding, the guy's definitely from Queens; as a local, I can attest that.*

SEARCHING FOR FEYNMAN

CASSANDRA HATTON



FEYNMAN, RICHARD. Autograph manuscript signed, on proton collision. Sold in these rooms in 2008 (lot 54, Fine Books & Manuscripts)

While I had read and re-read the epic "*Surely You're Joking, Mr. Feynman!*" in college, I did not really catch the Feynman bug until 2008. I was working as a rare book & manuscript dealer in Los Angeles, and one day, at the behest of my employer Jay Penske, I registered to bid on a one page manuscript by Feynman offered at Sotheby's in New York. At the time, I had no idea just how rare manuscript material by Feynman was, and so I was a bit stunned by the fight I had to put up to win the lot, even taking the risk to go one increment beyond what I had been authorized to spend.

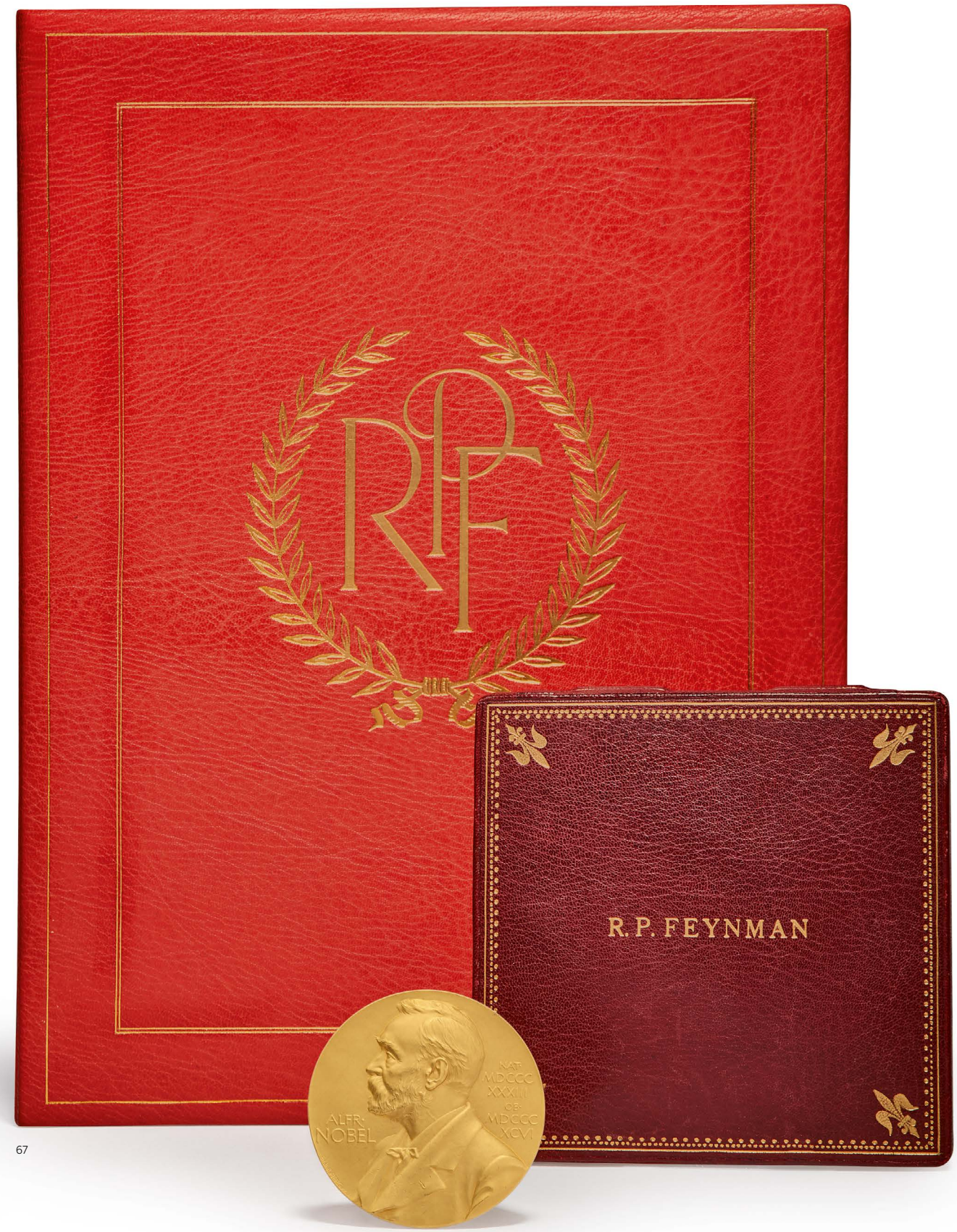
We had the manuscript framed together with a photograph of Feynman, and displayed it prominently in our shop, Dragon Books, where it garnered a great deal of attention. While we expected that our science collectors would be interested, we hadn't realized just how many of our regular customers were Feynman fans, and we learned that some of our clients were themselves curious characters who were completely Feynman-obsessed. When we sold the manuscript, I immediately began to search for other Feynman material. I quickly discovered just how impossible the task was, as Feynman had apparently deposited all of his papers in the archive at Caltech. The manuscript we bought originally came from the estate of a German autograph collector who had mailed Feynman requesting an autograph. Feynman had grabbed a sheet of calculations from his desk, signed it, and sent back what would become one of only two Feynman manuscripts to ever come to market (until now). The other, a few pages of lecture notes, sold at Sotheby's in 2006, having come from Feynman's student Fernando Morengo who had meticulously transcribed Feynman's post-graduate lectures on gravitation at Caltech in the early 1960s.

In the ten years since that exciting purchase, I have tirelessly continued my hunt for Feynman material. I have found four signed first editions of "*Surely You're Joking, Mr. Feynman!*" (including a copy that we sold here at Sotheby's in 2017 for the world record price of $43,750), and a cassette recording of an interview of Feynman done by journalist Larry Grobel. However, despite my best efforts, I have not found even a scrap of paper with Feynman's writing on it.

When I was first contacted about the possibility of selling Richard Feynman's Nobel Prize, I was absolutely thrilled, and when I discovered that he had not deposited all of his papers at Caltech, but had in fact kept a small archive of papers at home, I was in total disbelief. Spending the time with Feynman's books and papers, and writing this catalogue in collaboration with Prof. Tim Halpin-Healy, has been one of the greatest pleasures of my career. It is an absolute privilege to offer material of this caliber, what is quite simply one the most significant collections of twentieth-century scientific material to have ever come to market, and what more fitting a time to do so than during the centenary of Feynman's birth!

-Cassandra Hatton, VP, Senior Specialist, Books & Manuscripts, Sotheby's

Richard P. Feynman, formal Nobel portrait, 1965. (Photo by Clemens of Copenhagen, Pasadena. Courtesy of the Archives, California Institute of Technology)



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67 (ACTUAL SIZE)

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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

1965 Nobel Prize Medal in Physics, awarded to Richard Phillips Feynman for his fundamental work in Quantum Electrodynamics

Nobel Prize medal, struck in 23 carat gold, designed by Erik Lundberg and manufactured by the Swedish Royal Mint. Obverse with bust of Alfred Nobel left, *in field left,* ALFR·/ NOBEL; *behind head to right,* NAT·/MDCCC/ XXXIII/ OB·/ MDCCC/ XCVI; *at left edge, before bust,* E· LINDBERG 1902. Reverse with, INVENTAS · VITAM · IUVAT · EXCOLUISSE · PER · ARTES (*Life is enhanced through the arts of discovery*) — REG · ACAD · — SCIENT · SUEC · (*The Royal Swedish Academy of Sciences*); *below, incuse, on tablet in exergue,* R · P· FEYNMAN / MCMLXV, Nature, in the form of a goddess, standing left, her right arm holding a cornucopia, a figure representing the Genius of Science, standing right, holding up the veil of Science; *in field, left,* NATURA, *in field, right* SCIENTIA / ERIK / LINDBERG; the edge marked MJV (Mynt ochs Justeringsverket [Royal Mint and Assay]) GULD 1965; weight: 182.57 g.; diameter: 66 mm (2⅝ in.). Housed in the original red morocco case, top of case with border of a double-gilt rule and gilt dot-fillet, corner tools, and recipient's name (R.P. FEYNMAN) in the center; the fitter interior lined with suede and satin; interior case edges with gilt dentelles.

WITH: Richard P. Feynman's Nobel Prize Diploma: 2 vellum leaves (13¼ x 9¼ in; 336 x 235 mm) laid down in a crushed red morocco binding, covers with a border of 3 gilt fillets, the front cover with central gilt laurel enclosing Feynman's initials. Both leaves with calligraphic inscriptions in Swedish; the left-hand leaf with a design in ink, gouache, and gilt, by artist Elsa Noreen meant to give an idea of the movement of electrons around the protons. Protective cloth clamshell case.

AND: Richard P. Feynman's 1965 Nobel Festival Personal Prog ram, in original oblong black leatherette case (6 x 3½ in)

AND: *Traduction des Discours à la Fête Nobel 1965.* Oblong 8vo. (5¾ x 4 in), verso with doodles of Feynman diagrams drawn by Feynman, apparently during the Nobel ceremony.

THE NOBEL PRIZE AWARDED TO RICHARD PHILLIPS FEYNMAN —AMERICA'S GREATEST PHYSICIST AND ONE OF THE MOST BELOVED SCIENTISTS OF ALL TIME — FOR HIS GROUNDBREAKING WORK IN REMAKING THE THEORY OF QUANTUM ELECTRODYNAMICS.

King Gustav IV of Sweden Giving the Nobel Prize in Physics to Richard Feynman. (Photo by Keystone-France/ Gamma-Keystone via Getty Images)

At his home in Pasadena, Richard P. Feynman receives word that he is one of three physicists sharing the Nobel Prize for physics. October 21, 1965. (Bettman, Getty Images)

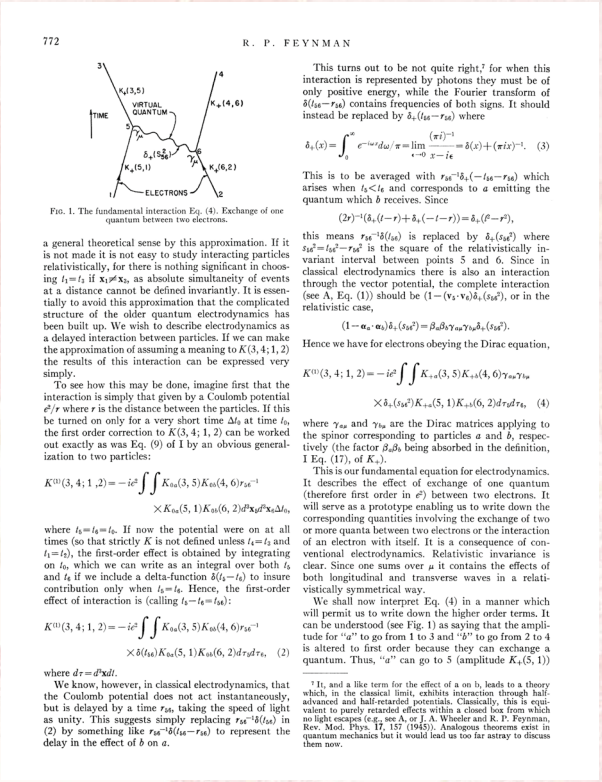

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FIG. 1. The fundamental interaction Eq. (4). Exchange of one quantum between two electrons.

a general theoretical sense by this approximation. If it is not made it is not easy to study interacting particles relativistically, for there is nothing significant in choosing $t_1=t_2$ if $\mathbf{x}_1\neq\mathbf{x}_2$, as absolute simultaneity of events at a distance cannot be defined invariantly. It is essentially to avoid this approximation that the complicated structure of the older quantum electrodynamics has been built up. We wish to describe electrodynamics as a delayed interaction between particles. If we can make the approximation of assuming a meaning to $K(3,4;1,2)$ the results of this interaction can be expressed very simply.

To see how this may be done, imagine first that the interaction is simply that given by a Coulomb potential e^2/r where r is the distance between the particles. If this be turned on only for a very short time Δt_0 at time t_0, the first order correction to $K(3,4;1,2)$ can be worked out exactly as was Eq. (9) of I by an obvious generalization to two particles:

$$K^{(1)}(3,4;1,2)=-ie^2\int\int K_{0a}(3,5)K_{0b}(4,6)r_{56}^{-1}\times K_{0a}(5,1)K_{0b}(6,2)d^3\mathbf{x}_0dt_0\Delta t_0,$$

where $t_3=t_4=t_0$. If now the potential were on at all times (so that strictly K is not defined unless $t_4=t_2$ and $t_1=t_2$), the first-order effect is obtained by integrating on t_0, which we can write as an integral over both t_5 and t_6 if we include a delta-function $\delta(t_5-t_6)$ to insure contribution only when $t_5=t_6$. Hence, the first-order effect of interaction is (calling $t_5-t_6=s_{56}$):

$$K^{(1)}(3,4;1,2)=-ie^2\int\int K_{0a}(3,5)K_{0b}(4,6)r_{56}^{-1}\times\delta(t_{56})K_{0a}(5,1)K_{0b}(6,2)d\tau_5d\tau_6,\quad(2)$$

where $d\tau=d^3\mathbf{x}dt$.

We know, however, in classical electrodynamics, that the Coulomb potential does not act instantaneously, but is delayed by a time r_{56}, taking the speed of light as unity. This suggests simply replacing $r_{56}^{-1}\delta(t_{56})$ in (2) by something like $r_{56}^{-1}\delta(t_{56}-r_{56})$ to represent the delay in the effect of b on a.

This turns out to be not quite right,[7] for when this interaction is represented by photons they must be of only positive energy, while the Fourier transform of $\delta(t_{56}-r_{56})$ contains frequencies of both signs. It should instead be replaced by $\delta_+(t_{56}-r_{56})$ where

$$\delta_+(x)=\int_0^\infty e^{-i\omega x}d\omega/\pi=\lim_{\epsilon\to0}\frac{(\pi i)^{-1}}{x-i\epsilon}=\delta(x)+(\pi ix)^{-1}.\quad(3)$$

This is to be averaged with $r_{56}^{-1}\delta_+(-t_{56}-r_{56})$ which arises when $t_5<t_6$ and corresponds to a emitting the quantum which b receives. Since

$$(2r)^{-1}(\delta_+(t-r)+\delta_+(-t-r))=\delta_+(t^2-r^2),$$

this means $r_{56}^{-1}\delta(t_{56})$ is replaced by $\delta_+(s_{56}^2)$ where $s_{56}^2=t_{56}^2-r_{56}^2$ is the square of the relativistically invariant interval between points 5 and 6. Since in classical electrodynamics there is also an interaction through the vector potential, the complete interaction (see A, Eq. (1)) should be $(1-(\mathbf{v}_5\cdot\mathbf{v}_6)\delta_+(s_{56}^2)$, or in the relativistic case,

$$(1-\boldsymbol{\alpha}_a\cdot\boldsymbol{\alpha}_b)\delta_+(s_{56}^2)=\beta_a\beta_b\gamma_{a\mu}\gamma_{b\mu}\delta_+(s_{56}^2).$$

Hence we have for electrons obeying the Dirac equation,

$$K^{(1)}(3,4;1,2)=-ie^2\int\int K_{+a}(3,5)K_{+b}(4,6)\gamma_{a\mu}\gamma_{b\mu}\times\delta_+(s_{56}^2)K_{+a}(5,1)K_{+b}(6,2)d\tau_5d\tau_6,\quad(4)$$

where $\gamma_{a\mu}$ and $\gamma_{b\mu}$ are the Dirac matrices applying to the spinor corresponding to particles a and b, respectively (the factor $\beta_a\beta_b$ being absorbed in the definition, I Eq. (17), of K_+).

This is our fundamental equation for electrodynamics. It describes the effect of exchange of one quantum (therefore first order in e^2) between two electrons. It will serve as a prototype enabling us to write down the corresponding quantities involving the exchange of two or more quanta between two electrons or the interaction of an electron with itself. It is a consequence of conventional electrodynamics. Relativistic invariance is clear. Since one sums over μ it contains the effects of both longitudinal and transverse waves in a relativistically symmetrical way.

We shall now interpret Eq. (4) in a manner which will permit us to write down the higher order terms. It can be understood (see Fig. 1) as saying that the amplitude for "a" to go from 1 to 3 and "b" to go from 2 to 4 is altered to first order because they can exchange a quantum. Thus, "a" can go to 5 (amplitude $K_+(5,1)$)

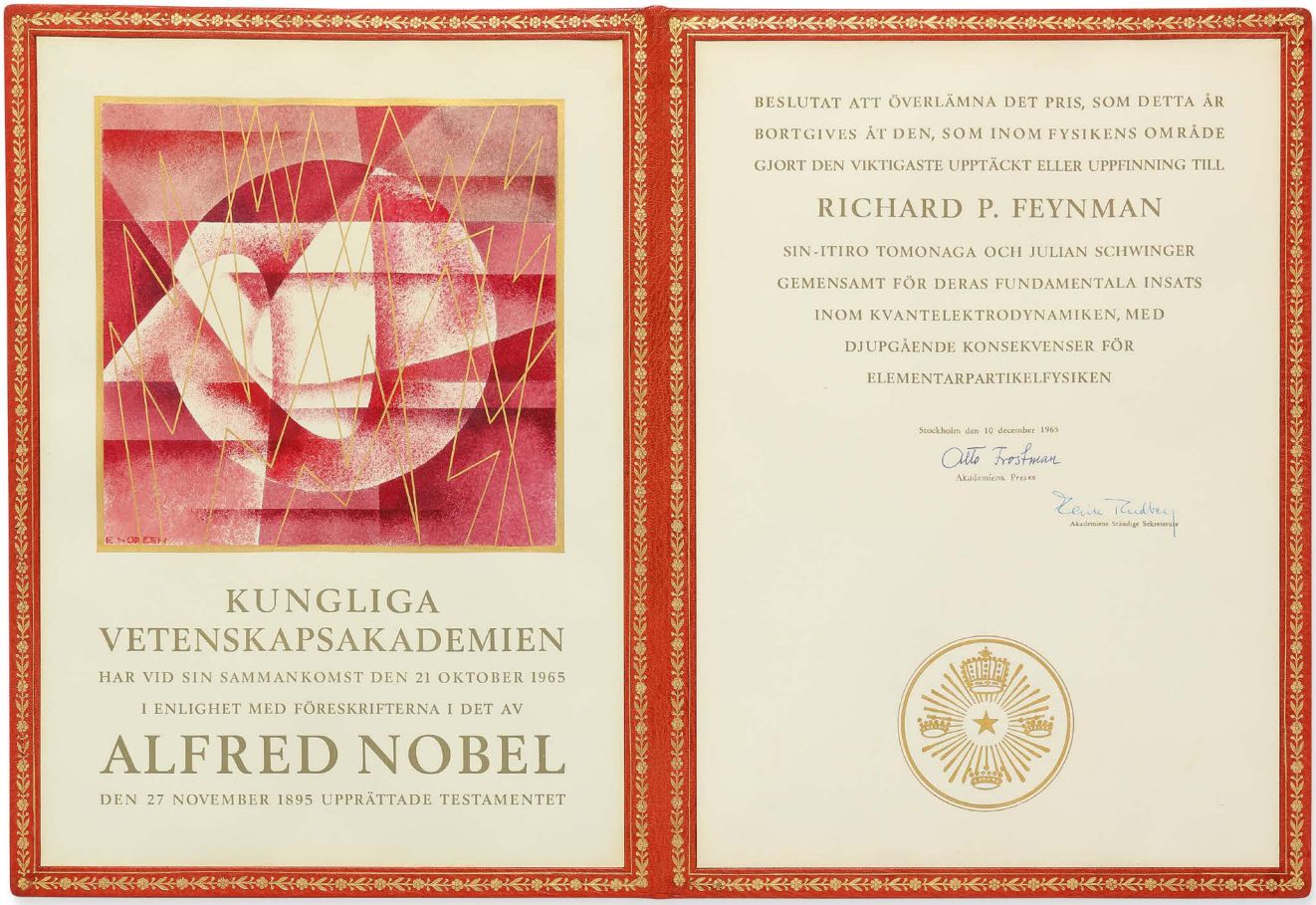
[7] It, and a like term for the effect of a on b, leads to a theory which, in the classical limit, exhibits interaction through half-advanced and half-retarded potentials. Classically, this is equivalent to purely retarded effects within a closed box from which no light escapes (e.g., see A, or J. A. Wheeler and R. P. Feynman, Rev. Mod. Phys. 17, 157 (1945)). Analogous theorems exist in quantum mechanics but it would lead us too far astray to discuss them now.

The first published Feynman diagram, published in: FEYNMAN, Richard "Space-Time Approach to Quantum Electrodynamics", IN: *Physical Review*, Vol. 76, No. 6, September 15, 1949. p. 772.

Along with Julian Schwinger and Shin'ichiro Tomonaga, Feynman shared the 1965 Nobel Prize in Physics for their "fundamental work in quantum electrodynamics, with deep-ploughing consequences for the physics of elementary particles." The three of them had independently come up with different ingenious ways to reconcile the electromagnetic field theory of the 19th century with the quantum mechanics of the 20th. While Tomonaga and Schwinger approached the problem using highly mathematical methods, Feynman tackled it in his own highly creative and original way; by creating his iconic "Feynman Diagrams", innovative pictures that provided a clear visual explanation of every possible interaction between electrons and photons.

This first general recognition of the significance of quantum electrodynamics was given for work that, in the words of Feynman's biographer, James Gleick, "tied together in an experimentally perfect package all the varied phenomena at work in light, radio, magnetism, and electrity." Gleick writes further that at least three of Feynman's later achievements might also have won a Nobel Prize: "a theory of superfluidity, the strange, frictionless behavior of liquid helium; a theory of weak interactions, the force at work in radioactive decay; and a theory of partons, hypothetical hard particles inside the atom's nucleus, that helped produce the modern understanding of quarks" (*Genius*, pp. 8–9). From his crucial work on the atomic bomb project at Los Alamos in the 1940s through his pivotal testimony at hearings of the presidential commission on the space shuttle *Challenger* disaster in 1986, Richard Feynman was recognized as a genius by both the community of elite physicists and by the world at large.

Feynman had begun the work for which he would win the Nobel while still an undergraduate at MIT, where he had read the groundbreaking work *Principles of Quantum Mechanics* by his hero, theoretical physicist and pioneer of both quantum mechanics and quantum electrodynamics, Paul Dirac (who shared the 1933 Nobel Prize in Physics with Erwin Schrödinger for "the discovery of new productive forms of atomic theory.") Feynman was often compared to Dirac, though only in terms of intellect, as physicist Eugene Wigner (Dirac's brother-in-law) best put it: "He is a second Dirac, only this time human." (Gleick, *Genius*, p. 184). Feynman openly acknowledged Dirac as the inspiration for his work, as he explained in his Nobel lecture:



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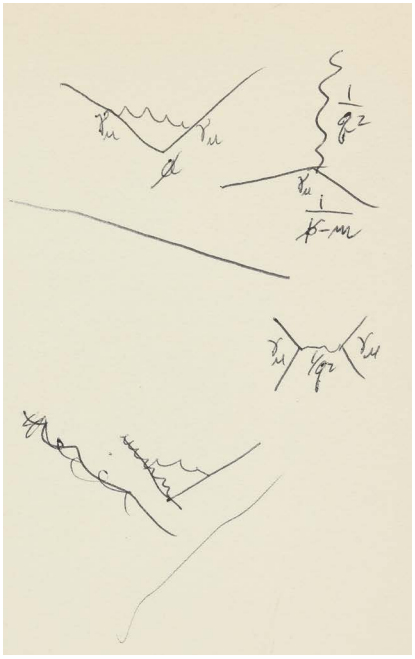
*"I worked on this problem about eight years until the final publication in 1947. The beginning of the thing was at the Massachusetts Institute of Technology, when I was an undergraduate student reading about the known physics, learning slowly about all these things that people were worrying about, and realizing ultimately that the fundamental problem of the day was that the quantum theory of electricity and magnetism was not completely satisfactory. This I gathered from books like those of Heitler and Dirac. I was inspired by the remarks in these books; not by the parts in which everything was proved and demonstrated carefully and calculated, because I couldn't understand those very well. At the young age what I could understand were the remarks about the fact that this doesn't make any sense, and the last sentence of the book of Dirac I can still remember, "**IT SEEMS THAT SOME ESSENTIALLY NEW PHYSICAL IDEAS ARE HERE NEEDED.**"* [see lot 100, Feynman's undergraduate copy of Dirac's *Principles of Quantum Mechanics*] So, *I had this as a challenge and an inspiration. I also had a personal feeling, that since they didn't get a satisfactory answer to the problem I wanted to solve, I don't have to pay a lot of attention to what they did do*." (Richard Feynman, Nobel Lecture, December 11, 1965, "The Development of the Space-Time View of Quantum Electrodynamics.")

The work for which Feynman was awarded the Nobel Prize revolutionized the field of quantum electrodynamics, and physics in general. What was perhaps just as revolutionary was his attitude about life, and the decision that ultimately led him down the path to the Nobel: to do only what he liked, and only for the fun of it, whether or not it was important.

Feynman made this decision while a professor of theoretical physics at Cornell, where he had gone to work with Hans Bethe, whom he had met during the war while the two worked together to develop the atom bomb at Los Alamos as part of the Manhattan Project:

"I went there with Hans Bethe, who I had gotten to love while we were at Los Alamos. I had to give two different classes, and I prepared my classes very rapidly because I was used to wartime action at high speed. I expected to go right back to continue the work that I'd interrupted, but for a long time I didn't seem to be able to do anything. I couldn't sit down at any real problem, and work stuff out... So I got the idea that I was burnt out by the war experience, and I would never accomplish anything after that. I have no idea why I got into this depressive condition over my own

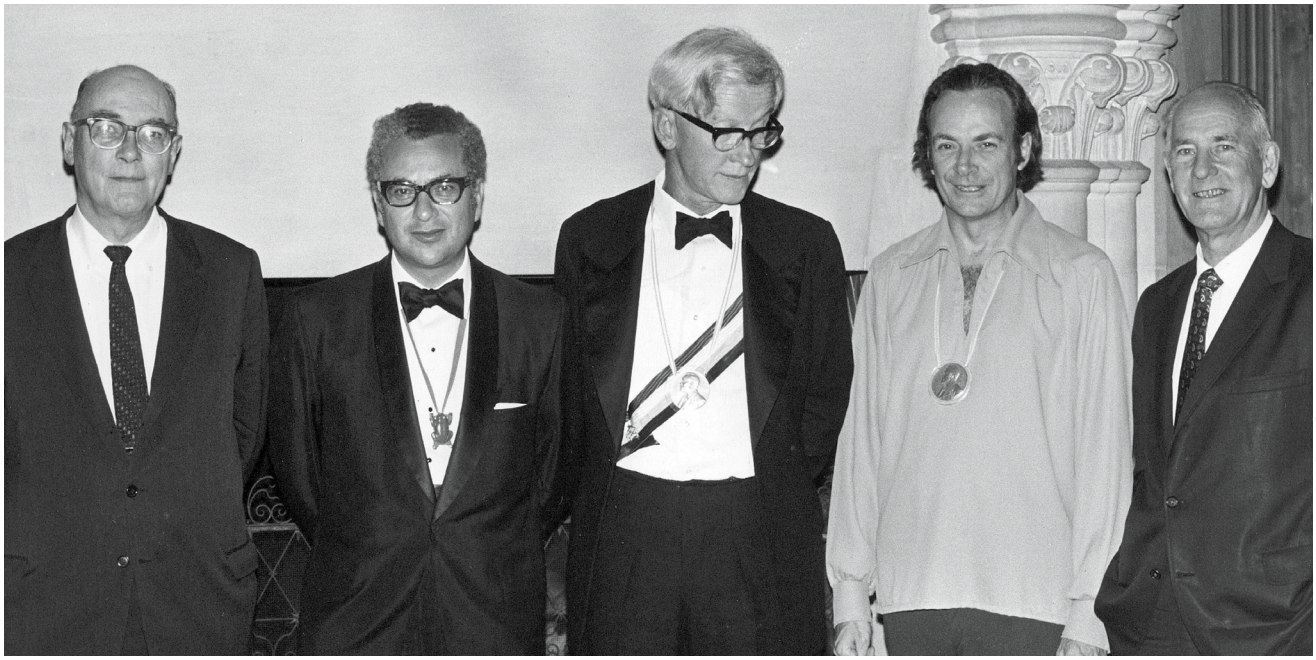
Richard P. and Gweneth Feynman at Student's Ball at Stockholm University, 1965. (Photo by Svenskt Pressfoto, Stockholm. Courtesy of the Archives, California Institute of Technology)



Lot 67 (part) Feynman diagrams, doodled by Feynman on the back of a Nobel speech pamphlet apparently during the ceremony.

work, but I did.... All during this period, there was a kind of inflation of salaries and interest in physicists because the other universities were trying to develop and everybody wanted to get the physicists. I was offered higher and higher salaries by different universities. I wanted to stay at Cornell with Bethe, so I wasn't paying much attention to that, but nevertheless it bothered my psychologically because I knew that I was burnt out, and I certainly wasn't worth the money. People expected me to succeed, and I wasn't going to succeed—or it seemed that way to me.... Finally, the Princeton Institute for Advanced Study, where Einstein and all these people were, sent me an invitation to join them. Now I thought this was crazy, that they were absolutely insane. They didn't know that I was burnt out, but even so, it was too high-class a job. It was so ridiculous that it set me thinking, and I suddenly realized, while I was shaving, "I can't live up to what other people expect me to do." They expected me to be wonderful to offer me a job like this, and I wasn't wonderful, and therefore I realized a new principle: "I'm not responsible for what other people think I am able to do. I don't have to be good because t hey think I'm going to be good." And somehow or another I could relax about this. I thought to myself, "I haven't done anything important, and I'm never going to do anything important, but I used to enjoy physics and mathematical things. It was never very important, but I used to do things for the fun of it." So I decided I'm going to only do things for the fun of it.

"*That afternoon while I was eating lunch some kid threw up a plate in the cafeteria. There was a blue medallion on the plate, the Cornell sign, and as he threw up the plate and it came down, the blue thing went around and it seemed to me that the blue thing went around faster than the wobble, and I wondered what the relation was between the two... and I started to play with this rotation, and the rotation led me to a similar problem of the rotation of the spin of an electron according to Dirac's equation, and that just led me back into quantum electrodynamics, which was the problem I had been working on. I kept continuing now to play with it in the relaxed fashion I had originally done, and it was just like taking the cork out of a bottle —everything just poured out, and in very short order I worked the things out for which I later won the Nobel Prize.*" (Richard Feynman, in: Sykes, *No Ordinary Genius: The Illustrated Richard Feynman,* pp. 71-73)



Five Caltech Nobelists, L-R: Carl Anderson, Murray Gell-Mann, Max Delbruck, Richard P. Feynman, George Beadle, 1969. (Photo by Floyd Clark. Courtesy of the Archives, California Institute of Technology)

As Feynman hilariously recounts in *"Surely You're Joking Mr. Feynman!",* he first found out that he won the Nobel from a phone call received at 4 am, which he was not happy about:

"*'Hey! Why are you bothering me at this time in the morning?'*

'I thought you'd like to know that you've won the Nobel Prize.'

'Yeah, but I'm sleeping. It would have been better if you had called me in the morning.' And I hung up.... Then I began to think, 'How can I turn this all off? I don't want any of this!' So the first thing was to take the telephone off the hook... I went down to the study to think: What am I going to do? Maybe I won't accept the Prize. What would happen then? Maybe that's impossible..."

Feynman did of course accept the Prize in the end, making a beautiful and inspirational banquet speech, stating that the reward was in the pleasure of finding things out, and in the joy and affection he felt from friends and family:

"*The work I have done has, already, been adequately rewarded and recognized. Imagination reaches out repeatedly trying to achieve some higher level of understanding, until suddenly I find myself momentarily alone before one new corner of nature's pattern of beauty and true majesty revealed. That was my reward... The Prize was a signal to permit them* [friends & family] *to express, and me to learn about, their feelings. Each joy, though transient thrill, repeated in so many places amounts to a considerable sum of human happiness. And, each note of affection released thus upon another has permitted me to realize a depth of love for my friend and acquaintances, which i had never felt so poignantly before*." (Richard Feynman "Banquet Speech", at the Nobel Banquet in Stockholm, December 10, 1965).

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Feynman, Richard "Space Time Approach to Quantum Electrodynamics." IN: *The Physical Review*, Volume 76, Number 6, September 15, 1949; Feynman, Richard & Ralph Leighton. "*Surely You're Joking Mr. Feynman!" Adventures of a Curious Character.* New York: W.W. Norton & Co., 1985; Feynman, Richard & Ralph Leighton. "*What Do You Care What Other People Think?" Further Adventures of a Curious Character.* New York: W.W. Norton & Co, 1988; Feynman, Richard; Michelle Feynman, ed. *Perfectly Reasonable Deviations from the Beaten Path. The Letters of Richard P. Feynman.* New York: Basic Books, 2005; Gleick, James. *Genius. The Life and Science of Richard Feynman.* New York: Pantheon Books, 1992; Halpern, Paul. *The Quantum Labyrinth: How Richard Feynman and John Wheeler Revolutionized Time and Reality.* New York: Basic Books, 2017; Sykes, Christopher. *No Ordinary Genius: The Illustrated Richard Feynman.* New York: W.W. Norton & Company, 1994

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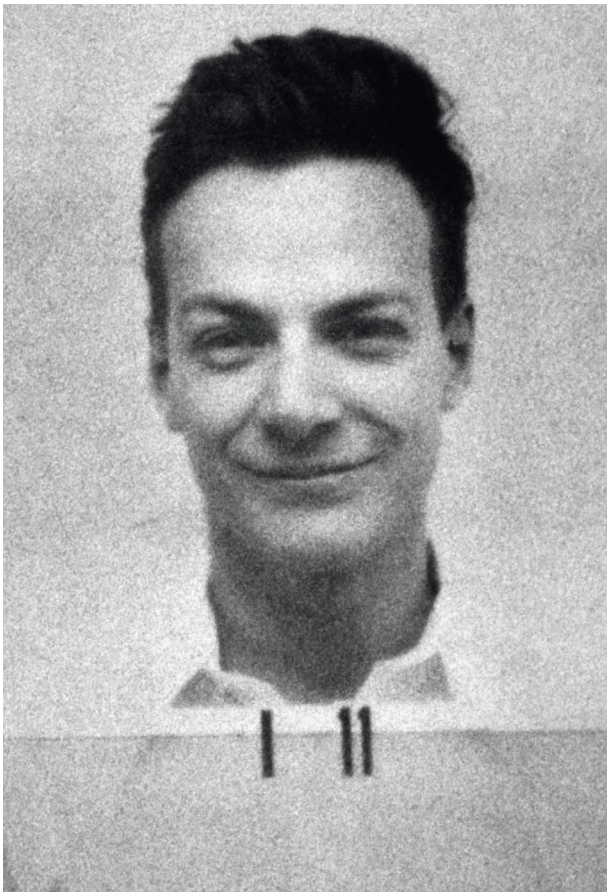
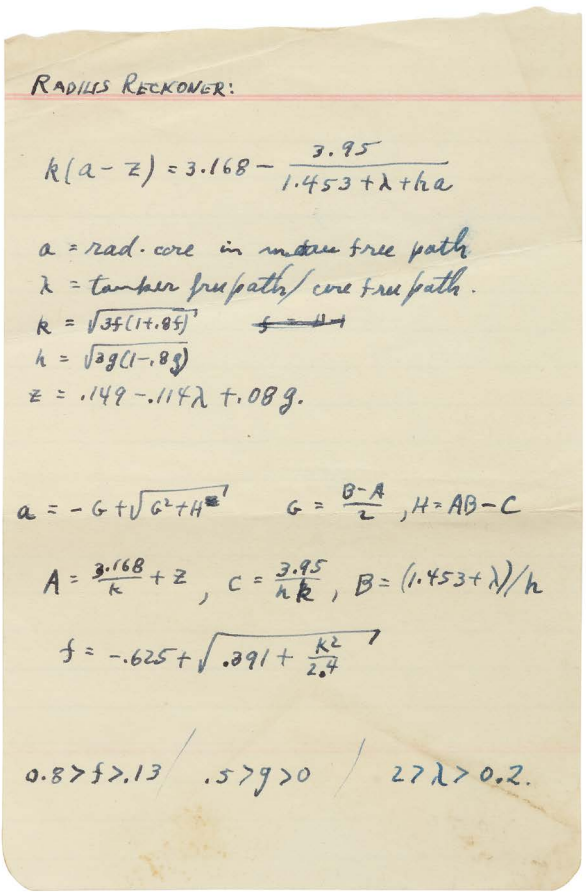


Richard P. Feynman's security badge photo from the Manhattan Project test site (Photo by © CORBIS/Corbis via Getty Images)



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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"Radius Reckoner," Los Alamos, New Mexico, ca 1943-44.

Autograph manuscript, 1 page, in blue ink on sheet of small ruled notebook paper (5¾ x 5¾ in), creases where previously folded, being details paramount to calculate the critical mass of the atom bomb.

CALCULATIONS TO DETERMINE THE CRITICAL MASS OF THE ATOM BOMB, LIKELY DONE AFTER HIS MEETING WITH THE GREAT PHYSICISTS NIELS AND AAGE BOHR IN ADVANCE OF THE FIRST TRINITY TEST.

After the attack on Pearl Harbor, Feynman, while still a graduate student, was recruited to work on a uranium enrichment project at Princeton University. The scientific director of the project was J. Robert Oppenheimer, and in 1943, the Princeton team, including Feynman, joined Oppenheimer at the Los Alamos laboratory in New Mexico. Feynman quickly distinguished himself as one of the most brilliant physicists at Los Alamos, becoming the youngest team leader in the Manhattan Project. His totally original way of tackling problems, the speed with which he could perform calculations, and his focus on the physics above all else led to his being trusted by those involved at the highest levels in the project.

The present sheet may possibly be the calculations Feynman mentions in the chapter "Los Alamos From Below" in "*Surely You're Joking Mr. Feynman!*" where he is summoned to meet Niels and Aage Bohr to work out how they could make the bomb more efficient. Feynman had caught the attention of Bohr previously:

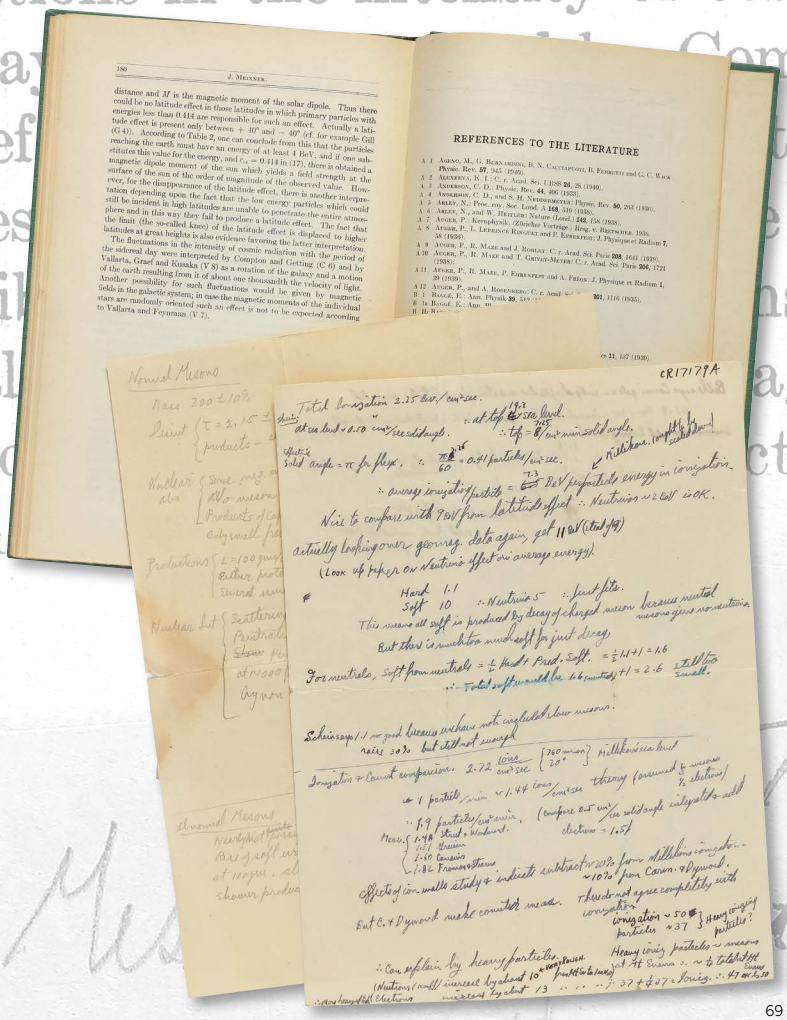
"*The last time he was there, Bohr said to his son, 'Remember the name of that little fellow in the back over there? He's the only guy who's not afraid of me, and will say when I've got a crazy idea. So* next *time when we want to discuss ideas, we're not going to be able to do it with these guys who say everything is yes, yes Dr. Bohr. Get that guy and we'll talk with him first."* (*"Surely You're Joking Mr. Feynman!"* p 155)

The key technical term here, "tamper", pertains to the heavy, non-fissile material that surrounded the explosive radiative core, reflecting the fast neutrons back into the rapidly expanding bomb material. Its presence was an essential design feature that dramatically reduced the critical mass of the rare isotope U-235 necessary to sustain the nuclear chain reaction as the bomb blew apart. Tamper details are amply discussed in Robert Serber's *"Los Alamos Primer- The First Lectures on How to Build An Atomic Bomb,"* a de-classified Manhattan Project classic.

Feynman was, by his own account, probably the only person who saw the bomb go off with the naked eye. He was twenty miles away from the site when the first Trinity test took place, and officials handed out dark glasses for everyone to wear. Realizing that "*Twenty miles away, you couldn't see a damn thing through dark glasses!*" he got behind a truck windshield to be sure to block the ultraviolet rays, and watched the bomb go off:

"*Time comes, and this tremendous flash out there is so bright that I duck... All this took about one minute. It was a series from bright to dark, and I had* seen *it. I am about the only guy who actually looked at the damn thing - the First Trinity test. Everybody else had dark glasses, and the people at six miles couldn't see it because they were all told to lie on the floor. I'm probably the only guy who saw it with the human eye...*" (*"Surely You're Joking"* p. 156)

$ 10,000-15,000



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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"*CR17179A... Total Ionization 2.25 Bev. / cm² sec...*", ca. 1944 & 1947.

Autograph manuscripts, 4 pp, in blue ink on plain white paper (8 x 10½ in) and pencil on lightly toned plain white paper (8½ x 11 in), treating Cosmic Rays and the Lamb shift, ca 1944 & 1947. Creases where previously folded.

WITH: HEISENBERG, W. ed. *Cosmic Radiation. Fifteen Lectures Edited by W. Heisenberg.* New York: Dover Publications, 1946. 8vo. 192 pp. Green publisher's cloth, lightly worn, gilt to spine rubbed off. FIRST EDITION IN ENGLISH, SIGNED "*R.P. FEYNMAN*" ON FRONT FLY-LEAF.

THE LAST WORD IN COSMIC RAYS.

Feynman's first paper, "The Scattering of Cosmic Rays from the Stars of the Galaxy" was published as a letter to the *Physical Review* on March 1st, 1939, the spring before his graduation from MIT, and was co-written with M.S. Vallarta, one of his professors who was the lead author. In 1946, a year after Feynman had joined the faculty at Cornell, Werner Heisenberg published an English-edition collection of lectures on cosmic radiation honoring Arnold Sommerfeld, his renowned mentor. This book concludes with a rather specific and historically-loaded mention of Vallarta & Feynman's paper, becoming the source of a classic Feynman anecdote as Gleick recounts:

"Vallarta let his student in on a secret of mentor-protegé publishing: the senior scientist's names comes first. Feynman had his revenge a few years later, when Heisenberg concluded an entire book on cosmic rays with the phrase, 'SUCH AN EFFECT IS NOT TO BE EXPECTED ACCORDING TO VALLARTA AND FEYNMAN.' When they next met, Feynman asked gleefully whether Vallarta had seen Heisenberg's book. Vallarta knew why Feynman was grinning. 'Yes,' he replied. You're the last word in cosmic rays.'" (*Genius* p. 82)

Indeed he was; quite the coup for a scientist's very first paper.

The present manuscripts consist of first: 2 pages, labeled at upper right "*CR17179A*" (the CR perhaps standing for Cosmic Rays), possibly investigating the effects of cosmic rays as a source of pre-detonation of the Bomb whilst at Los Alamos. Feynman notes the work of Millikan, Schein, Carmichael & Dymond, and Bethe, all being on the subject of cosmic rays, and all being published prior to the start of WWII, when Allied physicists abruptly terminated publication of sensitive scientific research.

The second manuscript revisits the topic of cosmic rays, and looks in particular at normal (i.e., pi & mu), as well as mysterious "abnormal" mesons, unknown exotic particles of heavier mass. Written post-1947, as it mentions the Lamb shift (earning Lamb the 1955 Nobel Prize in Physics); this was possibly penned after Feynman attended Hans Bethe's 1947 lecture transcending the Dirac equation to pin down Lamb's elusive, but foundational QED experiment. Feynman cites many of the same people as above, with the addition of Le Prince-Ringuet, Fermi & Rabi, Greisen, and Street & William.

REFERENCES

see *Genius,* p. 251

$ 10,000-15,000

70

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

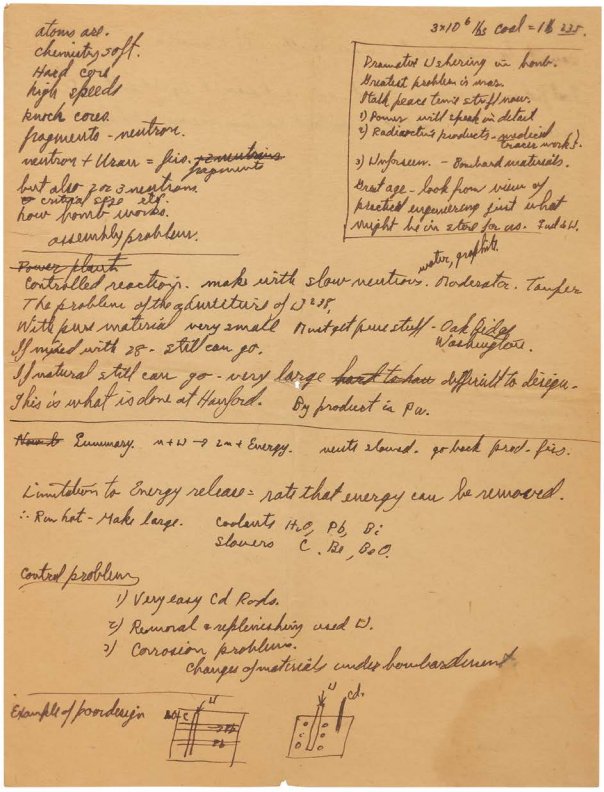
FEYNMAN, RICHARD P.

"*Inside the Atom",* drafts for two or possibly three different talks on the engineering problems of the atom bomb, ca 1944-1945.

Autograph manuscripts, 6 pp on 4 sheets (8 x 10½ in & 8½ x 11 in), in black ink on brown paper (1 sheet), in pencil, black ink, & brown ink on onion skin paper (2 sheets), and in pencil on brown paper (1 sheet), one sheet with small central hole, text unaffected.

"*WHAT WE WORRIED ABOUT AT LOS ALAMOS"*

$ 40,000-60,000


atoms are.
chemistry soft.
Hard core
high speeds
knock cores
fragments - neutrons.
neutrons + Uranium = fiss. fragments
but also 2 or 3 neutrons
& critical size etc.
how bomb works.
assembly problem.

Prometheus Ushering in bomb.
Greatest problem is mass.
Talk years ago stuff now.
1) Power will speak in detail
2) Radioactive products - medical (tracer work).
3) Uranium. - Bombard materials.
Great age - look from view of practical engineering just what might be in store for us. Ind & W.

Power plant
Controlled reaction. made with slow neutrons. Moderator. Tamper
The problem of the separation of U 235
With pure material very small mass pure stuff - Oak Ridge Washington.
If mixed with 28 - still can go.
If natural still can go - very large ~~mass~~ to have difficult to design.
This is what is done at Hanford. By product is Pu.

~~How to~~ Summary. n+U → 2n + Energy. neuts slowed. go back prod. fiss.

Limitation to Energy release = rate that energy can be removed.
∴ Run hot - Make Large. Coolants H_2O Pb Bi
Slowers C. Be D_2O

Control problem
1) Very easy Cd Rods.
2) Removal + replenishing used U.
3) Corrosion problems.
Changes of materials under bombardment

Example of poor design

70

At the request of Edward Teller, Feynman gave a series of lectures on the atom bomb to fellow members of the Manhattan Project, covering topics such as the design & chemistry of the bomb, and safety issues regarding the separation of the isotopes of uranium.

The first manuscript, on brown paper and headed "*INSIDE THE ATOM"* is very possibly a draft for the famous talk given by Feynman at Oak Ridge, the top-secret location of the Clinton Engineer Works, where the material for the bomb was being produced; it touches on many of the key topics we now know Feynman discussed there, including engineering problems, separation of the isotopes of uranium 238 and 235, and is clearly adapted for an audience who has a high level of understanding of chemistry. It is clear that the talk was given at a time when the new element of Plutonium was still classified, as Feynman refers to it using the code word "*49*" - the reverse of the new pure element's atomic number of 94; the phrase in caps "*WHAT WE WORRIED ABOUT AT LOS ALAMOS"* is written next to the heading "*Chain Reaction Described*", followed by 4 bullet points: 1) "Critical size", 2) "Reflector", 3) "Explosion energy needs extra mass", & 4) "Speed of assembly".

These bullet points represent 4 of the major topics that Feynman discussed at Oak Ridge. On the verso, in pencil in two different hands are several games of Tic-tac-toe, and the phrases "*Now, what did you want to know?", "Yes, I don't know."*

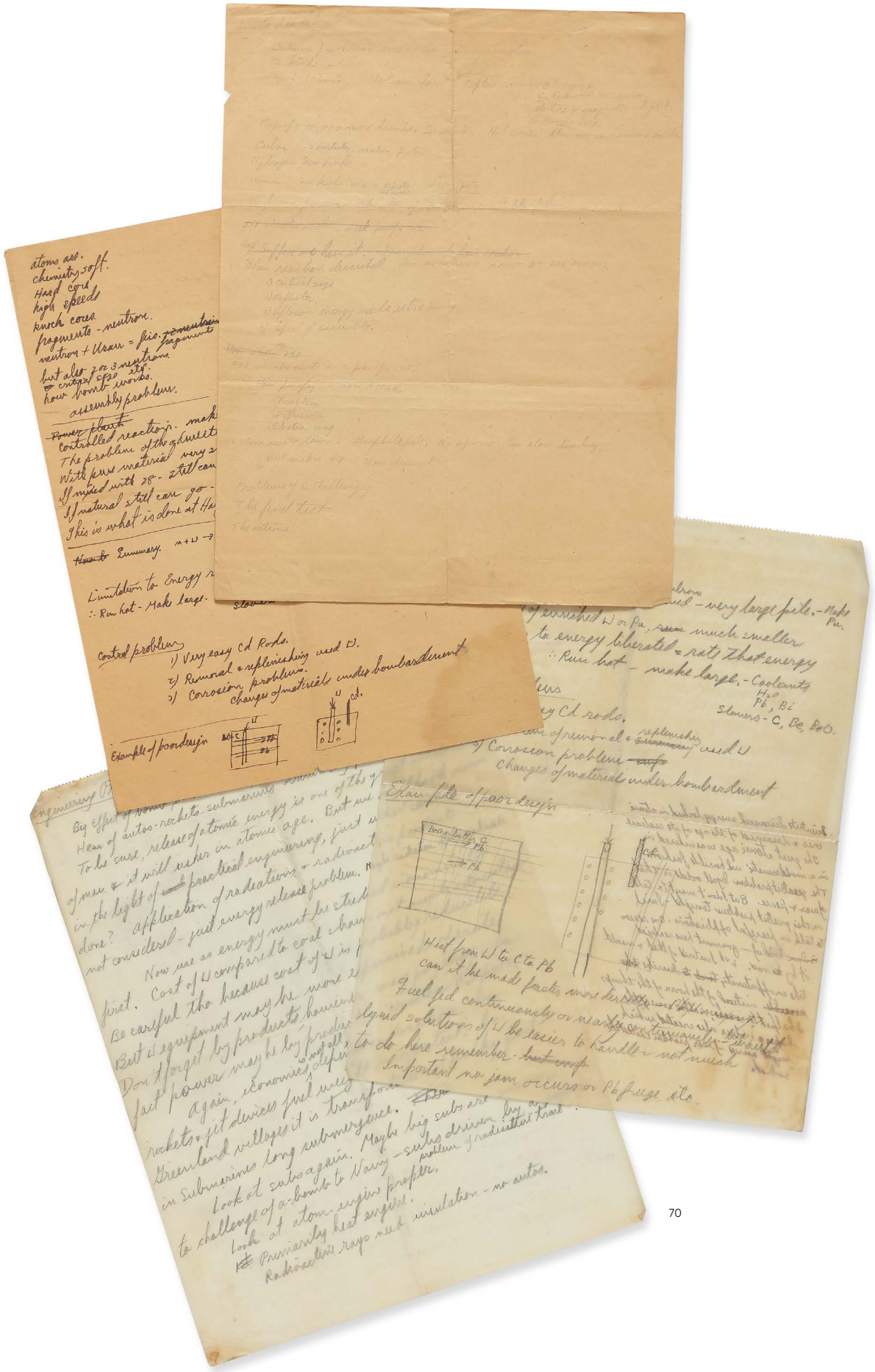
While the bomb was built at Los Alamos, the material used to make the bomb was produced at Oak Ridge. Emilio Segrè, one of Feynman's senior colleagues, decided to inspect the plant to make sure that the instructions sent by Los Alamos were being followed. What he discovered were extremely dangerous conditions, with high quantities of material being stored together that could lead to disaster if not corrected. Oppenheimer had two teams, one led by Robert Christy and the other by Feynman, calculate the amount of material that could be accumulated safely. Feynman was then sent to Oak Ridge to present the numbers, taking what was his first ever plane ride to get there. "*The first thing I did was have them take me to the plant, and I said nothing; I just looked at everything. I found out that the situation was worse than Segrè reported... I went to my room that night, and went through the whole thing, explained where the dangers were, and what you would have to do to fix this. It's rather easy. You put cadmium in the water, and you separate the boxes so they are not too dense..." ("Surely You're Joking Mr. Feynman*!", p. 142-43). The next morning, when preparing to give his talk to a room full of important generals, engineers, and other important personnel, Feynman was told that he was not to go into details of how everything worked, and to just stick to telling everyone what to do to keep things safe. His response was:

"*In my opinion it is impossible for them to obey a bunch of rules unless they understand how it works. It's my opinion that it's only going to work if I tell them, and* LOS ALAMOS CANNOT ACCEPT THE RESPONSIBILITY FOR THE SAFETY OF THE OAK RIDGE PLANT UNLESS THEY ARE FULLY INFORMED AS TO HOW IT WORKS."

Feynman was convincing, and was allowed to share the details. He is now credited with saving the lives not only the workers, but the people living around the area of Oak Ridge.

The second manuscript, on brown paper in black ink, contains some similar information to the first, but has the added dimension of discussing control problems, issues of assembly and control, and problems regarding heat transfer and corrosion, plus two diagrams giving examples of poor design. The third longer draft, on onion skin paper, is likely a version of the second manuscript, adapted to be given to a post-war audience, as it includes the same technical details and diagrams, but adds an expanded section on peace-time applications of atomic power. On the verso of this second draft, written in brown ink, is what appears to be an introduction for a post-war talk, possibly one delivered or planned to be delivered at a nuclear physics conference he was invited to attend by R.D. Richtmeyer in 1947 (see Michelle Feynman, ed. *Perfectly Reasonable Deviations,* p. 75). It begins:

"*Scientists discovered energy locked in atomic cores & dreamed of the age of its release. The great atomic age was ushered in in a most dramatic and horrible fashion... The greatest problem by all odds is that of war & peace... I am tired of that & would like an opportunity to describe instead of the horror of the things I helped to make, rather some of the hopes & values..."*



70

Richard P. Feynman, ca 1950, possibly at Cornell. (Courtesy of the Archives, California Institute of Technology)

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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

POST-HIROSHIMA TALKS ON THE ATOM BOMB, CA 1945.

Autograph manuscripts, 7 pp on 4 sheets, pencil, black pen, & blue pen on yellow ruled paper (1 sheet), plain white paper (2 sheets) and Cornell letterhead (1 sheet) (8 x 10½ in - 8½ x 11 in), creases where previously folded, one sheet with open tear at foot, text unaffected.

"*AND WE SCIENTISTS ARE CLEVER — TOO CLEVER — ARE YOU NOT SATISFIED? IS 4 SQUARE MILES IN ONE BOMB NOT ENOUGH? JUST TELL US HOW BIG YOU WANT IT*!"

Drafts for one or more post-Hiroshima talks on the atom bomb, the first likely given very shortly after the dropping of the bomb, the first before Feynman had left Los Alamos for Cornell. All of the manuscripts closely resemble each other in terms of topic and content; two of them have the same 4 underlined sections, and the same phrase quoted by James Gleick in pp 203-204 in *Genius,* under the same heading of "*Skill & Knowledge":*

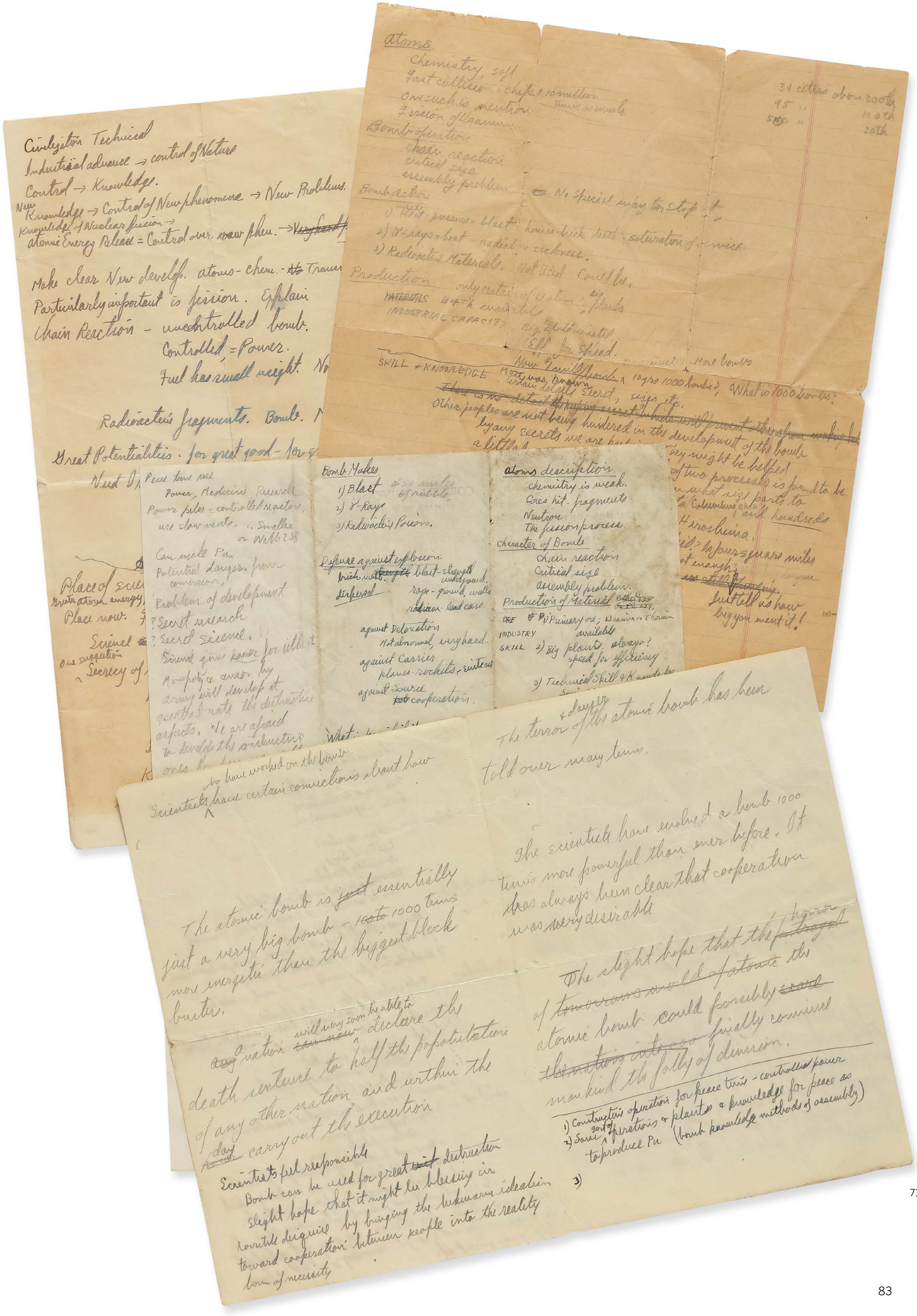
"Other people are not being hindered in the development of the bomb by any secrets we are keeping.... But soon they will be able do to Columbus, Ohio, and hundreds of cities like it what we did to Hiroshima. And we scientists are clever — too clever — are you not satisfied? Is 4 square miles in one bomb not enough? Just tell us how big you want it!"

The manuscript on yellow lined paper (quoted in Gleick's *Genius*, p 203) has an outline of a talk to be given by Feynman on the atom bomb written in pencil to the verso in a hand other than Feynman's. While it is not signed, it is very possibly in the hand of Edward Teller, who had requested that Feynman give a series of lectures on the atom bomb. It begins: "*5 m. 1. : Illustrate the destructive powers of the bomb. 10m. 2. No monopoly. 5m. 3. No defense. 5m. 4. No security until we have control on a world level. "*

In 1947, Feynman received an invitation from R.D. Richtmeyer of the Los Alamos Scientific Laboratory to attend a nuclear physics conference that was being planned (see Michelle Feynman, ed. *Perfectly Reasonable Deviations*, p. 75); it is possible that at least one of these manuscripts is a draft for that talk, as one of the paragraphs reads:

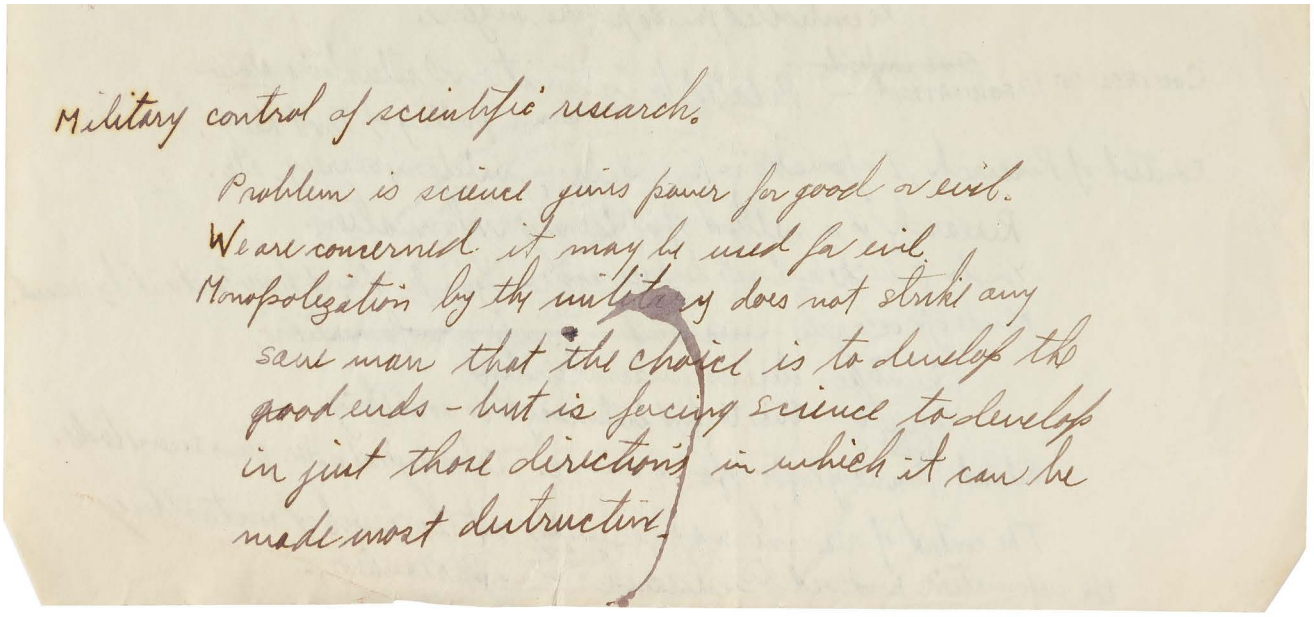
"*The brotherhood which we are attempting this week is not a viewpoint to have for seven days. Nor is it simply a concept to be kept in mind for all time. Brotherhood must be a program of action... And this cooperation is not simply a desirable thing. Cooperation is a necessity for the survival of a great fraction of the vast population of the earth — you, and I included."*

$ 30,000-50,000



Civilization Technical
Industrial advance → control of Nature
Control → Knowledge.
New Knowledge → Control of New phenomena → New Problems.
Knowledge of Nuclear fission → atomic Energy Release = Control over new phen. → ~~...~~
Make clear New develops. atoms - chem. - Transm...
Particularly important is fission. Explain
Chain Reaction - uncontrolled bomb.
Controlled = Power.
Fuel has small weight. No...
Radioactive fragments. Bomb. ...
Great Potentialities. for great good - for ...
Need ...
Place of scie...
Greater atomic energy,
Place now.
Science ...
One suggestion
Secrecy of ...
atoms
Chemistry, soft
Fast collisions - chips 10 million times as much
One such is neutron
Fission of Uranium
Bomb operation
chain reaction
critical size
assembly problem — No special way to stop it.
Bomb action
1) Heat - pressure - blast - houses - brick - death - saturation of ...
2) γ-rays - heat - radiation sickness.
3) Radioactive Materials. Not used. Could be.
Production only certain of isotopes; big plants
MATERIALS U-235 available
INDUSTRIAL CAPACITY Big 2 ... waste
Eff. for speed.
SKILL + KNOWLEDGE Now 1 mill. bomb, 10 yrs 1000 bombs; What is 1000 bombs?
Most was known. certain details secret, sizes etc.
~~There is no detail ... secret which will prevent others from making bomb~~
Other peoples are not being hindered in the development of the bomb by any secrets we are keeping ... they might be helped a little ...
... of two processes is found to be ... what size parts to ... a Columbus ... and hundreds
Hiroshima.
... 4 square miles ... enough ...
Just tell us how big you want it!
31 cities above 300th
95 " 100th
500 " 20th
Peace time use
Power, Medicine, Research
Power piles - controlled reactors, use slow neutrons. ∴ Smaller or with 238
Can make Pu.
Potential dangers from conversion.
Problem of development
? Secret research
? Secret science.
Science gives power for either ...
Monopoly ... army will develop at ... the destructive aspects. We are afraid to develop the destructive ones ...
Bomb Makes
1) Blast 4 sq miles of rubble
2) γ-Rays
3) Radioactive Poisons.
Defense against explosion.
brick ... blast - strength underground.
dispersal rays - ground, walls radiation - lead cars.
against Detonation Not abnormal, very hard.
against Carriers planes - rockets - suitcase
against Source cooperation.
What ...
atoms description
chemistry is weak.
Cores hit - fragments
Neutron
The fission process
Character of Bomb
chain reaction
Critical size
assembly problem.
Production of Material
ORE 1) Primary ore; Uranium or Thorium available
INDUSTRY
SKILL 2) Big plants always? speed for efficiency
3) Technical Skill & Knowledge ...
Scientists who have worked on the bomb have certain convictions about how
The atomic bomb is ~~just~~ essentially just a very big bomb - ~~100~~ to 1000 times more energetic than the biggest block buster.
~~any~~ A nation will very soon be able to ~~can now~~ declare the death sentence to half the population of any other nation and within the ~~hour~~ day carry out the execution
Scientists feel responsible
Bomb can be used for great destruction
slight hope that it might be blessing in horrible disguise by bringing the lukewarm idealism toward cooperation between people into the reality born of necessity
The terror & danger of the atomic bomb has been told over many times.
The scientists have evolved a bomb 1000 times more powerful than ever before. It has always been clear that cooperation was very desirable
The slight hope that the ~~portrayal~~ horror of ~~tomorrow's world of atomic~~ the atomic bomb could possibly ~~sound~~ ~~the nations into coo~~ finally convince mankind the folly of division.
1) Constructive operation for peace time - controlled power
2) Same sort of operations & plants & knowledge for peace as to produce Pu (bomb knowledge methods of assembly)
3)

71



72 (DETAIL)

72

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

OPPOSITION TO MILITARY CONTROL OF SCIENTIFIC RESEARCH, CA 1946

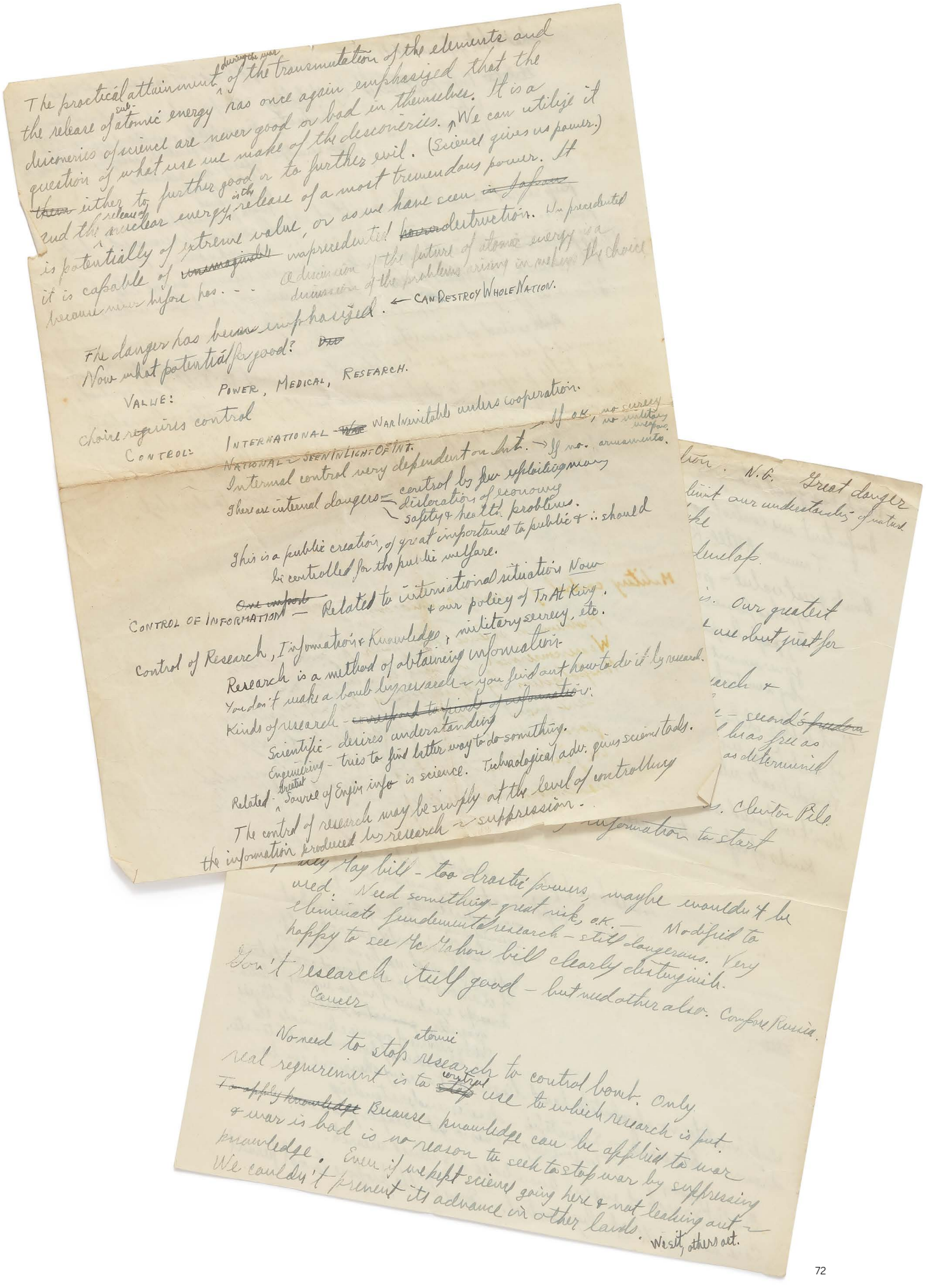
Autograph manuscript, 4 pp (8 x 10½ in) in blue & brown ink on white paper with watermark of Cornell University, creases where previously folded.

"*THE PRACTICAL ATTAINMENT DURING THE WAR OF THE TRANSMUTATION OF THE ELEMENTS AND THE RELEASE OF ATOMIC ENERGY HAS ONCE AGAIN EMPHASIZED THAT THE DISCOVERIES OF SCIENCE ARE NEVER GOOD OR BAD IN THEMSELVES. IT IS A QUESTION OF WHAT USE WE MAKE OF THE DISCOVERIES. WE CAN UTILIZE IT EITHER TO FURTHER GOOD OR TO FURTHER EVIL.*"

In October of 1945, the draft legislation for the May-Johnson Bill reached President Truman's desk. The Bill, if passed, would have granted sweeping powers to the government over atomic power, with the idea that only government control could prevent its misuse. The Bill was opposed by many scientists, including those from the Met Lab at Oak Ridge, because it gave the military continued control over scientific research — something that was no longer acceptable after the end of the war.

Feynman was very clearly amongst those that opposed the Bill, and was glad to instead see the passage of the Atomic Energy Act, also known as the McMahon Bill, in 1946. The act established the Unites States Atomic Energy Commission, with the purpose of ensuring that nuclear research and development would remain under civilian, rather than military control. While Feyman's earlier papers on the atom bomb focus on the problems of science & engineering, this paper shows a distinct shift in focus towards the moral and ethical implications of nuclear research.

$ 30,000-50,000



The practical attainment during the war of the transmutation of the elements and the release of atomic energy has once again emphasized that the discoveries of science are never good or bad in themselves. It is a question of what use we make of the discoveries. We can utilize it either to further good or to further evil. (Science gives us power.) And the release of nuclear energy is the release of a most tremendous power. It is potentially of extreme value, or as we have seen in Japan it is capable of unprecedented destruction. Unprecedented power has become ours before has. — A discussion of the future of atomic energy is a discussion of the problems arising in making the choice. ← CAN DESTROY WHOLE NATION.

The danger has been emphasized.
Now what potential for good?

VALUE: POWER, MEDICAL, RESEARCH.

Choice requires control

CONTROL: INTERNATIONAL — WAR inevitable unless cooperation.
NATIONAL — SEE IN LIGHT OF INT.
Internal control very dependent on Int. → If OK, no secrecy, no military weapons. If no, armaments.
There are internal dangers — control by few exploiting many
— deliberate slowing of economy
— safety & health problems.
This is a public creation, of great importance to public + ∴ should be controlled for the public welfare.

CONTROL OF INFORMATION — Related to international situation. Now + our policy of TrAt King.

Control of Research, Information & Knowledge; military secrecy, etc.
Research is a method of obtaining information.
You don't make a bomb by research — you find out how to do it by research.
Kinds of research — ~~confused to kinds of information~~:
Scientific — desires understanding
Engineering — tries to find better way to do something.
Related — source of Engin info is science. Technological adv. gives scientists.
The control of research may be simply at the level of controlling the information produced by research — suppression.

N.B. Great danger
limit our understanding of nature
knl
develop
is. Our greatest
+ are about just for
search +
— second ~~freedom~~
has free as
as determined
s. Clinton Bills
information to start

May bill — too drastic powers, maybe wouldn't be used. Need something — great risk, OK. — Modified to eliminate fundamental research — still dangerous. Very happy to see McMahon bill clearly distinguish.
Don't research itself good — but need other also. Compare Russia.
Career

No need to stop atomic research to control bomb. Only real requirement is to control use to which research is put.
~~To apply knowledge~~ Because knowledge can be applied to war & war is bad is no reason to seek to stop war by suppressing knowledge. Even if we kept science going here & not leading ourselves
We couldn't prevent its advance in other lands. We sit, others act.

Richard P. Feynman as a young man, ca. 1942. Courtesy of Michelle Feynman & Carl Feynman

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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"*Atomic Bomb as Military Weapon*," ca 1946.

Autograph manuscript, 2 pp (8 x 10½ in) in blue ink and pencil on white paper with Cornell watermark, creases where previously folded.

WITH: Feynman's copy of: [Department of State], *The International Control of Atomic Energy. Scientific Information Transmitted to the United Nations Atomic Energy Commission. June 14, 1946 - October 14, 1946.* Washington, D.C: The United States Government Printing Office, [1946]. 8vo. Original printed wrappers.

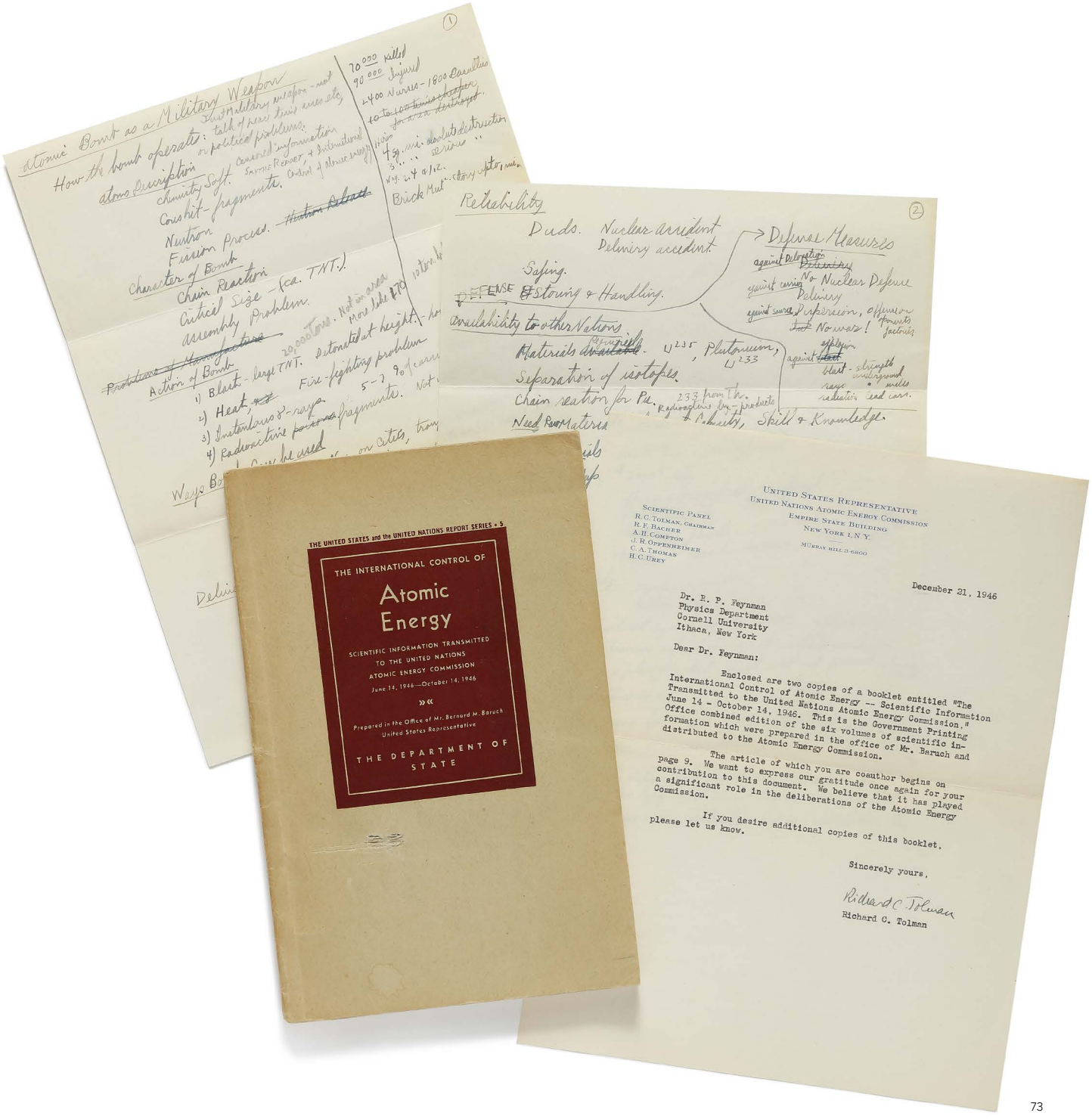
WITH: TOLMAN, RICHARD C. Typed letter signed "Richard C. Tolman", to Richard Feynman, December 21, 1946, on United States Representative United States Atomic Energy Commission letterhead. Informing him that the article that he co-authored has been published in the above.

"*WHAT IS NEW ABOUT THE ATOMIC BOMB. ANY NATION CAN DECIDE ON DESTRUCTION OF OTHER NATION (NOT NEW — BEEN DONE BEFORE) — AND IN ONE DAY CAN CARRY OUT THAT DESTRUCTION. LIABLE OF COURSE TO OWN DESTRUCTION — BUT CAN STILL DESTROY OTHER.*"

In his early days as professor of theoretical physics at Cornell, Feynman gave a number of talks and lectures on the atom bomb. The present manuscript was surely written very soon after arriving at Cornell, as we do not yet see some of the more ethical dimensions of his papers on the topic that would follow later in 1946-47, where he starts to turn his focus more directly on the peace-time applications of atomic power. He makes mention of the Smythe Report, published by the Princeton University Press in August 1945, just a few days after the bombings of Hiroshima and Nagasaki.

Feynman's article published in the *International Control of Atomic Energy* Report, co-written with R. F. Bacher, Feynman's colleague at Cornell (and former head of the Bomb Physics Division at Los Alamos Laboratory), is entitled "Introduction to Atomic Energy." It is interesting to note that Richard Tolman, who sent Feynman the pamphlet along with the letter, also worked on the Manhattan Project, and went on to teach, like Feynman did, at Caltech.

$ 25,000-35,000


Atomic Bomb as a Military Weapon
How the bomb operates:
Reliability
Duds. Nuclear accident
Delivery accident.
Defense Measures
Saving.
Storing & Handling.
Availability to other Nations
Materials - U235, Plutonium, U233
Separation of isotopes
Chain reaction for Pu.
Need Raw Materials
Skill & Knowledge.
THE UNITED STATES and the UNITED NATIONS REPORT SERIES • 5
THE INTERNATIONAL CONTROL OF
Atomic Energy
SCIENTIFIC INFORMATION TRANSMITTED TO THE UNITED NATIONS ATOMIC ENERGY COMMISSION
June 14, 1946—October 14, 1946
Prepared in the Office of Mr. Bernard M. Baruch United States Representative
THE DEPARTMENT OF STATE
UNITED STATES REPRESENTATIVE
UNITED NATIONS ATOMIC ENERGY COMMISSION
EMPIRE STATE BUILDING
NEW YORK 1, N.Y.
MURRAY HILL 3-6800
SCIENTIFIC PANEL
R. C. TOLMAN, CHAIRMAN
R. F. BACHER
A. H. COMPTON
J. R. OPPENHEIMER
C. A. THOMAS
H. C. UREY
December 21, 1946
Dr. R. P. Feynman
Physics Department
Cornell University
Ithaca, New York
Dear Dr. Feynman:
Enclosed are two copies of a booklet entitled "The International Control of Atomic Energy -- Scientific Information Transmitted to the United Nations Atomic Energy Commission, June 14 - October 14, 1946. This is the Government Printing Office combined edition of the six volumes of scientific information which were prepared in the office of Mr. Baruch and distributed to the Atomic Energy Commission.
The article of which you are coauthor begins on page 9. We want to express our gratitude once again for your contribution to this document. We believe that it has played a significant role in the deliberations of the Atomic Energy Commission.
If you desire additional copies of this booklet, please let us know.
Sincerely yours,
Richard C. Tolman
Richard C. Tolman

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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"*Two objectives. (1) To point out the peculiar point. (2) To formulate a M_e in a definite number of assumptions (Non-relativistic Schröd),"* ca 1946-51.

Autograph manuscripts, 5 pp (8½ x 11 & 8 x 10½ in) in pencil on plain white paper (2 sheets), and Cornell watermarked paper (2 sheets).

FEYNMAN DERIVES THE SCHRÖDINGER EQUATION VIA THE FEYNMAN PATH INTEGRAL, SHOWING THE EQUIVALENCE OF THESE DISTINCT, BUT COMPLEMENTARY FORMULATIONS OF QUANTUM MECHANICS.

$ 30,000-40,000

Richard P. Feynman, ca 1952. (Bettman, Getty Images)

By 1925-26, Heisenberg's Matrix Mechanics & Schrödinger's Equation, both based on so-called "Hamiltonian" methods, were the algebraic & differential cornerstones of the "new" quantum physics, garnering their inventors the 1932 & 1933 Nobel Prizes, respectively. A generation later, Feynman formulated a entirely distinct and original way of thinking about quantum particles, encoded in his celebrated *Feynman Path Integral,* based on a complementary "Lagrangian" viewpoint, having its roots in an obscure 1933 paper of Feynman's hero, Paul Dirac. In the first manuscript, possibly written at some point before coming to Cornell, perhaps while still at Princeton, Feynman brilliantly uses his *Path Integral* to "derive" the Schrödinger Equation. This bit of magic, in its first incarnation dating to a chance 1941 Princeton chat over beers with Herbert Jehle (a student of Schrödinger recently escaped from Nazi Germany), has been famously recounted many times. The key insight hinged on Dirac's use of the word "analogue," which Feynman had mistakenly interpreted as "equal"; once Jehle explained the next day that Dirac's language implied "proportional", rather than equal, Feynman was unleashed. In a flash, the equivalence between Hamiltonian & Lagrangian formulations of quantum mechanics was established, the proportionality constant (essentially "A" in the manuscript...) calculated, and with this creative assault upon the black board, Feynman had hurled himself (as well as the stunned Jehle, along for the ride) far beyond Dirac, and forged a powerful new tool of quantum physics:

"Jehle told Feynman he made an important discovery. He was struck by the unabashed pragmatism in Feynman's handling of the mathematics, so different than Dirac's more detached, more aesthetic tone. 'You Americans!' he said. 'Always trying to find a use for something.'" (Gleick, pp. 128-9)

Following his time at Los Alamos, and after his arrival at Cornell, Feynman returned to these fundamental questions of quantum mechanics. In the second manuscript, on Cornell watermarked paper, he again invokes the essential Feynman notion of a "sum over histories", highlighting the key mathematical object $F_o(2,1)$, known as the "free-particle propagator," bottom recto, before turning his attention, au verso, to the Dirac Equation. Eventually, these ideas, greatly extended, were consolidated in the 1965 Caltech classic, *Quantum Mechanics and Path Integrals,* by Feynman & Hibbs (lot 109).

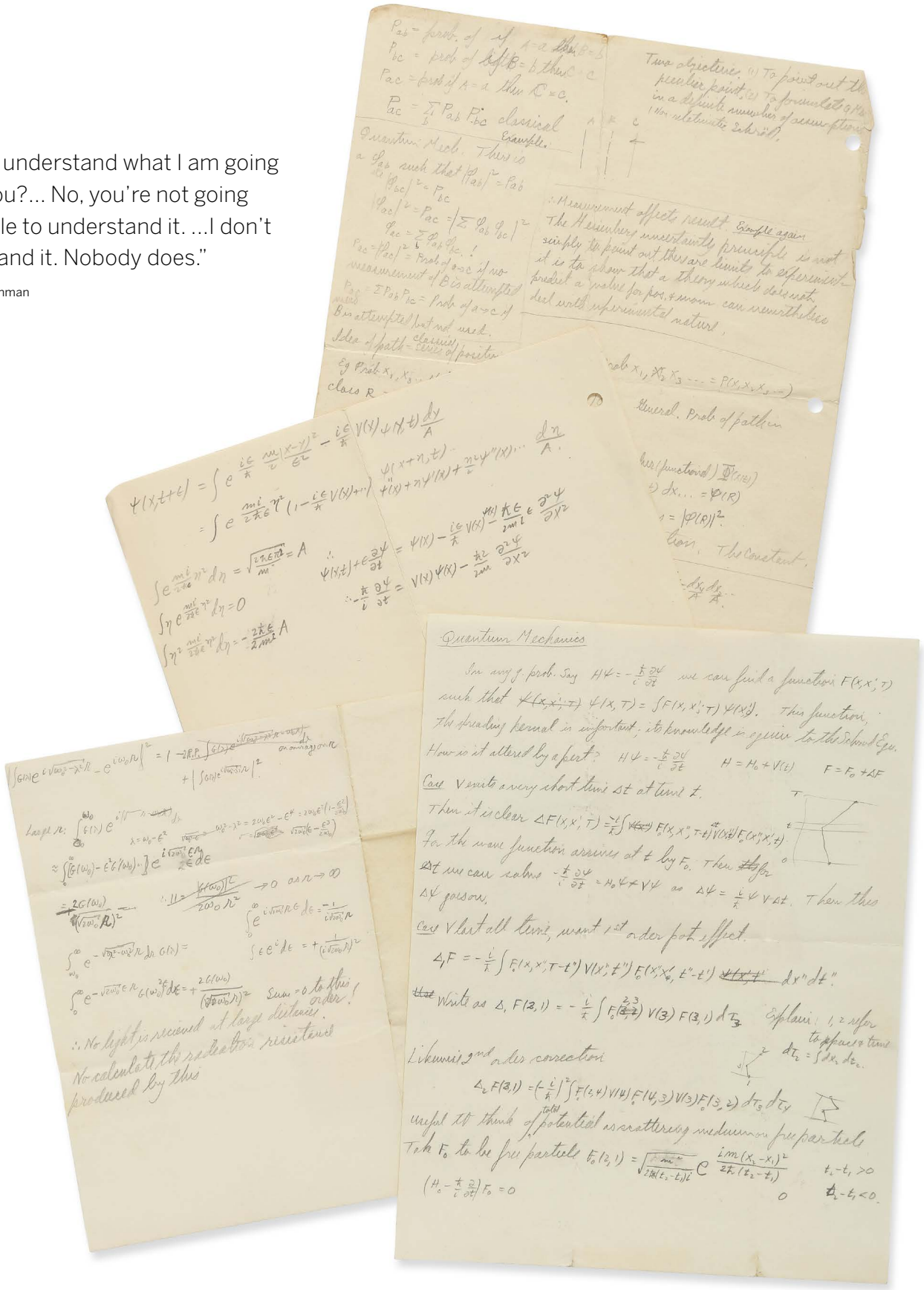
Ironically, Feynman had been exposed, in apocryphal fashion, to *classical* Lagrangian mechanics by Abram Bader, his legendary High School physics teacher (Feynman Lectures, vol II, ch. 19) but had surprisingly rejected, indeed throughout his entire MIT days..., this elegant approach in favor of more direct, workman-like force analyses. Nevertheless, his eventual embrace of the Lagrangian formulation at this critical point not only cleared the way for the resolution of his Princeton PhD work with Wheeler, (see below), but more importantly laid the architectural foundation for his functional integration techniques, with their implicit homage to the Least Action Principle, permitting him to craft his very own special brand of QED, entirely complementary to that of his fellow Laureates Schwinger & Tomonoga.

The 3rd Cornell page refers, most likely, to the original 1941 "Absorber Theory" of Feynman and Wheeler — or perhaps a 1949 electromagnetic extension (Rev. Mod. Phys. **21**, 425) — with its associated focus on radiation reaction effects and, amusingly here, captures a specific eureka moment ("Sum = 0 to this order!) when the calculation reveals that there is "No light received at large distances." In the original formulation, the clever inclusion of an "advanced" (i.e., traveling backward in time) component to the traditional "retarded" solution established the possibility that emission of radiation will not be realized lest there be absorbers in place everywhere, all of the time — a Nobel-calibre, yet impish tip of the hat to the proverbial question: "If a tree falls in a forest, and no one is there..." (Gleick, pp. 110-123).

BEAUTIFUL, CLEAN EXAMPLES OF FEYNMAN'S BRILLIANCE.

"Will you understand what I am going to tell you?... No, you're not going to be able to understand it. ...I don't understand it. Nobody does."

Richard P. Feynman



Richard P. Feynman speaking to a class, 1963. From French magazine *Réalités* (Courtesy of the Archives, California Institute of Technology).

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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"Classical theory — self energy difficulties. Quantum theory — still in trouble...", ca 1948-49.

Autograph manuscripts, 8 pp on 6 sheets (8½ x 11 in), in pencil on white paper watermarked "Eaton's Cascade Bond Berkshire 11" (3 sheets), on white paper watermarked "Arena Bond" (1 sheet), and on plain white wove paper (2 sheets). Creases where previously folded.

Apparently a collection of separate, but likely contemporaneous lecture notes dating to the seminal moment when Feynman pivots from his Fall 1948 papers which invoke *Relativistic Cut-Offs for Classical & Quantum Electrodynamics* (Phys. Rev. **74**, 939 & 1430), and turns, making the revolutionary leap the following Spring, to the celebrated 1949 Nobel Prize-winning work *Space-Time Approach to QED* (Phys. Rev. **76**, 769), in which Feynman diagrams, with their characteristic virtual quanta, appear for the first time in the literature- see Fig. 1,2, etc., therein. The earlier pair of papers were written in the months following the famed Pocono Conference, 29 March-2 April 1948, where Feynman & Schwinger had presented complementary theories of QED and the latter had emerged as victor (*Genius*, pp.265-258). Nevertheless, Feynman's *Diagrammatica* prevailed on the next occasion, the Oldstone Conference, 11-14 April 1949 and he submitted that Nobel paper just 3 weeks later...

Feynman looks at the different problems encountered with Classical theory, and indicates where there is still work to be done in Quantum theory. In the first 5 pages or so (on the Eaton's watermarked paper), he cites various attempts to straighten out the Classical theory due to Bom & Infeld, Dirac, Bhabha, Peierls, and Wheeler-Feynman, before writing "*The quantization of these have all gotten stuck. I have another way very similar to Peierls, which I can quantize & which does give finite results in Q. Mech....*"

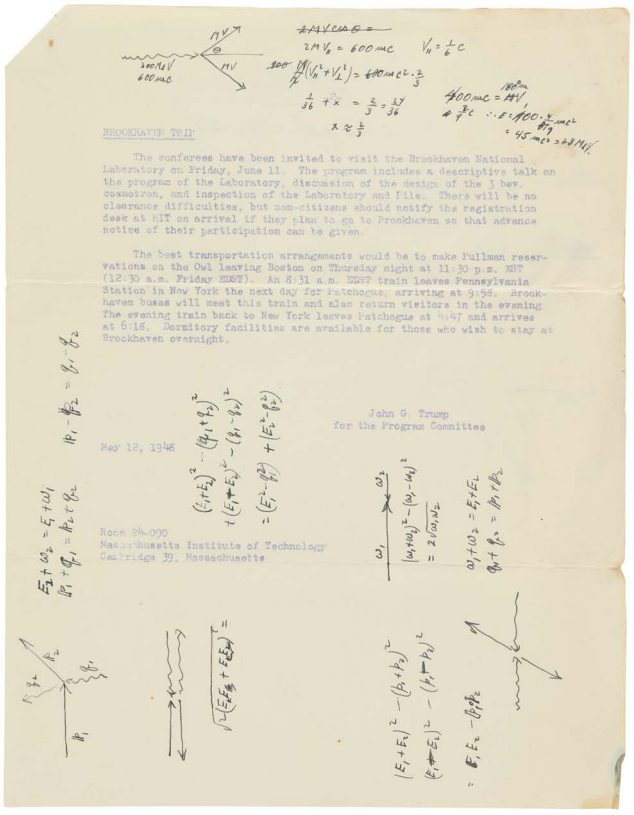
He goes on to describe this Classical approach in detail, showing how calculation of the self-energy "*Gives infinity.*" He then proposes his idea of cutting off this divergence, which yields a finite result, by swapping out the troublesome Dirac delta-function for a "very handy" Bessel function J_1, the natural choice by virtue of its simple Fourier transform. In a second section he states "*2) Do not have time to go into many beautiful results of this* [pair production] *but go directly to Q. Mech. Again look at solutions. Start wave function at x....*" Later, he continues "*What to do for electrodynamics if retarded? Big problem of quantum electrodynamics. Answer is....*" In a third section, he continues "*3) However there is also self action no one particle.... the effect is to change the phase of the wave func*[tion] *at B just as a change in mass would...*"

The 4th sheet (on Arena watermarked paper) appears to be an early draft for the first three sheets, as much of the introductory text is the same.

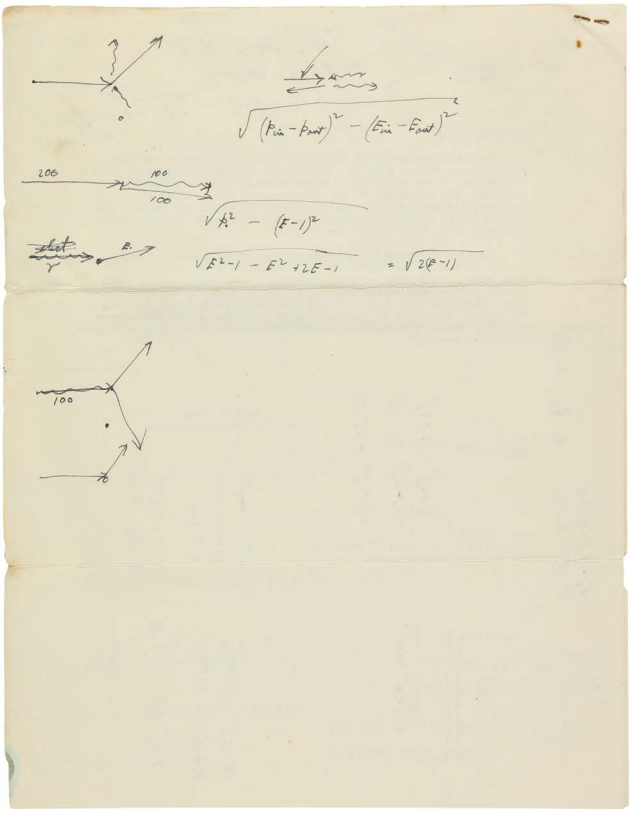
The last two sheets, on plain wove paper, again treat the difficulties with Quantum Electrodynamics, opening with "*Difficulty with Q Elect. that gives infinite self energy. (emit & absorb + Vac Pol). Weiss (& Bethe) scheme diff bound & free. Schwinger formulates which terms renormalize mass. Finish. I MAKE THEORY, A MODEL FOR SCHWINGER, ALL EFFECTS ARE FINITE. ADVANTAGE OF NO AMBIGUITY....* He then revisits the Dirac-Bessel swap, taming the divergence in the Classical theory- "Self energy finite "For Dirac eqn., S is operator..." Final of these last two sheets, top- Feynman lays out the situation for *Two Particles,* initially in non-relativistic setting, but then indicating the necessary refinements to go to fully relativistic treatment; i.e. QED, w/ its tell-tale virtual photons. The very last equation articulates the mathematical contribution of the infinite *Self-Energy* Feynman diagram to its left, which can be found as Fig. 2 in the seminal 1949 paper, but may have had, in Feynman's own hand, a precursor appearance here....

$ 50,000-70,000


Classical theory selfenergy difficulties (field on self)
Quantum theory - still trouble - emit quant & reabsorb.
→ infinity as we go to infinite energy quanta
(also Vac Pol.)
Experiment of Lamb. → Bethe & Weiss. difference of bound & free selfenergy (ambiguous?)
Lewis & Oppy → Radiative Scattering - subtract guessed terms representing change in mass.
Schwinger - Formulate which terms to omit from Ham. 1st order
I - make theory which gives finite result for all effects such as self energy ∴ Can get complete answers. Any subtraction would be of finite quantities & ∴ not ambiguous.
Idea In class. pot. when Δt = r/c or t² − r² = 0.
Influence δ(t² − r²)
Change to f(t² − r²)
At large distances no effect (t − r of order a²/r) at small weakens effect.
Other interesting results of this classical theory no time to discuss. Selfenergy finite
Quantum Interaction thru superposition of quanta various directions & wave length & frequency (ω = k ordinarily).
∴ Have to integrate matrix elements over ∫ dK/k (- - -)
Now f needs different distribution of ω, K. Need ∫∫ g(ω, K) dK dω (- - -)
g is fourier transform of f. Most convenient in form,
g(ω, K) = ∫ G(λ) dλ [δ(ω² − k²) − δ(ω² − k² − λ²)]
Least action
Idea change δ to f(t² − r²)
at large distances no effect t − r of order a²/r. at small weakens effect.
Self energy finite. Show how. Other results not describe
Quantum Need non-Hamilt form. Define S(2,1) = ampl. at x_B time t_B
For Dirac eq. S is operator
Idea with no interaction is S₀. First order pert by pot U(x₁) at time t₁ in Δt,
S = S₀ + S₁
Eff mass = m = μ + δμ
Here, we do not get all the mass. Even for λ very high δμ ≪ μ.
in given potential = Radiationless Scattering,
on Nucleus: Result Old(μ) + Stuff ln λ/μ + Const + μ²/λ²
Stuff = δμ ∂Old/∂μ
∴ Result Old(m) + Const + m²/λ²
Hence propose suff. accurate Old(m) + Const. actually proposed first by Lewis that mass terms eliminate divergences. Let λ → ∞ keeping m const.
All expected to be finite. In particular Bethe's self energy.
Compton effect total emission rate decreased a little (order 1/λ²) by λ quanta.
Q: 2nd order Mass. Polaris of Vac.
what to do for electrodynamics. answer is put e²/r₁₂ δ(t₁ − t₂ − r₁₂)
Q. Electro for transitions with no permanent emission shows up as decreasing exponential.



76 Part



76 Part

76

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"[I] *Would like to talk about what new Q.*[uantum] *Electr.*[rodynamics] *predicts...."*, ca May, 1948.

Autograph manuscript, together 4 pp (8½ x 11 in) with 3pp consisting primarily of diagrams and calculations in black ink on rectos & verso of the 12 May 1948 *Final Announcement of Conference on Electrostatic and High-Energy Accelerators* at MIT, & 1 p being the draft of the talk corresponding to the diagrams, in black ink on ruled paper. Apparently a draft for a paper to be presented at said conference.

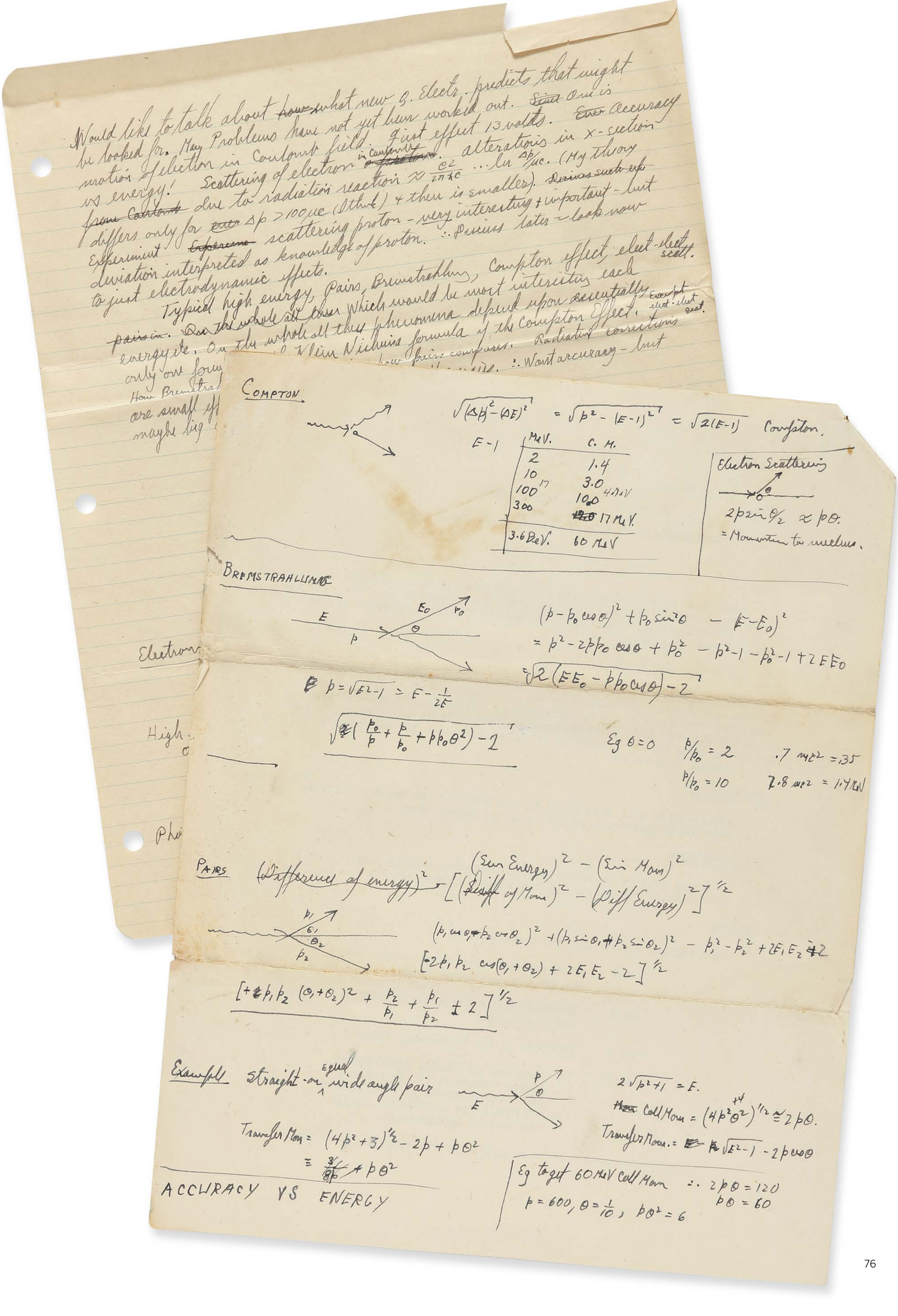
DRAFT FOR AN EARLY, EXPERIMENTALLY-MOTIVATED CONFERENCE TALK ON QED, A YEAR BEFORE PUBLICATION OF HIS SEMINAL PAPER "SPACE-TIME APPROACH TO QUANTUM ELECTRODYNAMICS" AND 17 YEARS BEFORE HE WOULD WIN THE NOBEL PRIZE FOR HIS WORK ON THIS SUBJECT.

A wonderful early item, giving us great insight into Feynman's thought processes during a critical moment in the development of his new quantum electrodynamics, shortly after the famed Pocono Conference of late March 1948 when Julian Schwinger's competing approach to QED held sway, and likely preceding Feynman's legendary cross-country road-trip that June with Freeman Dyson, who later explained the equivalence of the two complementary approaches (Gleick, pp. 262-266). The diagrams drawn on the conference program represent the key physical processes constituting crucial experimental tests of QED: i) Compton effect; i.e., the inelastic scattering of electrons by hard x-rays, ii) Bremsstrahlung- "braking radiation," emitted by rapidly decelerated electrons and, finally, iii) the production of electron-positron pairs by high-energy gamma rays. Feynman at the time was a professor of theoretical physics at Cornell University and it was this work that would lead to his being awarded the 1965 Nobel Prize in Physics.

The text begins: "[I] *Would like to talk about what new Q.*[uantum] *Electr.*[odynamics] *predicts that might be looked for. Many problems have not yet been worked out. One is motion of electron in Coulomb field. First effect 13 volts. Accuracy vs. energy!... Typical high energy, Pairs, Bremsstrahlung, Compton effect, elect -elect. scatt..."*

As with much of Feynman's oeuvre, we can locate no published version of this talk.

$ 15,000-20,000


Would like to talk about ~~how~~ what new Q. Electr. predicts that might be looked for. Many Problems have not yet been worked out. ~~Since~~ One is motion of electron in Coulomb field. Just effect 13 volts. ~~Even~~ Accuracy vs energy! Scattering of electron in Coulomb ~~[illegible]~~ alterations in x-section ~~from Coulomb~~ due to radiation reaction $\approx \frac{e^2}{2\pi\hbar c}$ ... ln $\Delta p/\mu c$. (My theory differs only for ~~[illegible]~~ $\Delta p > 100\mu c$ (Other) + then is smaller). Discuss such exp Experiment ~~Experimen~~ scattering proton - very interesting + important - but deviation interpreted as knowledge of proton. ∴ Discuss later - look now to just electrodynamic effects.

Typical high energy, Pairs, Bremstrahlung, Compton effect, elect-elect scatt. ~~pairs in. On the whole all these which would be most interesting each~~ Except elect-elect scat. energy etc. On the whole all these phenomena depend upon essentially only one formula [illegible] Klein Nishina formula of the Compton Effect. [illegible] how pairs compares. Radiative corrections are small eff[illegible] ∴ Want accuracy - but maybe big [illegible]

How Bremstrah[illegible]

Electron[illegible]

High [illegible]

Phi[illegible]

COMPTON

$\sqrt{(\Delta p)^2 - (\Delta E)^2} = \sqrt{p^2 - (E-1)^2} = \sqrt{2(E-1)}$ Compton.

E-1 MeV.	C. M.
2	1.4
10	3.0
100	10.0 4 MeV
300	17 MeV.
3.6 BeV.	60 MeV

Electron Scattering

$2p \sin \theta/2 \approx p\theta$.

= Momentum to nucleus.

BREMSTRAHLUNG

E, p, E_0, p_0, θ

$(p - p_0\cos\theta)^2 + p_0\sin^2\theta - (E - E_0)^2$

$= p^2 - 2pp_0\cos\theta + p_0^2 - p^2 - 1 - p_0^2 - 1 + 2EE_0$

$= \sqrt{2(EE_0 - pp_0\cos\theta) - 2}$

$p = \sqrt{E^2-1} \simeq E - \frac{1}{2E}$

$\sqrt{(\frac{p_0}{p} + \frac{p}{p_0} + pp_0\theta^2) - 2}$

Eg $\theta = 0$ $p/p_0 = 2$ $.7\ mc^2 = .35$

$p/p_0 = 10$ $2.8\ mc^2 = 1.4$ MeV

PAIRS ~~(Difference of energy)²~~ $(\text{Sum Energy})^2 - (\text{Sum Mom})^2$

$[(\text{Diff of Mom})^2 - (\text{Diff Energy})^2]^{1/2}$

$p_1, \theta_1, \theta_2, p_2$

$(p_1\cos\theta_1 + p_2\cos\theta_2)^2 + (p_1\sin\theta_1 + p_2\sin\theta_2)^2 - p_1^2 - p_2^2 + 2E_1E_2 \mp 2$

$[-2p_1p_2\cos(\theta_1+\theta_2) + 2E_1E_2 - 2]^{1/2}$

$[+p_1p_2(\theta_1+\theta_2)^2 + \frac{p_2}{p_1} + \frac{p_1}{p_2} \pm 2]^{1/2}$

Example straight-on equal wide angle pair

E, p, θ

$2\sqrt{p^2+1} = E$.

~~Mom~~ Coll Mom $= (4p^2\theta^2 + 4)^{1/2} \cong 2p\theta$.

Transfer Mom. $= \sqrt{E^2-1} - 2p\cos\theta$

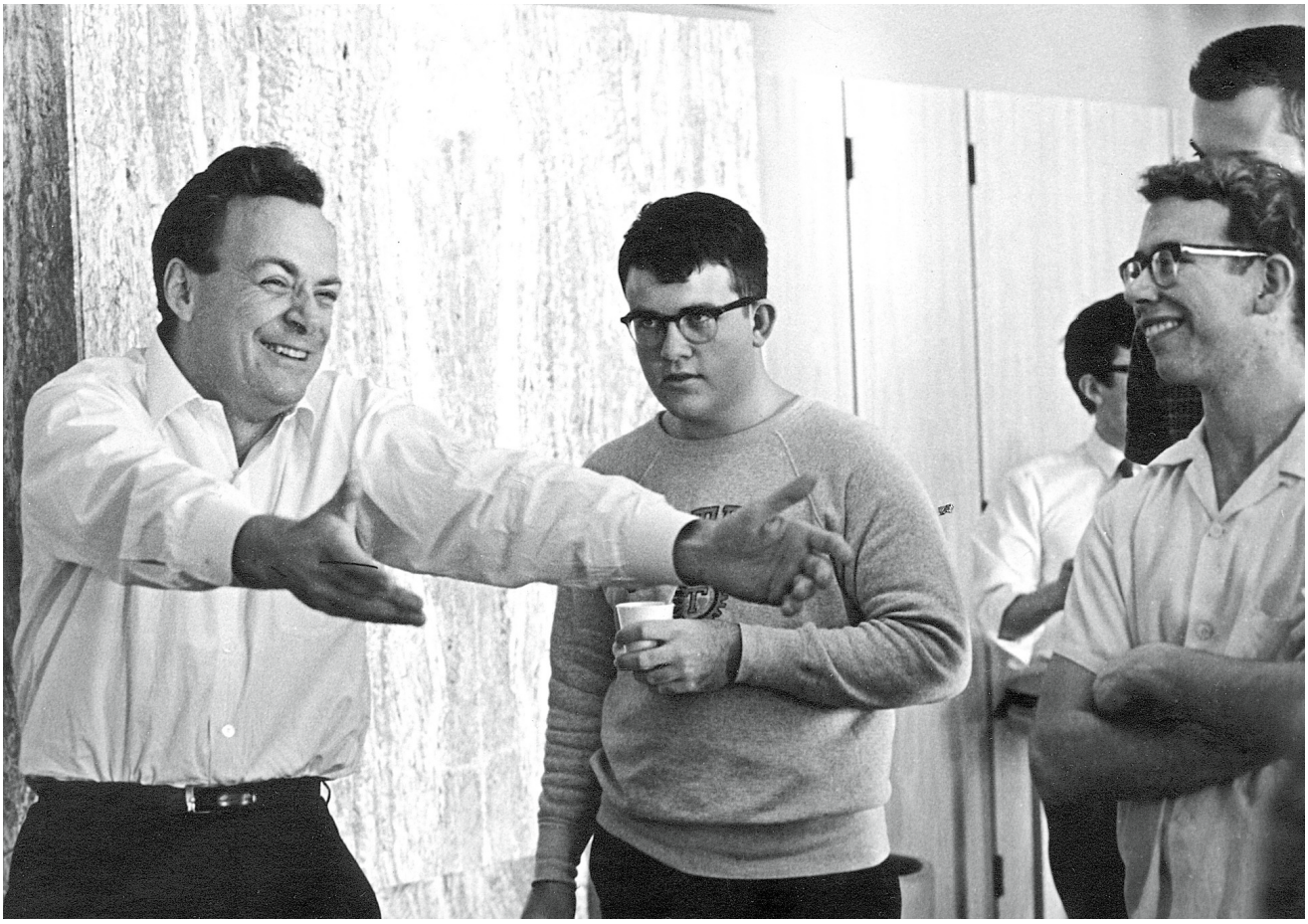
Transfer Mom $= (4p^2+3)^{1/2} - 2p + p\theta^2$

$= \frac{3}{4p} + p\theta^2$

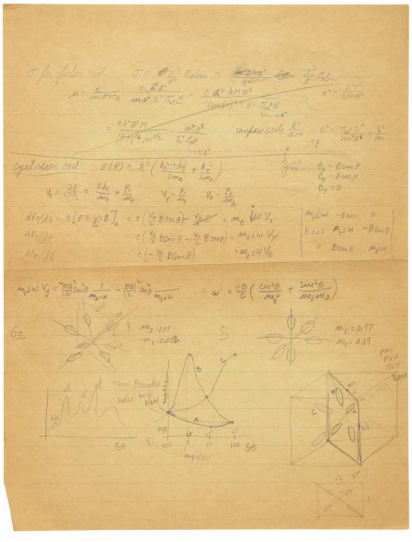
Eg target 60 MeV Coll Mom ∴ $2p\theta = 120$, $p\theta = 60$

$p = 600$, $\theta = \frac{1}{10}$, $p\theta^2 = 6$

ACCURACY VS ENERGY



Richard P. Feynman with Caltech students, during coffee hour in Winnett Center, June 1964. (Photographer, Kent McCaulley. Courtesy of the Archives, California Institute of Technology)



77 (PART)

77

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

ARCHIVE OF MANUSCRIPTS TREATING SOLID STATE PHYSICS — SPANNING THE LENGTH OF FEYNMAN'S CAREER, CA 1948-1985

Autograph manuscripts, 31 pp on 24 sheets (8½ x 11 in), in pencil on yellow lined paper (3 sheets), plain white wove paper (14 sheets), yellow wove paper (2 sheets), plain white hole-punched wove paper (2 sheets), and black & red ink on thin plain white wove paper (3 sheets). Creases where previously folded, some sheets age-toned, last few pages with marginal tatters.

A SPECTACULAR ARCHIVE OF PAPERS SPANNING THE MAJORITY OF FEYNMAN'S CAREER, DEMONSTRATING HIS LIFELONG INTEREST IN SOLID STATE PHYSICS.

Solid state physics is the study of solids using the tools & techniques of quantum mechanics, statistical mechanics, electromagnetism, metallurgy, and crystallography. In the present manuscripts, Feynman considers various aspects of this field of study, including the Shockley experiment, cyclotron resonance, electrical conductivity, lattice defects, semi-conductors, impurities, solar cells, lasers, rectifiers & transistors, free electron gas, tunnel diodes, forces on electrons, and more. While some of the papers appear to span from his early days as a professor at Cornell, the majority are likely lecture notes for courses he taught at Caltech in the mid-1960s. This archive is best considered as the inspired legacy of his 1950's commitment to this subfield, which is most closely allied to electrical engineering aspects girding the advent of the modern computers, but also provides a kind of parallel track to Feynman's sustained commitment to coding. It speaks directly to his desk-top copy of Kittel- (see lot 84), the classic tome on the subject.

$ 100,000-150,000


p-n junction
Solar Cells
Rectifier.
Tunnel Diode
Hall Effect.
Get negative result for holes.
Hall effect
what determines τ:
Impurities
Lattice defects
Temperatures osc.
Neg Resistance!
Point Contact Transistor
What is energy max.
Hyperbola

78

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"$(x_1-x_2)^2\,(x_3-x_4)^2 + (x_1-x_3)^2\,(x_2-x_4)^2 + (x_1-x_4)^2\,(x_2-x_3)^2$", ca 1951.

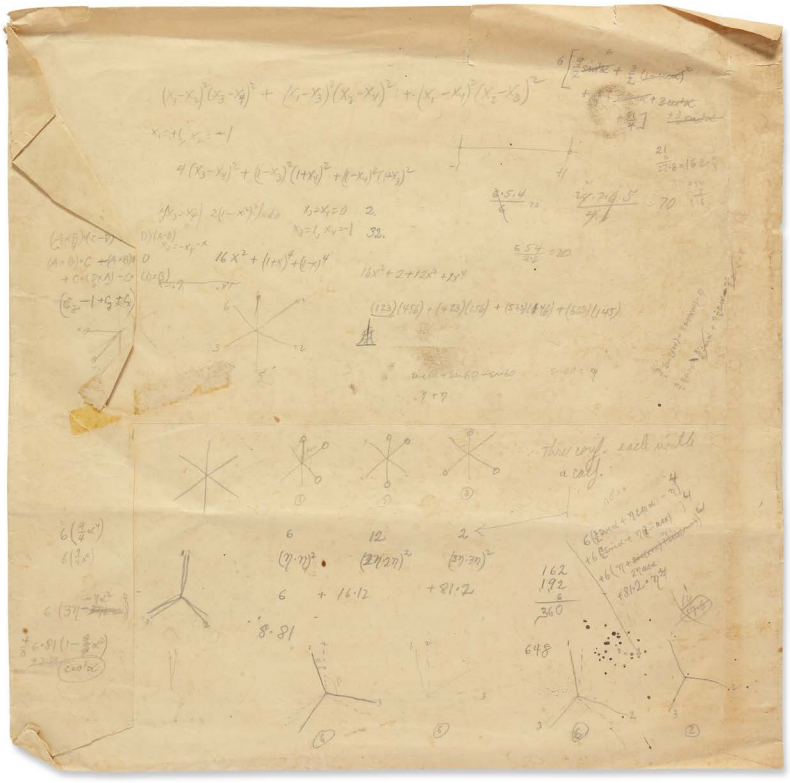
Autograph manuscript, 1 page, in pencil, (11½ x 11½ in) on verso of LP sleeve from W.M. Reis in Rio de Janeiro, Brazil.

A NICE EXAMPLE OF FEYNMAN'S QUICK SKETCHWORK OF CALCULATIONAL DETAILS.

Here, a classic Feynman mix of algebraic, trigonometric, and graphical elements. In center, on verso, 3 diagrams labeled as such, accompanied by their statistical weights- 6,12,2 which multiply their quadratic contributions.

"Feynman would do his work, not on block paper, but on paper laying around" (Physicist John Archibald Wheeler, Feynman's collaborator and PhD advisor at Princeton, in: Sykes, Christopher *No Ordinary Genius: The Illustrated Richard Feynman,* p. 47)

$ 5,000-8,000



78

79

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

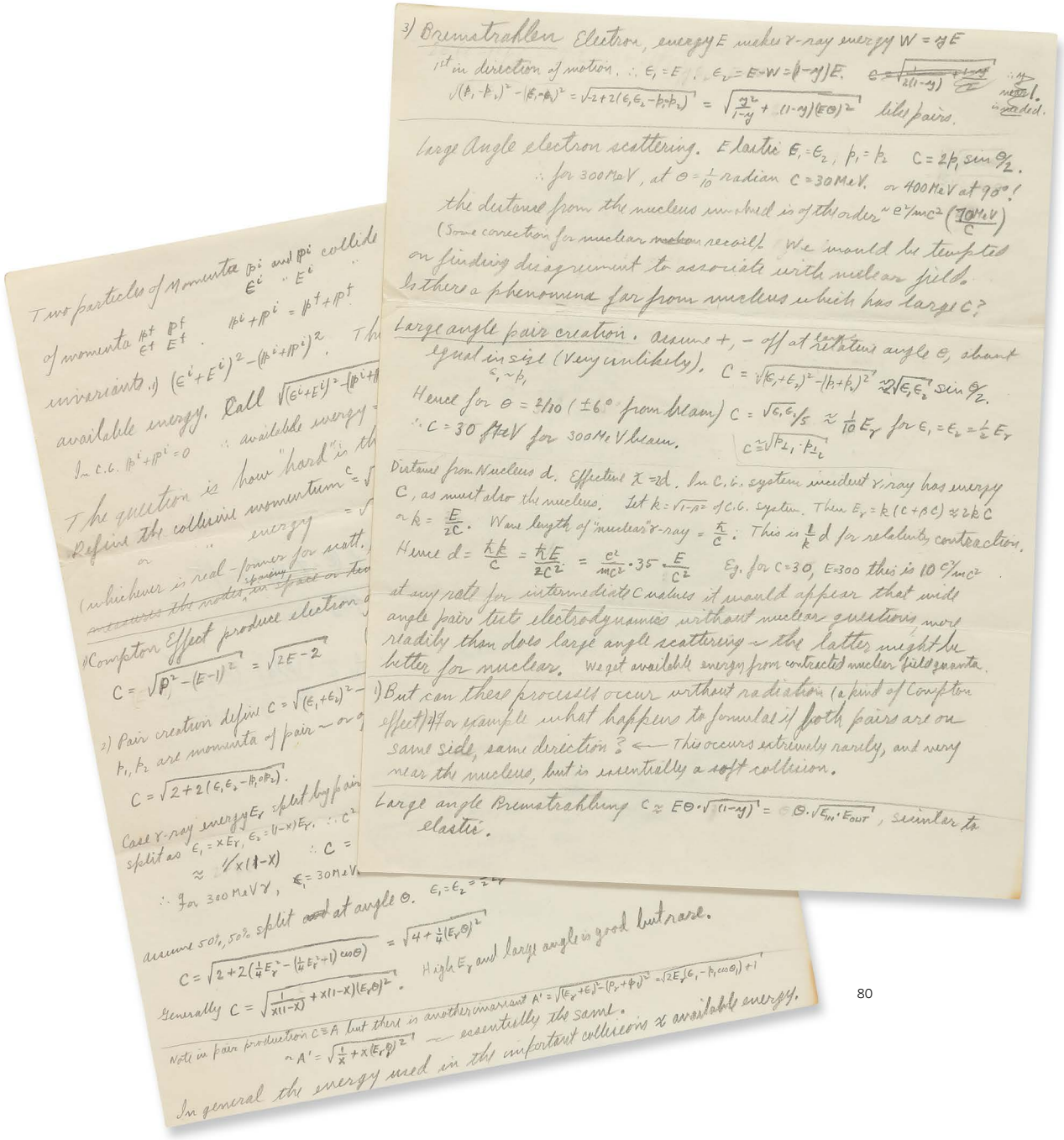
[FEYNMAN, RICHARD P.] RICHARD FEYNMAN'S TAMBOURINE ACQUIRED IN BRAZIL, CA 1951

An 11 inch diameter *Pandeiro,* wood, metal, and goat skin. Skin torn from use. SIGNED BY RICHARD FEYNMAN "R.P. FEYNMAN. HOTEL MIRAMAR / COPACABANA, RIO."

FEYNMAN'S TAMBOURINE FROM BRAZIL, SIGNED BY HIM. Feynman spent a sabbatical year in Brazil as a lecturer at the Brazilian Center for Physics Research. He lived in the Miramar Hotel while he was there, and not only taught himself Portuguese, but learned to play in a samba band. "There was a man at the U.S. Embassy who knew I liked samba music. I think I told him that when I had been in Brazil the first time, I had heard a samba band practicing in the street, and I wanted to learn more abut Brazilian music. He said a small group, called a "regional," practiced at his apartment every week, and I could come over and listen to them play.... One guy had a tambourine that they called a *pandeiro,* and another guy had a small guitar. I kept hearing the beat of a drum somewhere, but there was no drum! Finally I figured out that it was the tambourine, which the guy was playing in a complicated way, twisting his wrist and hitting the skin with his thumb. I found that interesting, and learned to play the *pandeiro*, more or less." (Richard Feynman, *"Surely You're Joking Mr. Feynman!"* p. 235)

$ 3,000-5,000

79



80

80

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

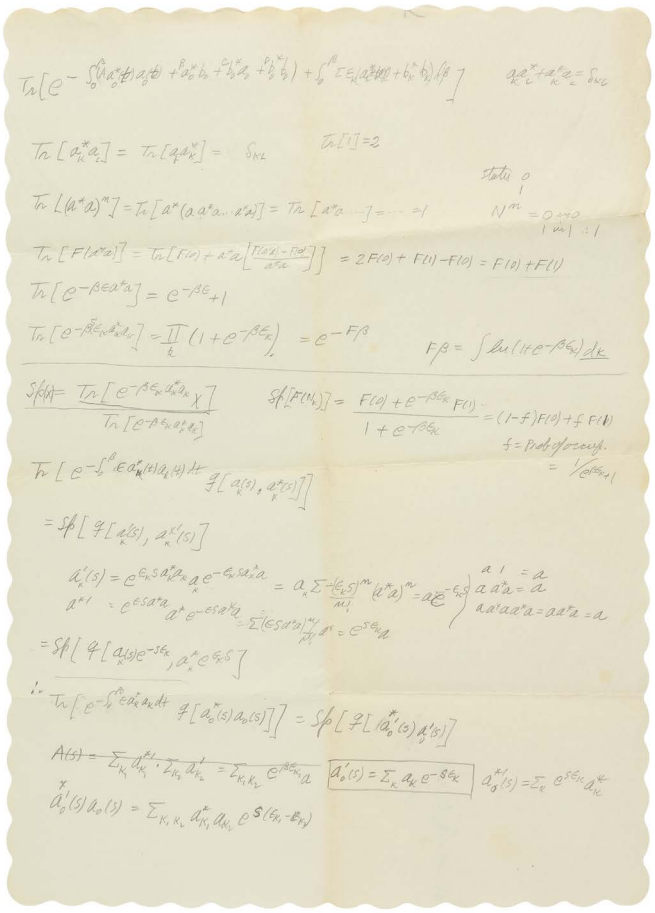
"*Two particles of momenta... collide. They produce final states of momenta... This is the square of the max available energy... The question is how "hard" is the collision?*", ca early 1950s.

Autograph manuscript, 3 pp (8 x 10½ in), in pencil on plain white paper, creases where previously folded.

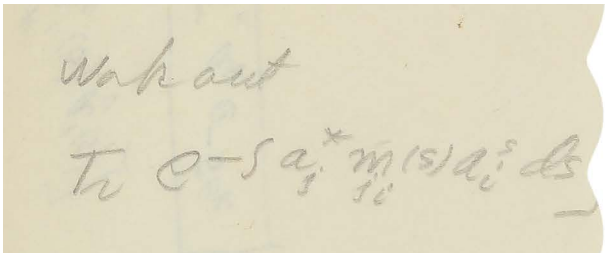
FEYNMAN ON THE KEY PHYSICAL PROCESSES THAT ARE THE HALLMARK TO THE SUCCESS OF QED; COMPTON EFFECT, PAIRS, & BREMSSTRAHLUNG.

An important pre-Nobel manuscript on Quantum Electrodynamics. Here, relying upon relevant energy-momentum 4-vectors as well as the underlying machinery of Einstein's Special Theory of Relativity, Feynman uses relativistic invariants to analyze the signature high-energy physical processes, involving electrons & gamma rays, which constitute important experimental tests of QED.

$ 12,000-18,000



81



81, VERSO (DETAIL)

81

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"*Work out T_r e-fa^*_i...*", ca 1959.

Autograph manuscript, 2 pages (14 x 10 in), in pencil on recto and partial verso of white placemat with scalloped edges, creases where previously folded.

FEYNMAN'S OPERATOR CALCULUS ON A PLACE MAT FROM ONE OF HIS FAVORITE HANGOUTS, GIANONNI'S TOPLESS BAR, IN PASADENA, CA.

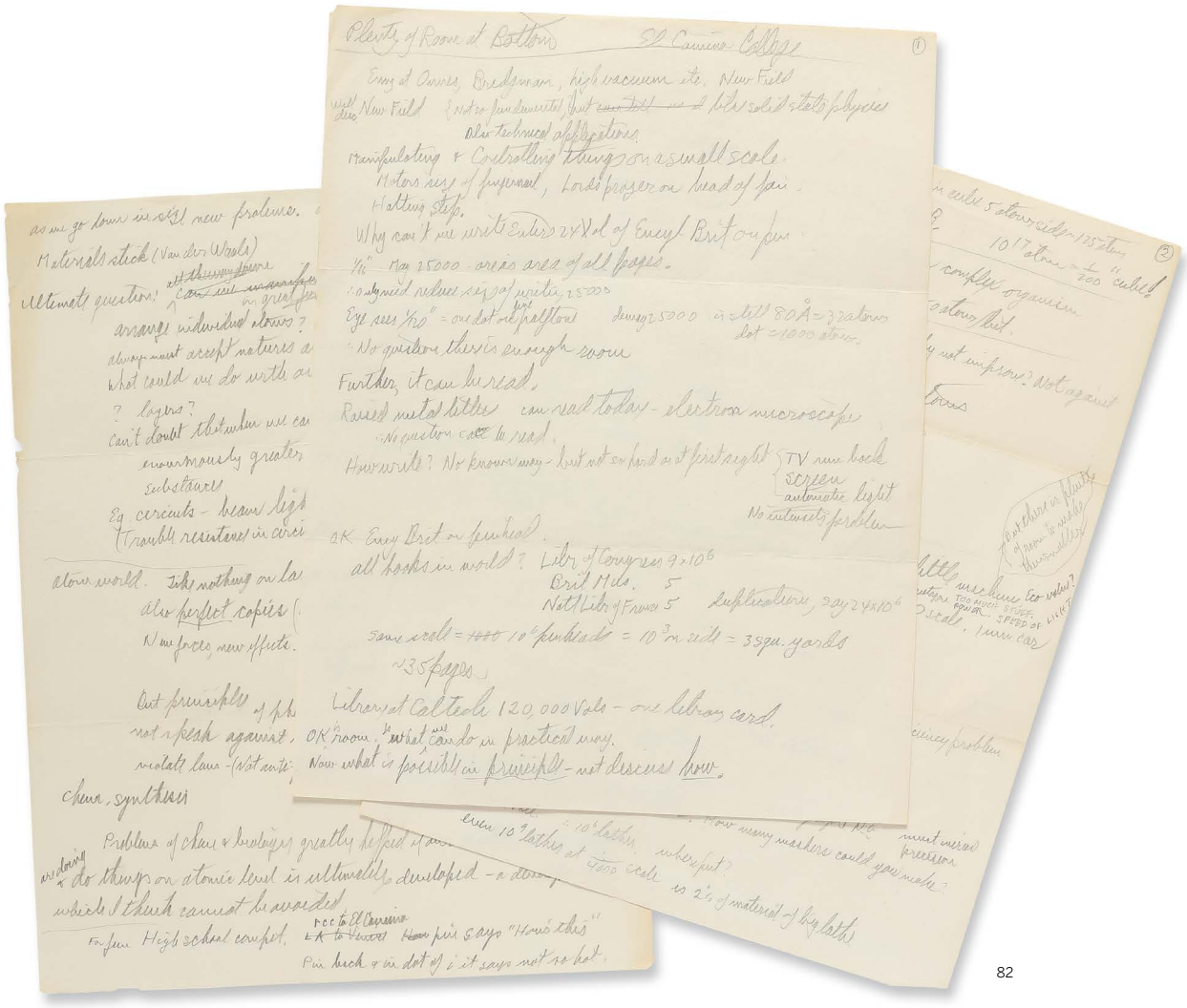
Gianonni's was one of Feynman's favorite hangouts, and it seems that their placemats were one of his preferred items on which to work out whatever physics problems were occupying his mind at the moment. In his own words:

"*There was a period when there were topless restaurants in town: You could go there for lunch or dinner, and the girls would dance without a top, and after a while without anything. One of these places, it turned out, was only a mile and a half away from my house, so I went there very often. I'D SIT IN ONE OF THE BOOTHS AND WORK A LITTLE PHYSICS ON THE PAPER PLACEMATS WITH THE SCALLOPED EDGES, AND SOMETIMES I'D DRAW ONE OF THE DANCING GIRLS OR ONE OF THE CUSTOMERS, JUST TO PRACTICE.*" (Richard Feynman, "*Surely You're Joking Mr. Feynman!*", p. 309)

His colleagues and students were well aware of Feynman's fondness for doing work at Gianonni's, including his doctoral student Richard Sherman: "*Sometimes Richard would suddenly say, "Let's knock off and go somewhere and fool around!" The usual place we went was a topless bar in Pasadena, called Gianone's (sic). There was always something happening at Gianone's in the afternoon, every day of the week. We'd walk in, grab a table. Feynman knew everybody there—all the ladies, Gianone the owner, and anybody who was a regular. He would go behind the bar and pick up an orange juice, because he never drank anything alcoholic. He would also grab a half-inch stack of those paper doilies, or place mats that they put down on tables in restaurants, and come back to the table. We might continue doing physics, or we might watch the ladies dancing on the stage. Frequently people would come by and chat, and this was the sort of entertainment that he liked. BUT IT WAS KIND OF DECEPTIVE BECAUSE, BELIEVE IT OR NOT, ALTHOUGH THIS PARTICULAR ENVIRONMENT MIGHT NOT SEEM CONDUCIVE TO DOING SOMETHING LIKE THEORETICAL PHYSICS, OVER THE YEARS, FEYNMAN ACTUALLY DID AN ENORMOUS NUMBER OF CALCULATIONS IN THAT PLACE.* " (Richard Sherman, in: Christopher Sykes, *No Ordinary Genius: The Illustrated Richard Feynman,* pp 100-101)

Distracted perhaps by the setting, Feynman's riffs here pertain mainly to his Operator Calculus, an elegant & powerful mathematical shorthand he had invented for QED, where proper ordering of noncommuting objects is essential; underlying formal work was published in a much-cited 1951 Physical Review paper the year he was in Brazil, before heading to Caltech. It is likely that Feynman's creation of Operator Calculus owes its inspiration, in part, to his learning Umbral ("shady"; i.e., from the "Dark Side") Calculus as a precocious Far Rockaway teenager fascinated by Faulhaber's Power Sums & the magical Bernoulli numbers encountered therein. Regrettably, not standard fare in college calculus courses these days...

$ 10,000-15,000



82

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"*Plenty of Room at Bottom*," ca, 1959.

Autograph manuscript, 3 pp (8½ x 11 in), in pencil on plain white paper, creases where previously folded, being a draft of his famous lecture "There's Plenty of Room at the Bottom: An Invitation to Enter a New Field of Physics," originally given at the annual American Physical Society at Caltech on December 29, 1959. This draft was apparently prepared for a version of the talk given at El Camino College, in Torrance, Ca.

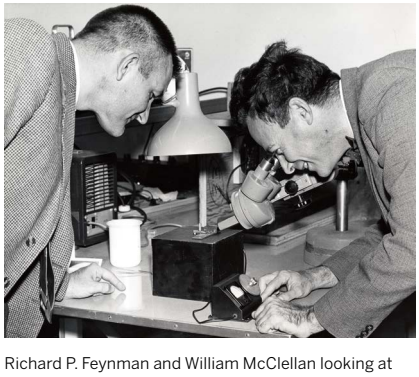
THE BIRTH OF NANOTECHNOLOGY. In his famed address, Feynman imagined "that we could arrange atoms one by one, just as we want them," and in this spirit he posed two challenges that would lead to the development of the field of Nanotechnology, offering $1,000 dollars each to whomever could 1) construct a tiny motor (achieved much to Feynman's surprise by Caltech grad William McClellan in 1960), and 2) to whomever could fit the entire *Encyclopedia Brittanica* on the head of a pin. The second challenge was met in 1985 by Tom Newman, a graduate of Stanford University.

From the published transcript of the talk given at the annual meeting of the American Physical Society, given December 29, 1959 at Caltech: "*I would like to describe a field, in which little has been done, but in which an enormous amount can be done in principle...What I want to talk about is the problem of manipulating and controlling things on a small scale.... They tell me about electric motors that are the size of the nail on your small finger. And there is a device on the market, they tell me, by which you can write the Lord's Prayer on the head of a pin... It is a staggeringly small world that is below. In the year 2000, when they look back at this age, they will wonder why it was not until the year 1960 that anybody began to move seriously in this direction...*"

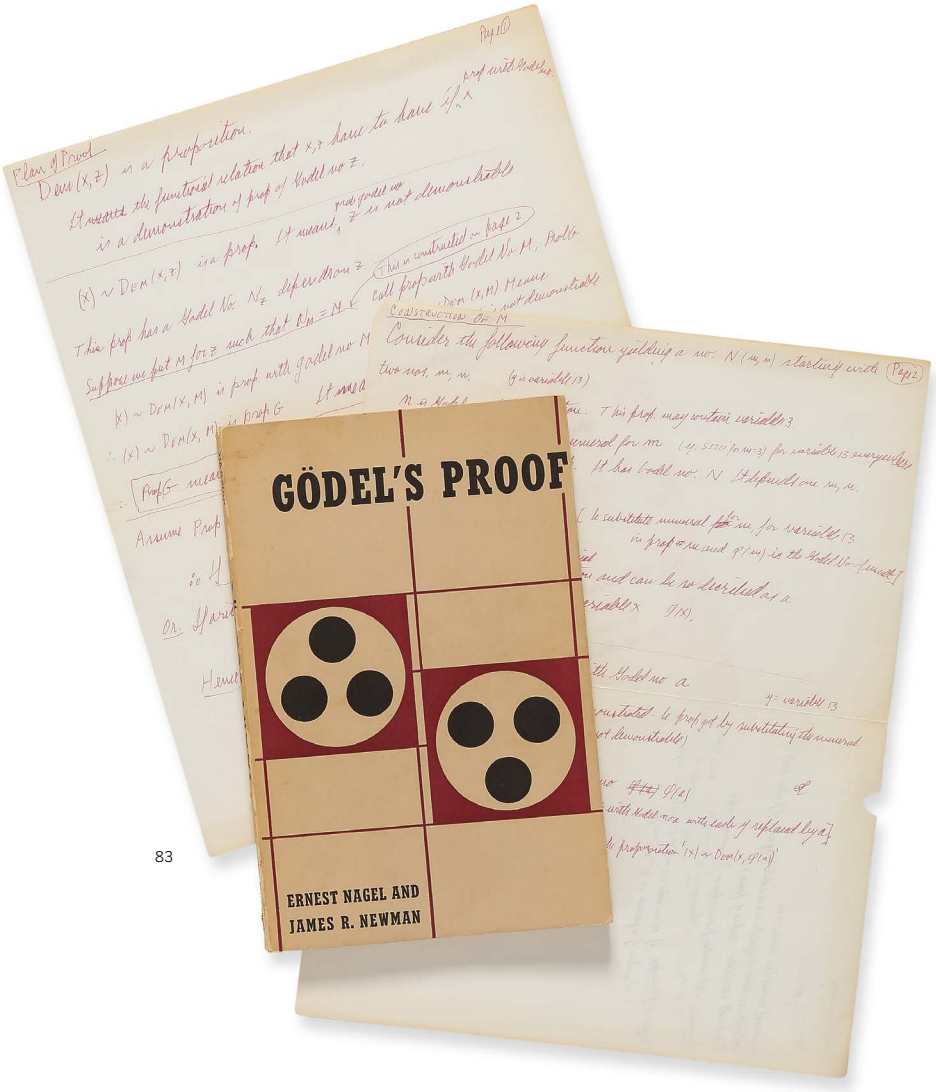
REFERENCES

see Philip Ball, "Feynman's Fancy" In: *Chemistry World*, January 2009, pp 58-62

$ 20,000-30,000



Richard P. Feynman and William McClellan looking at the "World's smallest motor" designed by McLellan in response to Feynman's challenge, ca 1960. (Photo by McClanahan. Courtesy of the Archives, California Institute of Technology)



83

83

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P. & KURT GÖDEL

"PLAN OF PROOF. Dem (x, z) is a proposition. It means the functional relation that x, z have to have if ^ prop with Godel no. x is a demonstration of prop of Godel no z...", ca. 1960.

Autograph manuscript, 2 pp (8½ x 11 in), red ink on plain white paper, creases where previously folded, some small chips and toning to fore-edge, apparently being notes for a lecture on logic at Caltech.

WITH: [GÖDEL, KURT] Ernest Nagel & James R. Newman. *Gödels' Proof.* New York: New York University Press, 1960. SIGNED TWICE BY FEYNMAN, *"R.P. Feynman / Cal. Instit. of Tech./ Pasadena, Ca. / 1-213-797-1262."* (in pen on fly-leaf), and *"R.P. Feynman / Cal. Instit. of Tech"* (in pencil on half-title). With several marginal autograph annotations by Feynman, in both pen and pencil.

A LEGENDARY PHYSICIST'S THOUGHTS ON THE WORK OF A LEGENDARY MATHEMATICIAN; FEYNMAN ON KURT GÖDEL'S FAMED INCOMPLETENESS AND COMPLETENESS THEOREMS.

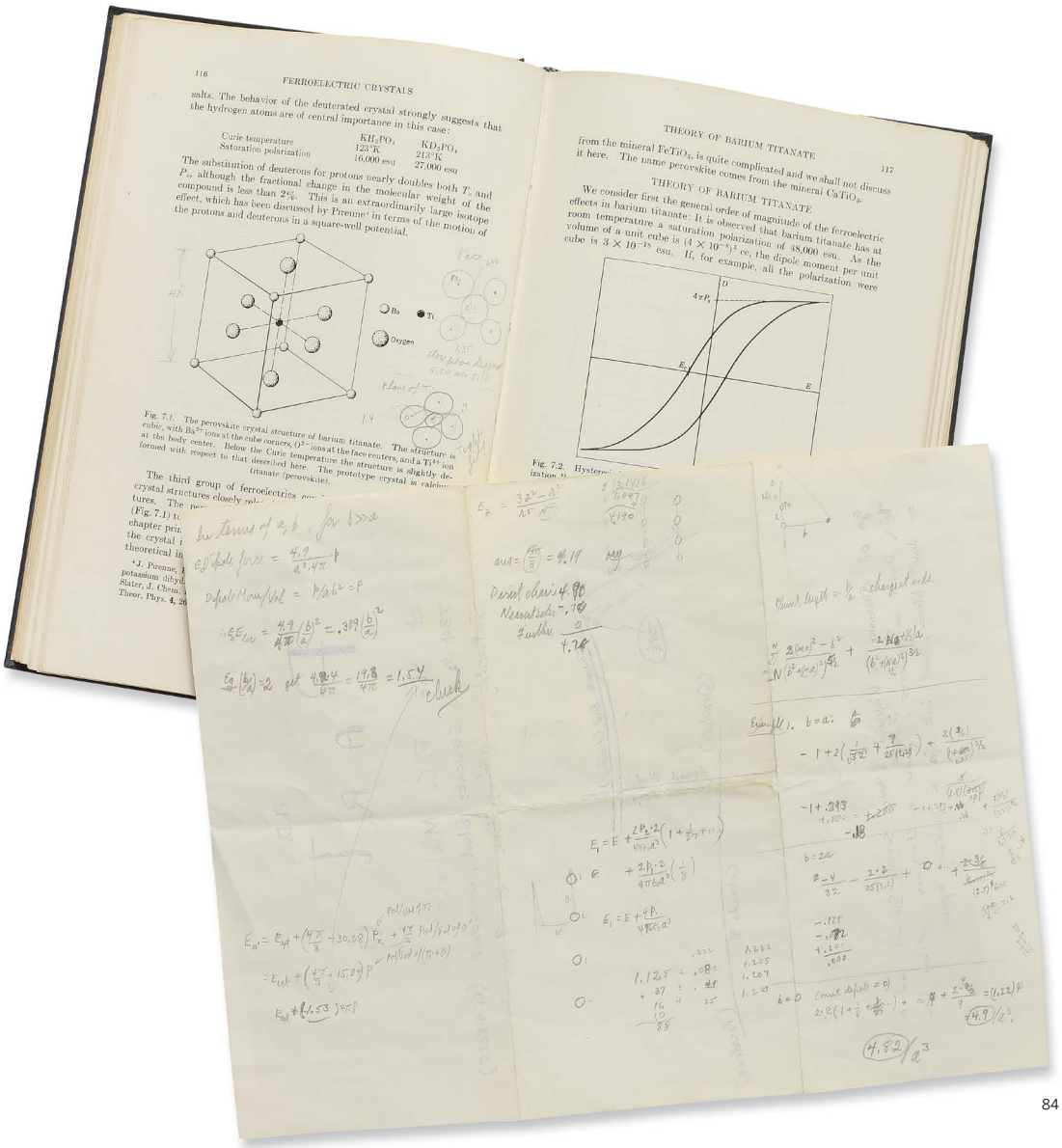
In his revolutionary paper "Über formal unentscheidbare Sätze der Principia Mathematica und verwandter Systeme I," Gödel introduced his Incompleteness Theorem, which "showed that even powerful logical systems could not hope to encompass the full scope of mathematical truth." Gödel showed that, for any axiomatic system powerful enough to describe the natural numbers 1: If the system is consistent, then it cannot be complete, and 2: the consistency of the axioms cannot be proven within the system. Just a year earlier, Gödel had published "Die Vollständigkeit der Axiome des logischen Funktionenkalküls," a concise version of his 1929 doctoral thesis, in which he gave the first proof of his Completeness theorem, showing that the axiomatic system of logic is complete.

Known in English as "On formally Undecidable Propositions in Principia Mathematica and Related Systems I," and "The Completeness of the Axioms of the Functional Calculus of Logic" the papers had an enormous impact on the fields of mathematics, computer science, and philosophy. Von Neumann said of them: "Kurt Gödels' achievement in modern logic is singular and monumental. Indeed it is more than a monument, it is a landmark which will remain visible far in space and time. The subject of logic has certainly completely changed its nature and possibilities with Gödel's achievement." (Halmos)

At this stage in his life, Feynman had no need to work out Gödel's proof for himself, so was likely preparing to explain to proof to his students; one of the several annotations in the book made by Feynman includes the underlined of the sentence *"Gödel showed (i) how TO CONSTRUCT AN ARITHMETICAL FORMULA G THAT REPRESENTS THE META-MATHEMATICAL STATEMENT: 'THE FORMULA G IS NOT DEMONSTRABLE'"* noting in the margin *"This is the hard part. All the rest of the steps are easy and evident."*

Kurt Gödel, along with Feynman's co-Nobelist Julian Schwinger, was the first of only 13 recipients of the Albert Einstein Award. Feynman was the third recipient.

$ 10,000-15,000



84

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"*In terms of a, b, for b≫a ∈ dipole force=....*", ca 1962.

Autograph manuscript, 1 p, (8½ x 11 in), in pencil on verso of an invitation flyer to a PhD party for prominent astrophysicist and NASA astronaut Frank Curtis Michel, who received both his BS and PhD degrees (in 1962) in physics at Caltech.

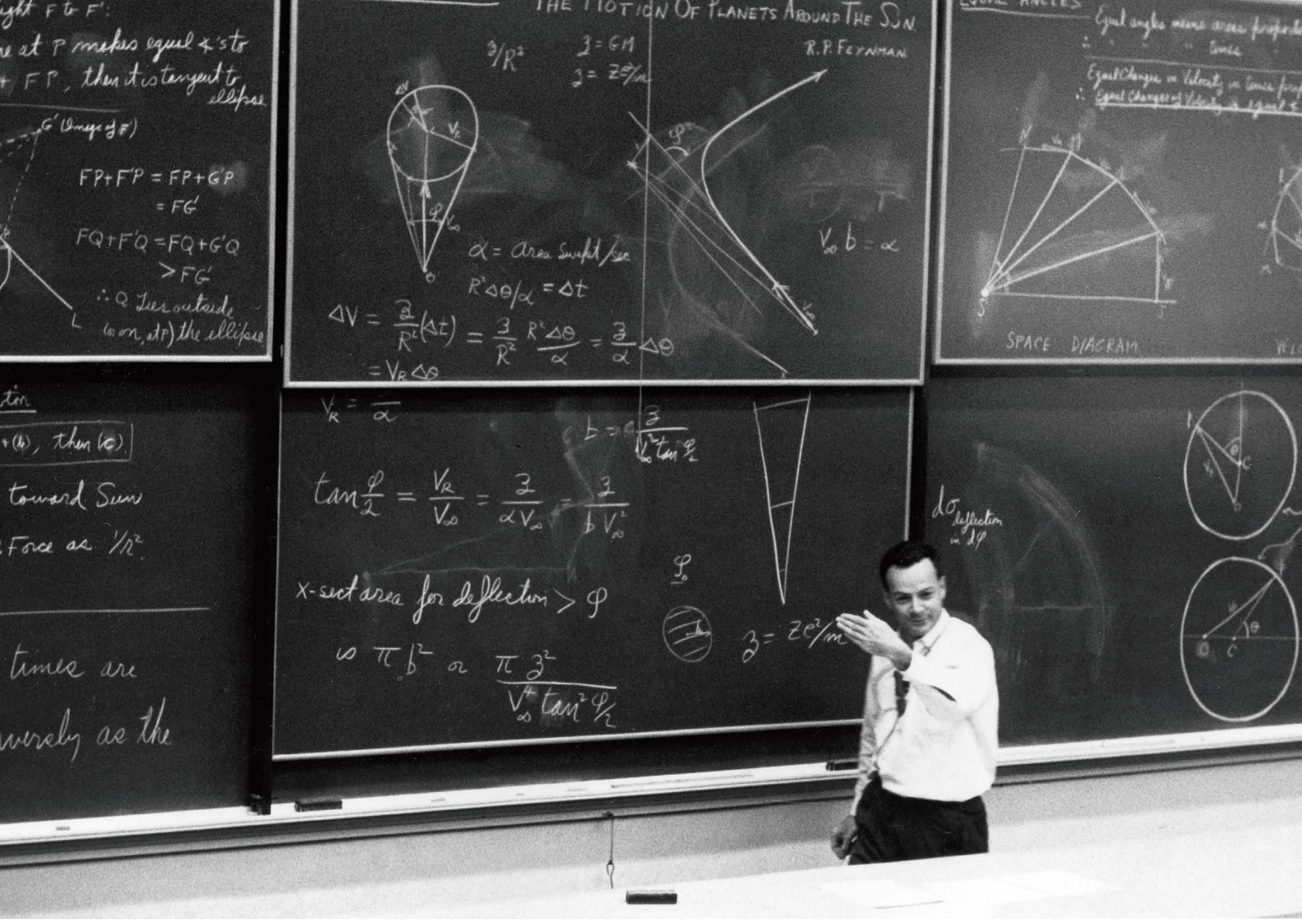
WITH: KITTEL, CHARLES. *Introduction to Solid State Physics.* New York: John Wiley & Sons, [1953]. SIGNED "*R.P. FEYNMAN*" ON FRONT FLYLEAF, WITH DIAGRAMS AND NOTES IN FEYNMAN'S HAND TO PAGE 116.

Another excellent example of Feynman's habit of working out problems on the closest piece of paper at hand. The calculations on verso of invitation flyer involve summing over contributions of individual electric moments thereby determining, off-axis & on axis, the net electric field created by a one-dimensional crystalline lattice of dipoles.

Kittel's book, published by the Berkeley physicist in 1953 (shortly after Feynman had arrived at Caltech...), became the premier graduate-level [and research-grade] text in solid-state physics for the next 25+ years. Post-QED success, and amidst the excitement the new semiconductor & transistor physics in the mid-50's, Feynman went hunting for new types of problems to work on. It was during this period that he published his celebrated paper "Slow Electrons in a Polar Crystal," Phys. Rev. **97**, 660 (1955), which utilized his favorite versatile trick of the Variational Method, beautifully handled later with great pedagogical detail as Ch. 8- "The Polaron Problem," in his advanced text on *Statistical Mechanics* (lot 91). This is a gorgeous bit of solid-state physics & it is no surprise, at all, that Kittel was his "go-to" solid-state book at this time.

The notes made by Feynman in Kittel pertain to a diagram showing the perovskite crystal structure of barium titanate.

$ 3,000-5,000



Richard P. Feynman delivering his lecture "The Motion of the Planets around the Sun" at Caltech, March 13, 1964. (Courtesy of the Archives, California Institute of Technology)

85

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"1. *Equal areas in equal times...* [diagrams] *2. Equal areas in equal times. Motion in times proportional to area. Equal angles in time prop. to square of radius...",* ca. 1964.

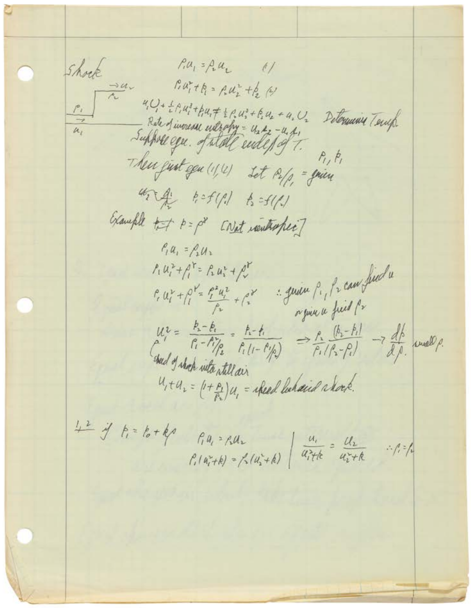
Autograph manuscript, 6 pp (8½ x 11 inches), in black ink on green hold-punched graph paper, some creases at lower edges, the first page likely being lecture notes for a freshman lecture on physics at Caltech, and the last 55 pages being an early draft for Feynman's so-called "Lost Lecture", "The Motion of the Planets around the Sun."

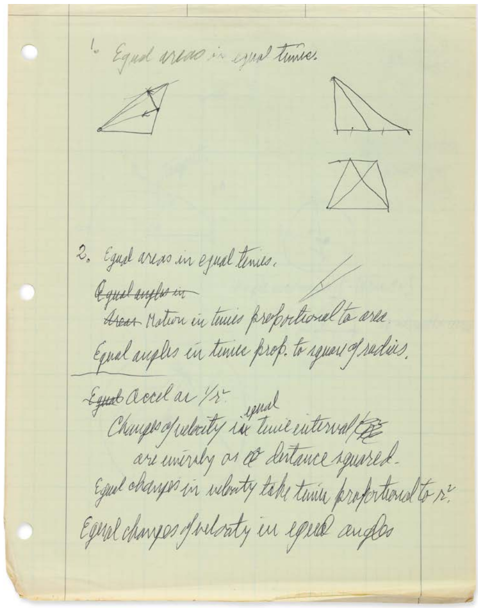
LECTURE NOTES, INCLUDING AN EARLY DRAFT FOR FEYNMAN'S SO-CALLED "LOST LECTURE", "THE MOTION OF THE PLANETS AROUND THE SUN", CA 1964.

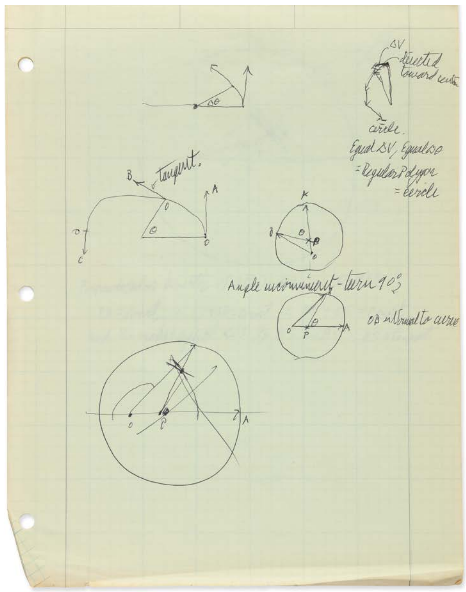
In March of 1964, Feynman was asked to give a guest lecture to the freshman class at Caltech. The lecture focused on Isaac Newton's geometric demonstration of the law of the ellipses, from the *Principia Mathematica.* Delivered in Feynman's totally original manner, he included his own proof of Kepler's laws of ellipses, using only plane geometry to do so. The lecture was recorded and transcribed, but was among the few that were not included in the epic three volume set *The Feynman Lectures on Physics.*

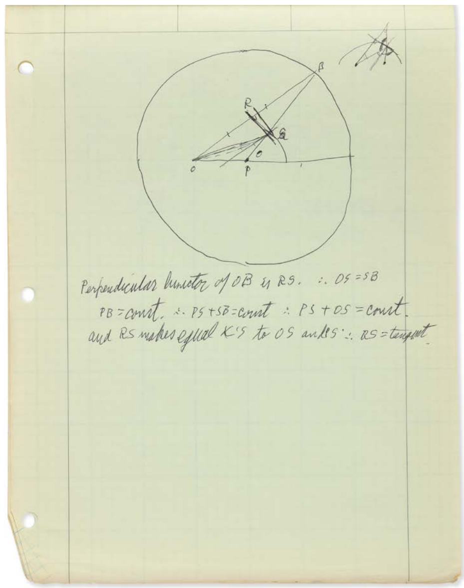
The first page of the manuscript appears to be notes for a lecture on the subject of hydraulic shock, and includes some detailed calculations, while the other five pages are all dedicated to diagrams, calculations, and explanations included in Feynman's lecture on planetary motion. Indeed these notes would appear to be more extensive than those written about in *Feynman's Lost Lecture* by Goodstein & Goodstein.

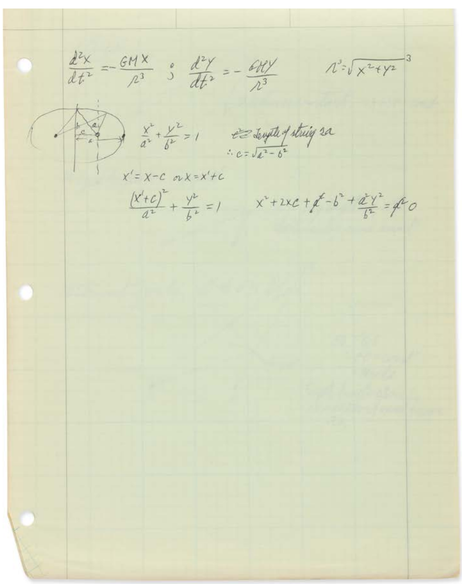
$ 20,000-30,000

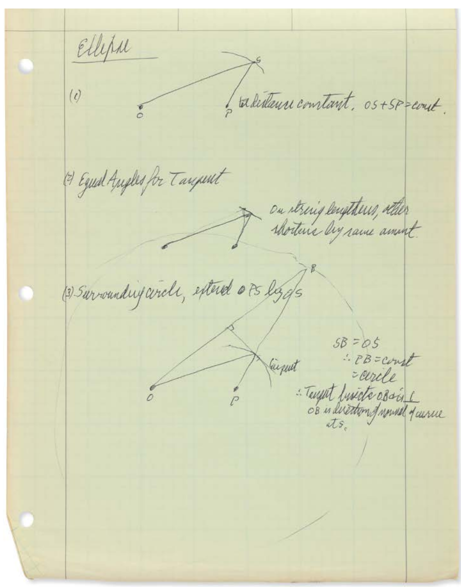

Shock
Determine Temp.
Example
[Not isentropic]

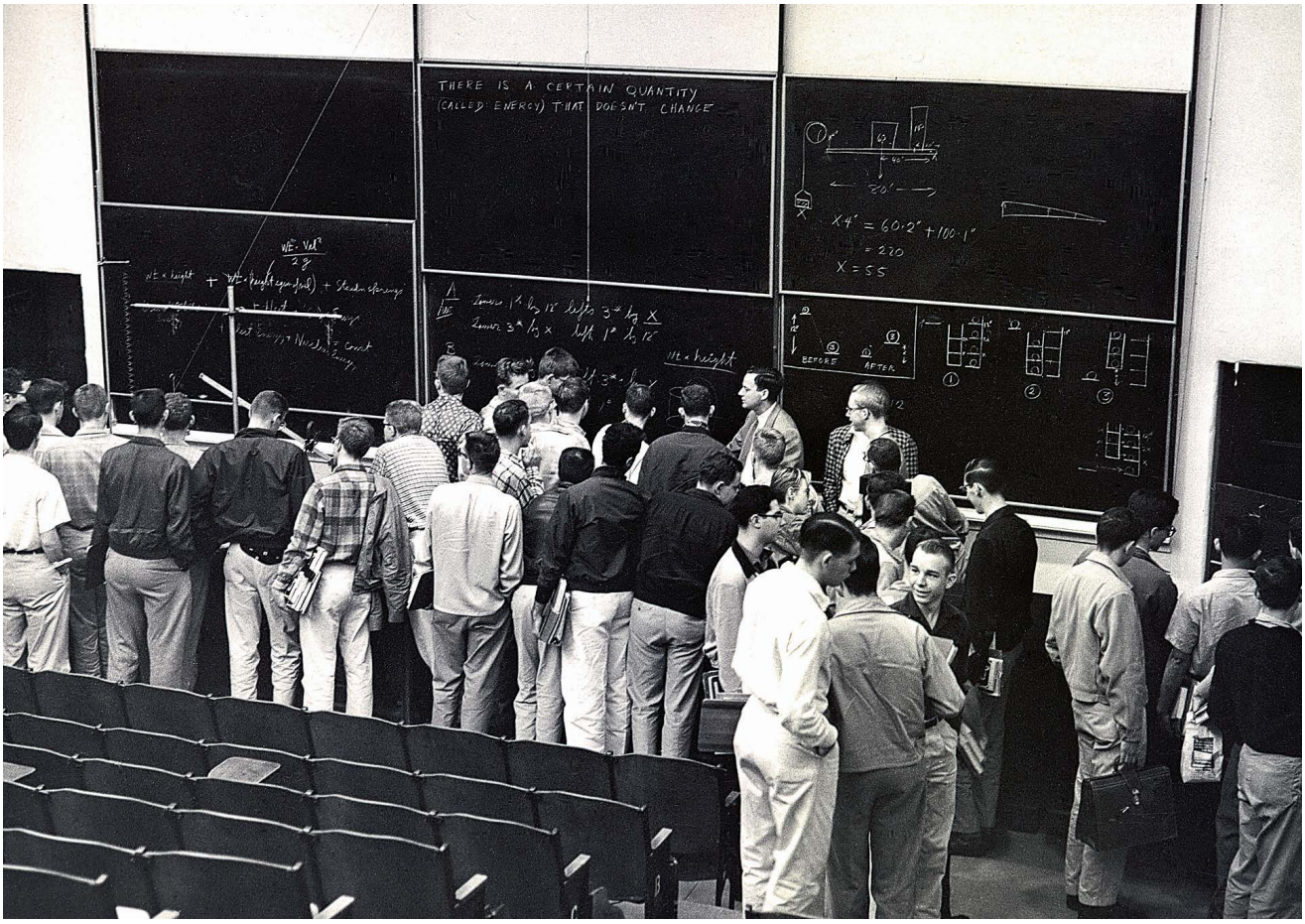

1. Equal areas in equal times.
2. Equal areas in equal times.
Equal angles in
Areas Motion in times proportional to area.
Equal angles in times prop. to square of radius.
Equal Accel as 1/r².
Changes of velocity in equal time interval
are inversely as distance squared.
Equal changes in velocity take times proportional to r².
Equal changes of velocity in equal angles


tangent.
directed toward center
circle.
Equal ΔV, Equal Δθ
= Regular Polygon
= circle
Angle increment - turn 90°
OB is normal to curve


Perpendicular bisector of OB is RS. ∴ OS = SB
PB = const. ∴ PS + SB = const ∴ PS + OS = const.
and RS makes equal ∠'s to OS and PS ∴ RS = tangent




Ellipse
(1) Sum of distances constant. OS + SP = const.
(2) Equal Angles for Tangent
(3) Surrounding circle, extend OPS to
SB = OS
∴ PB = const
= circle
tangent



Richard P. Feynman in classroom with students, ca. 1961. (Courtesy of the Archives, California Institute of Technology)

86

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"*Lecture Hughes. 11/2?/68. Sugars. Hayworth model* [diagrams] *Glucose.* [diagram] *Fructose* [diagram]...", 1968.

Autograph manuscripts, 22 pp on 20 sheets (8½ x 11 in) in black ink, blue ink, & pencil, on yellow ruled paper (2 sheets), white ruled paper (2 sheets), plain white paper (15 sheets), and 1 sheet of Altadena Tournament of Roses Association Letterhead (of which Feynman was the 1st Vice President). Being notes for the Hughes Lectures in Biology, Organic Chemistry, and MicroBiology, given at Hughes Aircraft Company, in Los Angeles, California from October 1969-May 1970.

A WONDERFULLY DETAILED SERIES OF LECTURE NOTES ON ORGANIC CHEMISTRY AND BIOLOGY, FULL OF DIAGRAMS, FROM A SERIES OF LECTURES GIVEN ON HUGHES AIRCRAFT COMPANY IN LOS ANGELES, CA.

From 1966 to 1971, Feynman delivered a series of lectures at Hughes Aircraft Company at their Research labs in Malibu. Hughes Aircraft was a military contractor, for whom Feynman consulted, including advising on a neural-net project that was sponsored by the Department of Defense (*Genius* p. 406). The lectures focused primarily on physics, including astrophysics, astronomy, electrodynamics, quantum mechanics, and engineering, but in the lectures given from October 1969-May 1970, Feynman decided to turn his focus to organic chemistry and biology. This was a topic that was outside Feynman's usual area of expertise, and the notes show that he worked out several topics and diagrams multiple times before lecturing on them.

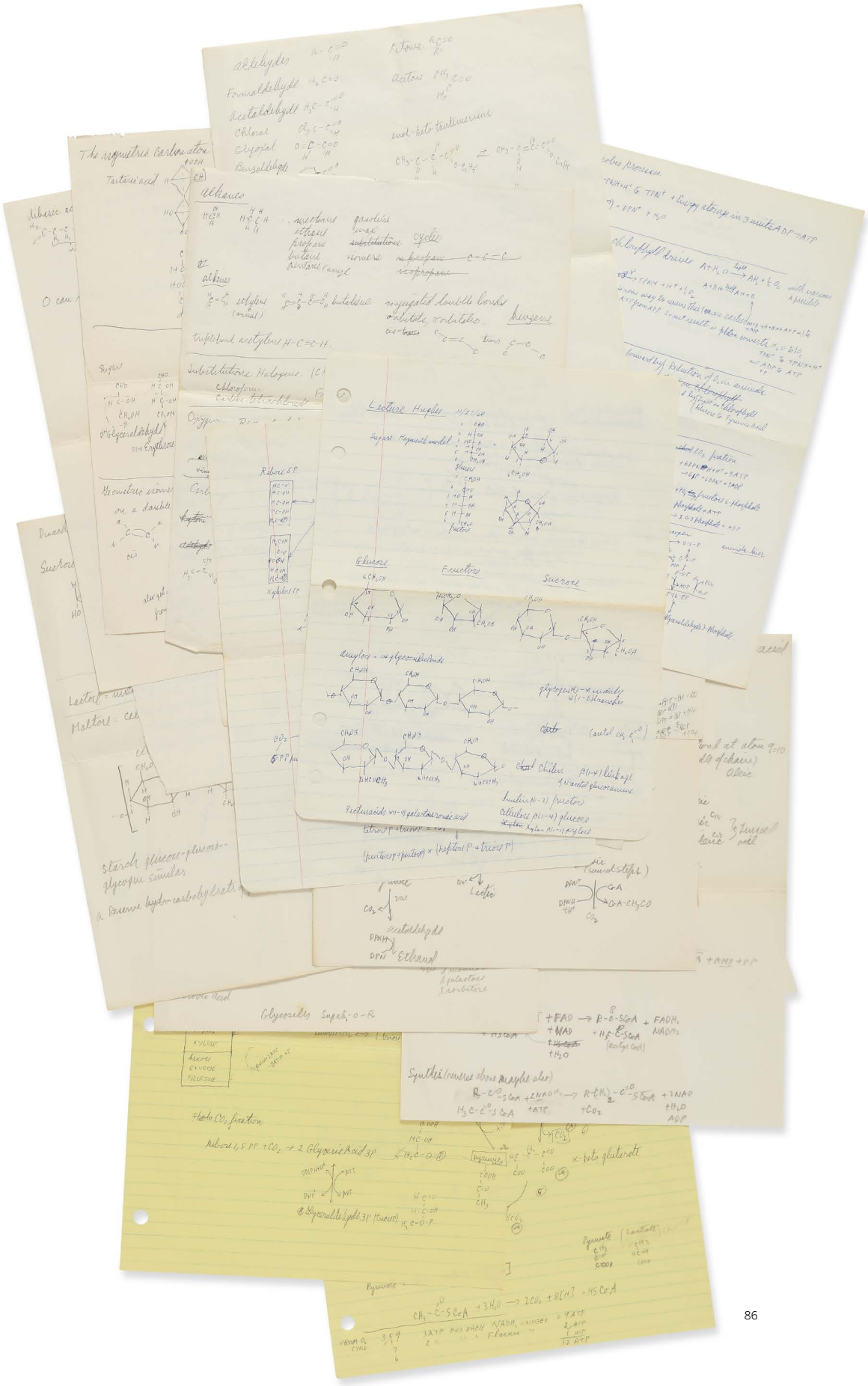
The present manuscripts correspond roughly with the first 25 pages or so of John T. Neer's excellent transcription of the notes he took while attending the Feynman-Hughes lectures, with Feynman covering topics such as alkanes, aminos, geometric isomersion, sugars, carbohydrates, aerobic processes, disacharides, the Citric Acid cycle, the respiration chain and much more, with a large portion of the notes devoted to diagrams, chemical structures, and the like. It is interesting to note that while Neer dates the lectures on Biology to October 1969-May 1970, Feynman has titled and dated one of the pages "*Lecture Hughes 11/2?/68.*"

REFERENCES

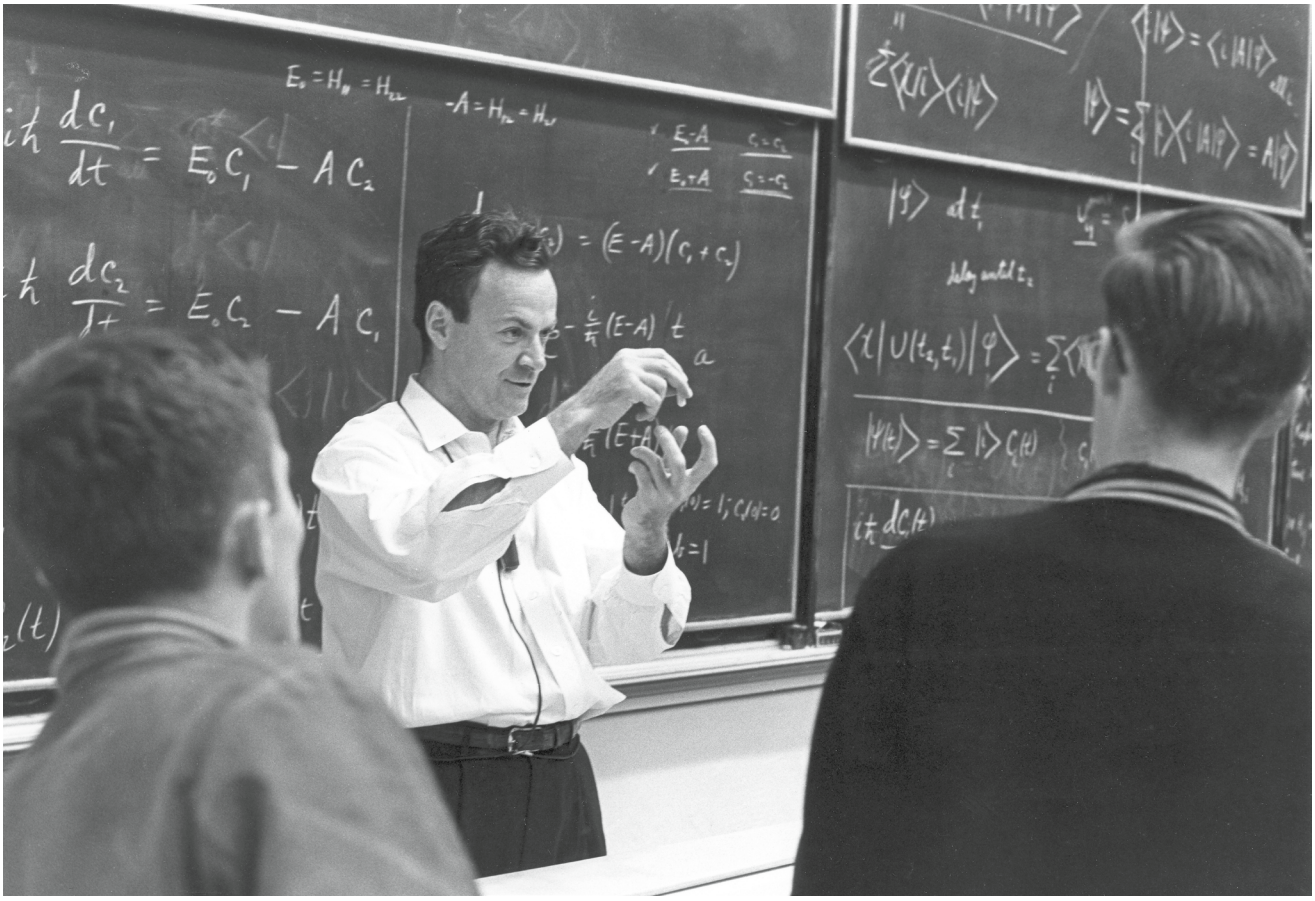
For John T. Neer's transcriptions of the notes he took while attending the Feynman-Hughes lectures, see: http://www.thehugheslectures.info/the-lectures/

For an excellent interview of John T. Neer on how the Feynman Hughes lectures affected him, see http://www.hrl.com/podcast/2017/12/18/episode-002-john-neer

$ 20,000-30,000



86



Feynman delivering his lecture "The Hamiltonian Matrix", one of the Feynman Lectures on Physics series, May 2, 1963. (Courtesy of the Archives, California Institute of Technology)

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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"DIRAC EQU.[ATION] *H ATOM... SCHRODINGER... KLEIN GORDON...*", 26 February, 1969.

Autograph manuscript, 4 pp (8½ x 11 in), in pencil on plain white paper, 26 February, 1969.

FEYNMAN EXAMINES THE RELATIVISTIC FINE STRUCTURE OF HYDROGEN VIA THE DIRAC, SCHRÖDINGER, AND KLEIN-GORDON EQUATIONS.

Written while at Caltech, in February of 1969, the present manuscripts are possibly notes for a graduate course in quantum physics, parsing the differences in these canonical quantum equations, explicitly solving them in the context of the H-atom. Next to the solution for the Dirac equation, he notes:

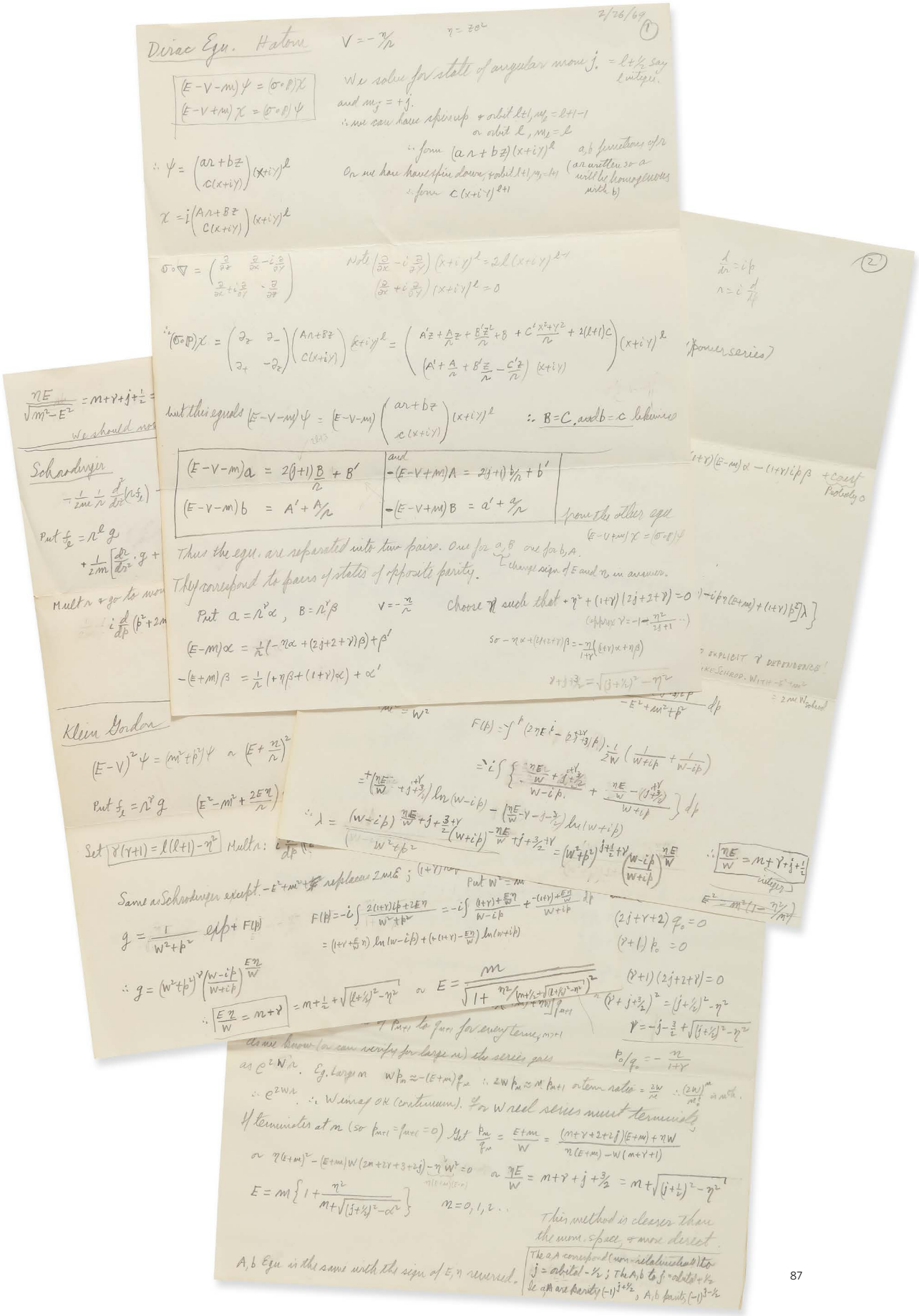
"*WOW. NO EXPLICIT* ɣ *DEPENDENCE! LOOKS LIKE SCHROD*[INGER]*....".* Under the Schrödinger section he points out "*Exactly like Dirac, except for sign...",* and in the Klein Gordon section, he notes "*Same as Schrödinger, except...*"

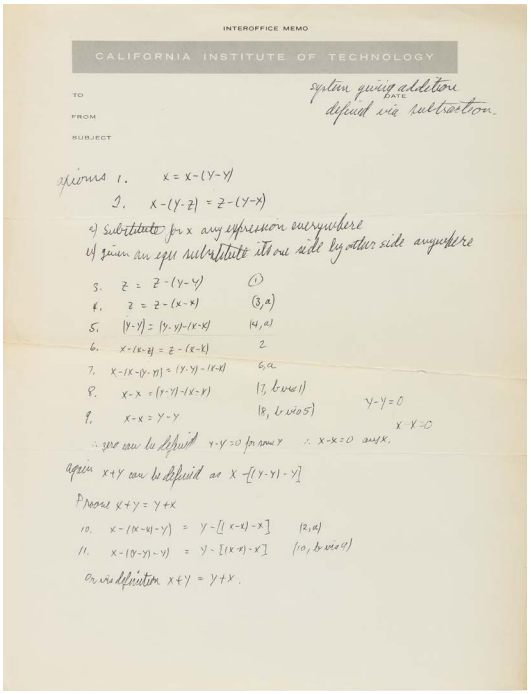
Among the most significant manuscript lots in this Sale, the trifecta of Dirac, Schrödinger, & Klein-Gordon illustrates Feynman's craft, deft hand and creative pedagogy at its finest hour.

Paul Dirac, who shared the 1933 Nobel Prize in Physics with Schrödinger, was Feynman's greatest hero and had thoroughly captured the imagination of the young MIT undergraduate, who had purchased Dirac's classic, *The Principles of Quantum Mechanics* as a teenager, but found it nearly impenetrable, though a tremendous inspiration (see lot 100). The intellectual legacy of this early inspiration was Feynman's QED Nobel Prize itself; Dirac deserves full credit for that. Nevertheless, the Klein-Gordon equation also figures quite prominently in the folklore of Feynman, who had dueled with MIT classmate Ted Welton on the matter of this field-theoretic alternative to the Dirac equation during their wunderkind Knabenphysik ("Boy Physics") days of Summer 1936 (Gleick, p. 74).

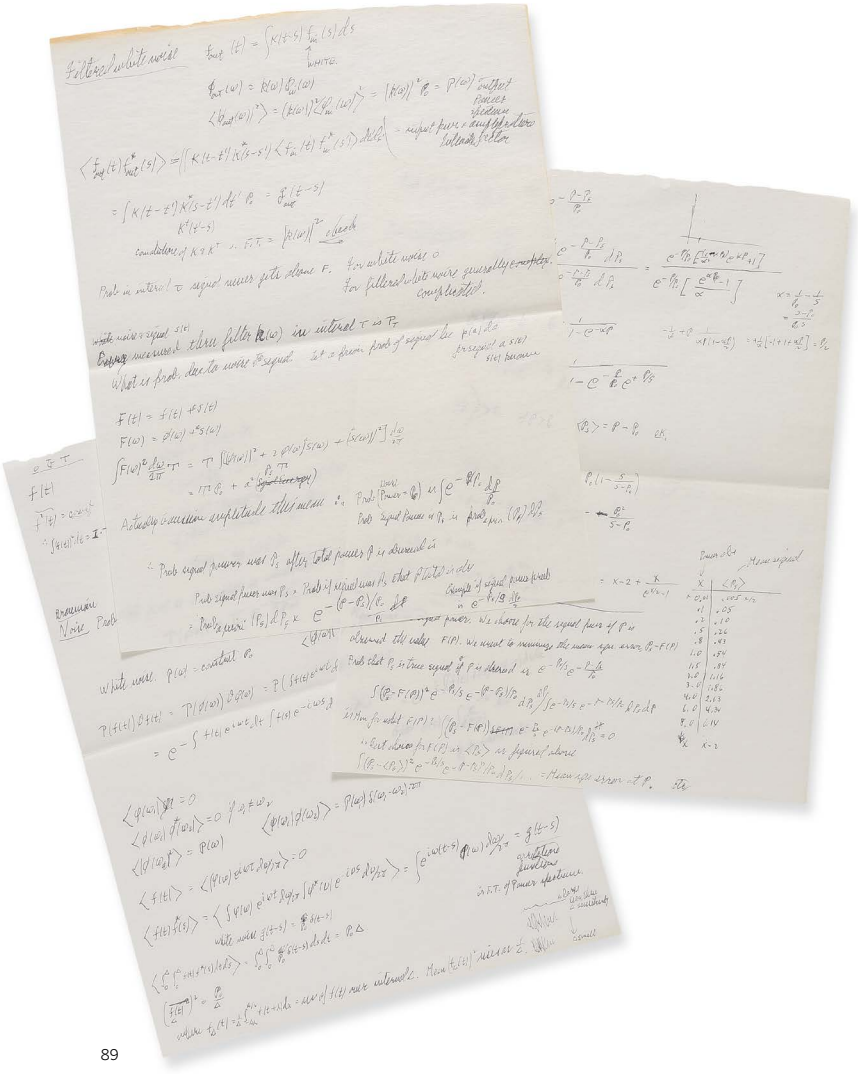
The derivations presented, which tease out intricate details of the relativistic fine-structure in the H-atom (so-called "spin-coupling" interaction) have antecedents in the early work of Bohr & Sommerfeld on precessing elliptical orbitals, but are remarkable here for their particular Feynmanesque resonance. It must have been with great satisfaction, post-Nobel and 30 years past his MIT graduation, that Feynman returned to these particular calculations with his students.

$ 30,000-50,000


Dirac Eqn. Hatom
Schrodinger
Klein Gordon



88



89

88

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"System giving addition, defined via subtraction", ca 1969.

Autograph manuscript, 1 page (8 x 11 inches), in black ink on California Institute of Technology Interoffice Memo letterhead, creases where previously folded, some tanning and one small hole to fold.

Amusing sheet, post-Nobel, that nonetheless speaks to Feynman's lifelong love affair with arithmetic, algebra, and symbolic manipulation. Here, the goal being to establish the commutative law of addition in, if you will, the absence of addition. The playfulness of it all recalls much from his youth- when at Far Rockaway High School he crafted his own version of *Calculus for the Practical Man*; then, in the 1936 summer preceding his sophomore year at MIT, trading algebraic manifestos with his classmate Ted Welton in the notebook that they shared, mailing back & forth (see Silvan Schweber's *QED & The Men Who Made It*; e.g., Fig. 17 there). Even at Princeton, with Wheeler in 1941, their joint work on the "Absorber Theory of Radiation," (Rev. Mod. Phys. **17**, 157) a critical advance resulting from the seemingly preposterous algebraic gambit-

R = [1/2(R)+1/2(A)] + [1/2(R)-1/2(A)]

where R & A refer to Retarded & Advanced fields. While this decomposition is algebraically trivial, it had a highly nontrivial physical interpretation since the 1st term in square brackets was related to the electromagnetic mass of the charged particle while the 2nd bracketed term, *being asymmetrical in time,* made the only contribution to the force of radiative reaction. Shortly thereafter, in Los Alamos, in his time during the Manhattan Project, Feynman delivered a 'public' lecture on "Some Interesting Properties of Numbers," constructing his arithmetic axiomatically from the bottom up- *'He invited his distinguished audience ("all the mighty minds," he wrote his mother a few days later) to discard all knowledge of mathematics and begin from first principles- specifically, a child's knowledge of counting in units.'*- (Gleick, pp. 182-3). Those present included Oppenheimer, Bethe, Teller, etc- no ordinary 'public' lecture.

Unclear where Feynman's headed here, privileging subtraction over addition, but he no doubt enjoyed the diversion...

$ 3,000-5,000

89

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYN MAN, RICHARD P.

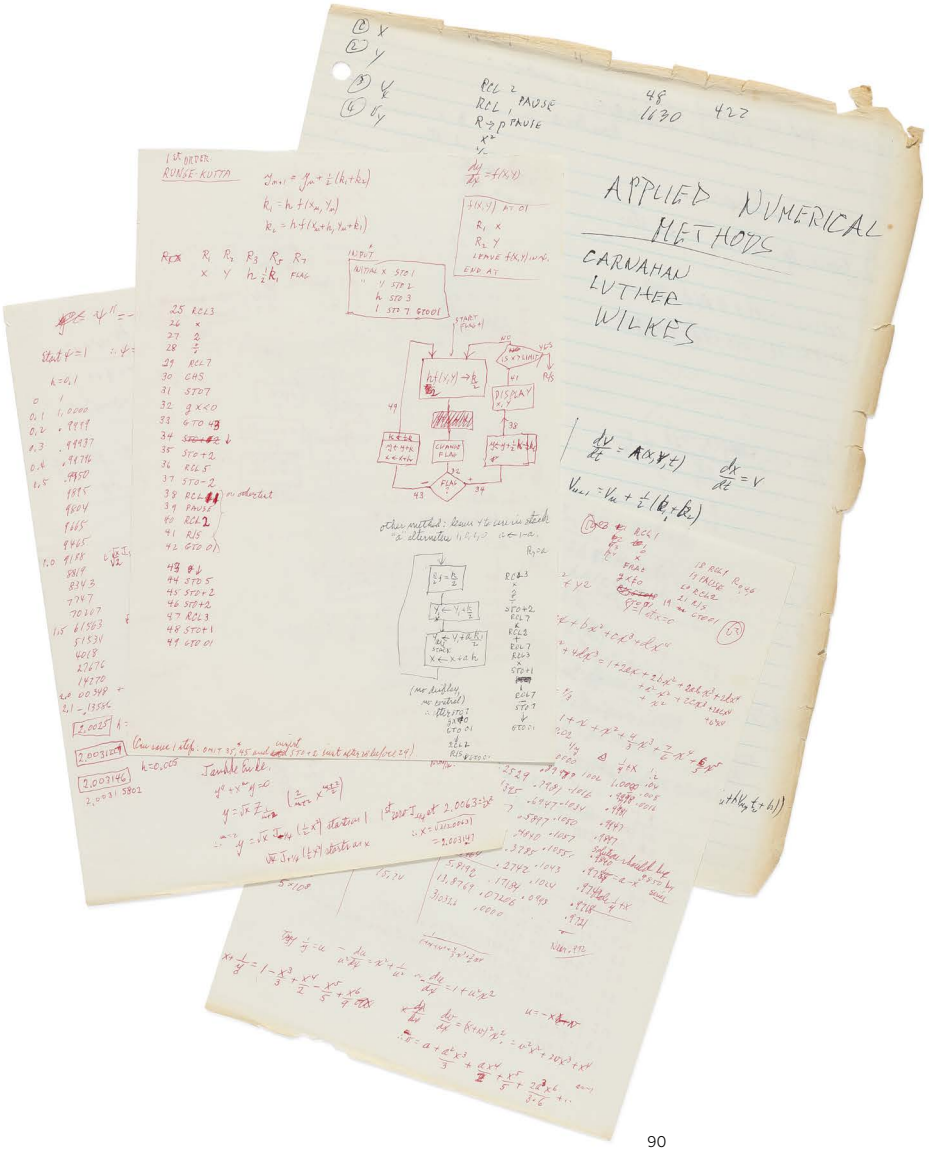
"NOISE Prob that ϕ(w) is ϕ (complex) is independent in each w...", ca 1970.

Autograph manuscript, 3 pp (8½ x 11 in) in black ink on white typewriter paper watermarked "Mead Erasable", likely being lecture notes for a graduate class taught at Caltech on mathematical methods of physics, ca. 1970.

WITH: MATHEWS & WALKER, *Mathematical Methods of Physics.* Menlo Park, Ca.: W. A. Benjamin, Inc., 1970. SIGNED "*R.P. FEYNMAN*" TO FLY-LEAF.

FEYNMAN ON FLUCTUATION THEORY & WHITE NOISE. The present highly detailed manuscript is very likely to be lecture notes for a course that Feynman taught on the mathematical methods of Physics at Caltech in the early 1970s. The Mathews & Walker text is well known even to this day and, with both Mathews and Walker being fellow faculty members at Caltech, it is not surprising that Feynman owned a copy. As the authors emphasize in the preface: "...this is a book *about mathematics, for physicists.*" Feynman no doubt heartily approved, given his predilections as a precocious teenager for "Calculus for the Practical Man," borrowed from the local library back home in Far Rockaway (Gleick, pp. 32-36.) The analysis herein invokes Fourier methods, as applied to temporal signal processing, investigating the effects of noise & fluctuations, its filtering, power spectra, etc.; classic fare in such a grad course. See Mathews & Walker, sect. 4-2, which makes quick work of Fourier, but ends with a quick derivation, using such tools, of Heisenberg's celebrated Uncertainty Relation.

$ 7,000-10,000



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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

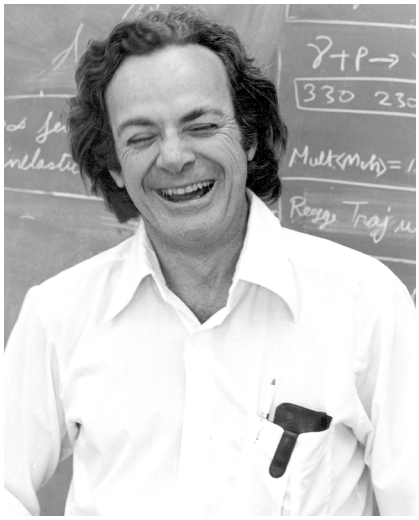
"1ST ORDER RUNGE-KUTTA...", ca 1970s-80s

Autograph manuscripts, 8 pp on 4 sheets, (5¾ x 8¼ in & 8½ x 11 in) in red and black ink on plain white wove paper (3 sheets) and black ink on white ruled paper (1 sheet). Some toning and tattering to edges of larger sheet.

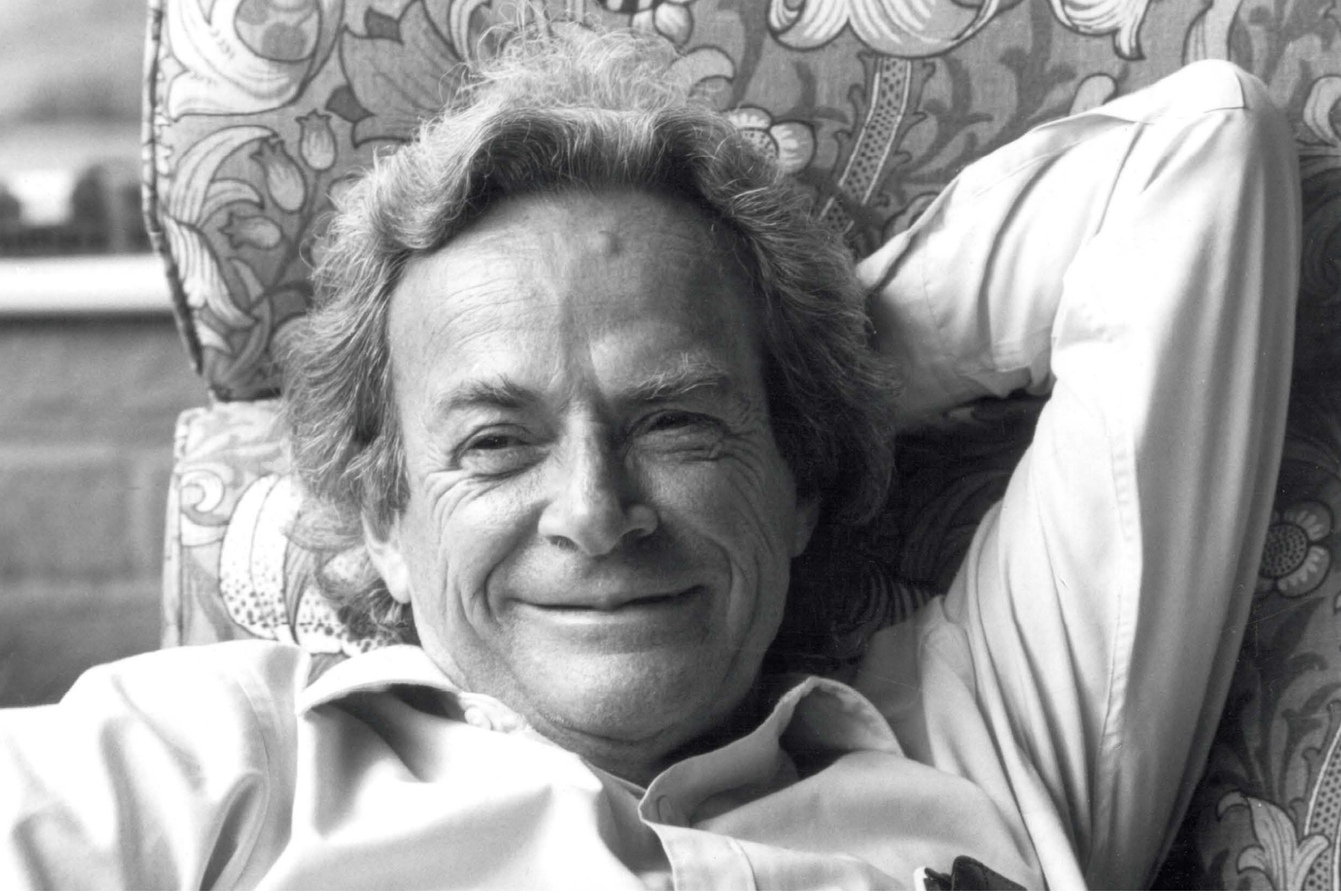
FEYNMAN WORKING ON FIRST AND SECOND ORDER RUNGE-KUTTA METHODS FOR THE NUMERICAL INTEGRATION OF ORDINARY DIFFERENTIAL EQUATIONS, SEEMINGLY IN RELATION TO COMPUTER CODING.

A wonderful pair of manuscripts showing Feynman's keen interest in computer coding and life-long love of arithmetic. The larger sheet focuses on 1st order Runge-Kutta, and cites Carnaham, Luther, and Wilkes' 1969 work *Applied Numerical Methods.* The second manuscript, in red ink, is very detailed, and contains neatly written codes, calculations and accompanying flow-charts, additionally citing Janhke & Emde, referring to their epic *Tables of Functions with Formulae and Curves.*

$ 10,000-15,000



Richard P. Feynman, 1974. (Photo by Floyd Clark. Courtesy of the Archives, California Institute of Technology)



Portrait of Richard P. Feynman, 1981 by Christopher Sykes. Courtesy Christopher Sykes

"I see much more about the flower than he sees... All kinds of interesting questions which a science knowledge only adds to the excitement and mystery and the awe of a flower. It only adds....."

Richard P. Feynman
Sykes, *No Ordinary Genius: The Illustrated Richard Feynman*

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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

AUTOGRAPH MANUSCRIPTS ON VARIOUS TOPICS, INCLUDING THE 2-D ISING MODEL, DENSITY MATRICES, AND COMPUTING, INTERLEAVED WITH ORIGINAL SKETCHES, CA 1972-81

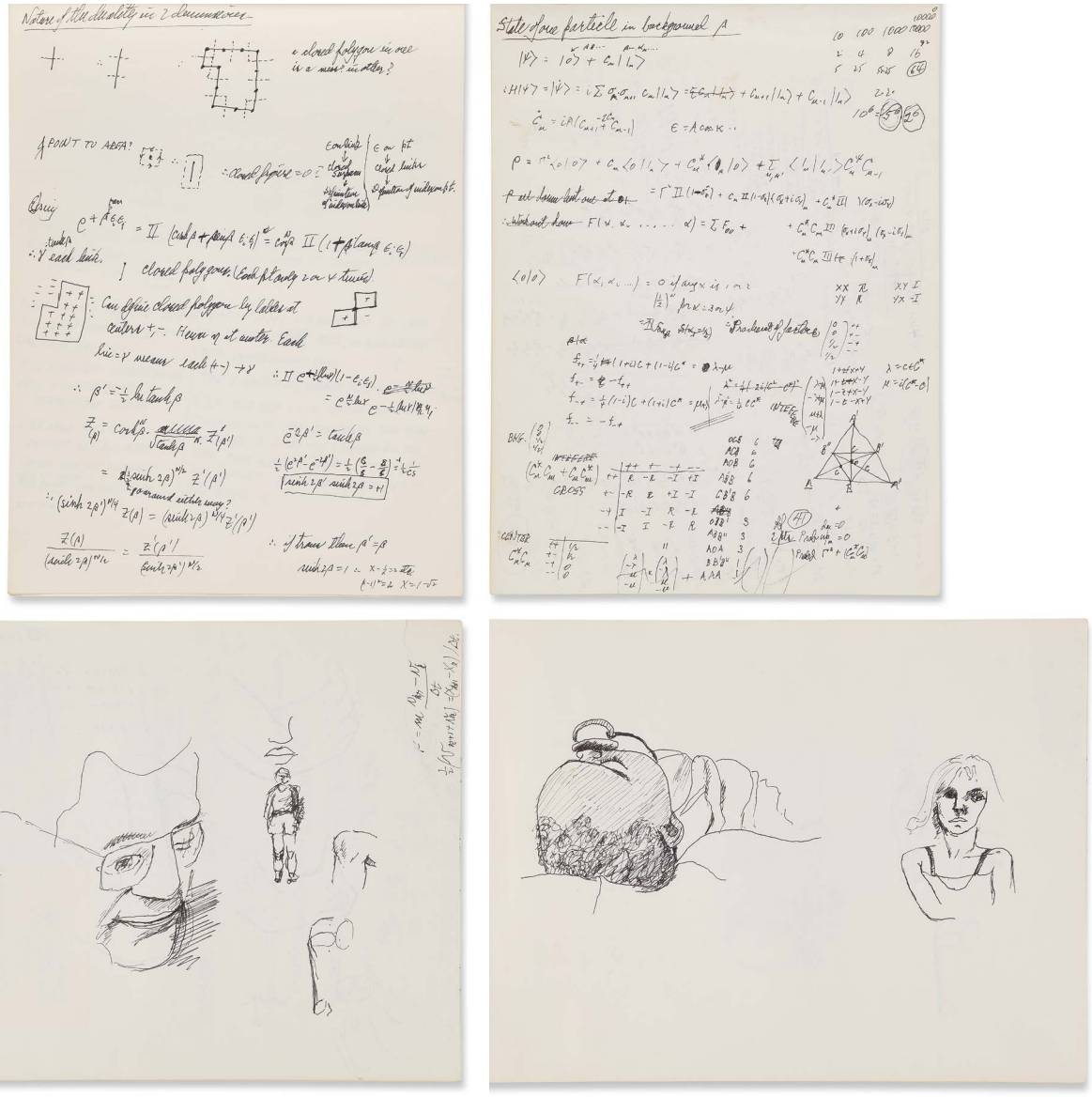
Autograph manuscripts, together 33 pages (8½ x 11 inches) in black & red ink on pad of plain white wove paper, ca 1972-1981.

WITH: Autograph manuscript, 2 pp (8½ x 11 inches), in black ink on plain white wove paper watermarked "CBA Western College Bookstore Association," ca 1972. Creases where previously folded and tucked into the below.

AND: FEYNMAN, RICHARD. *Statistical Mechanics. A Set of Lectures.* Reading, MA: W.A. Benjamin Inc, 1972.

A FUSION OF SCIENCE & ART, WITH ORIGINAL SKETCHES BY FEYNMAN INTERLEAVED WITH NOTES ON VARIOUS TOPICS.

This densely written notepad contains notes on several topics, including a Feynman prime number problem; 4 pages on the 2-D Ising Model & Kramers-Wannier Duality beginning *"Nature of the Duality in 2 dimensions"* and 8 pages relating to Density Matrices, beginning "*What does spin wave system look like in* f_{ts} *representation of the density matrix",* both likely being lecture notes for a course taught by Feynman at Caltech on Statistical Mechanics ca 1972; 4 pages titled "*Computer Conference"*, likely being notes taken at the *Physics of Computing Conference* at MIT in May of 1981. The bit on the Ising Model pertains to Feynman's wonderfully inspired random-walk riff, in the early 60's, on Lars Onsager's 1944 exact solution of this canonical toy model of two-dimensional magnetism. Feynman's solution, contemporaneous with a number of similarly streamlined combinatoric alternates to Onsager's formidable algebraic analysis, would eventually make for an elegant pedagogical set piece- see chapter 5: "Order-Disorder Theory," in his *Statistical Mechanics. A Set of Lectures,* this Lot. Kramers-Wannier Duality, perhaps



91

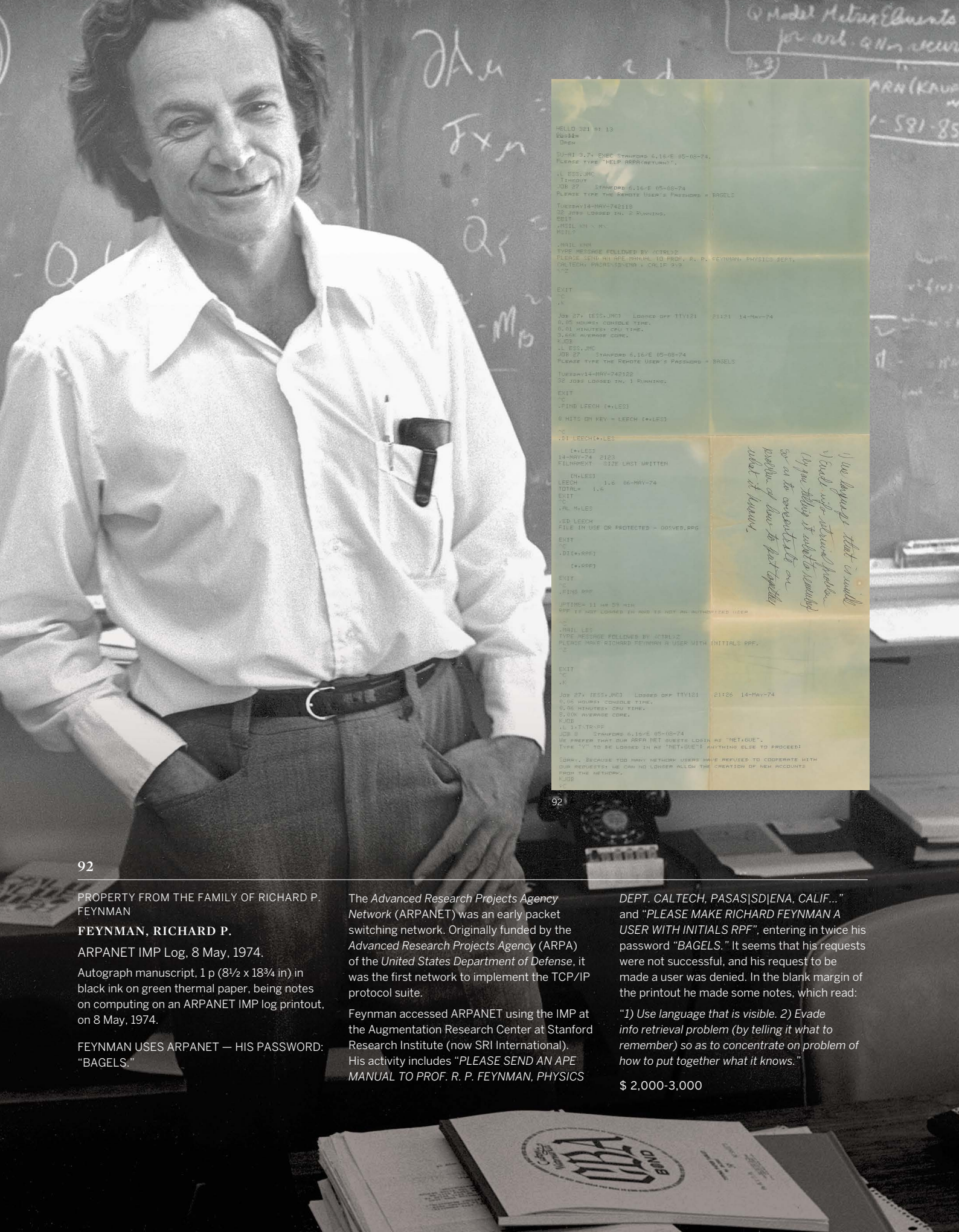
one of the most glorious & seductive sleights of hand in the history of statistical physics, makes a natural appearance in both Lots- an homage from one magician to another. Lars Onsager, a Norwegian physical chemist who spent the bulk of his career at Yale, was the 1968 Nobel Laureate in Chemistry.

The sketches include a horse fitted with English saddle, showing the lower half of the rider, a sleeping baby, a portrait of a young woman or girl, a man's face, studies of hands, legs, knees, a small standing figure, and a pig.

In 1962, at the age of 44, Feynman began learning to draw, starting by taking weekly classes at the home of artist/scientist Tom Van Sant. He developed into a talented artist over the years, often working with live models in his home, or simply sketching the people around him, and eventually began signing his works under the pseudonym "Ofey." His artwork has been published in *The Art of Richard P. Feynman. Images by a Curious Character."* Feynman's famous "Ode to a Flower" was a response to he and his artist friend Jirayr Zorthian's friendly arguments about science vs art:

"I have a friend who's an artist and he's taken a view which I don't agree with very well. He'll hold up a flower and say 'Look how beautiful it is!' and I'll agree. And he says 'You see, I as an artist can see how beautiful this is, but you, as a scientist... oh you take this all apart and it becomes a dull thing.' And I think that he's kind of nutty! First of all, the beauty he sees is available to other people — and me too, I believe... I see much more about the flower than he sees... All kinds of interesting questions which a science knowledge only adds to the excitement and mystery and the awe of a flower. It only adds.... Does it make any less of a beautiful smell of violets to know that it's molecules?" (Sykes, *No Ordinary Genius: The Illustrated Richard Feynman,* p. 107)

$ 100,000-150,000



92

92

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

ARPANET IMP Log, 8 May, 1974.

Autograph manuscript, 1 p (8½ x 18¾ in) in black ink on green thermal paper, being notes on computing on an ARPANET IMP log printout, on 8 May, 1974.

FEYNMAN USES ARPANET — HIS PASSWORD: "BAGELS."

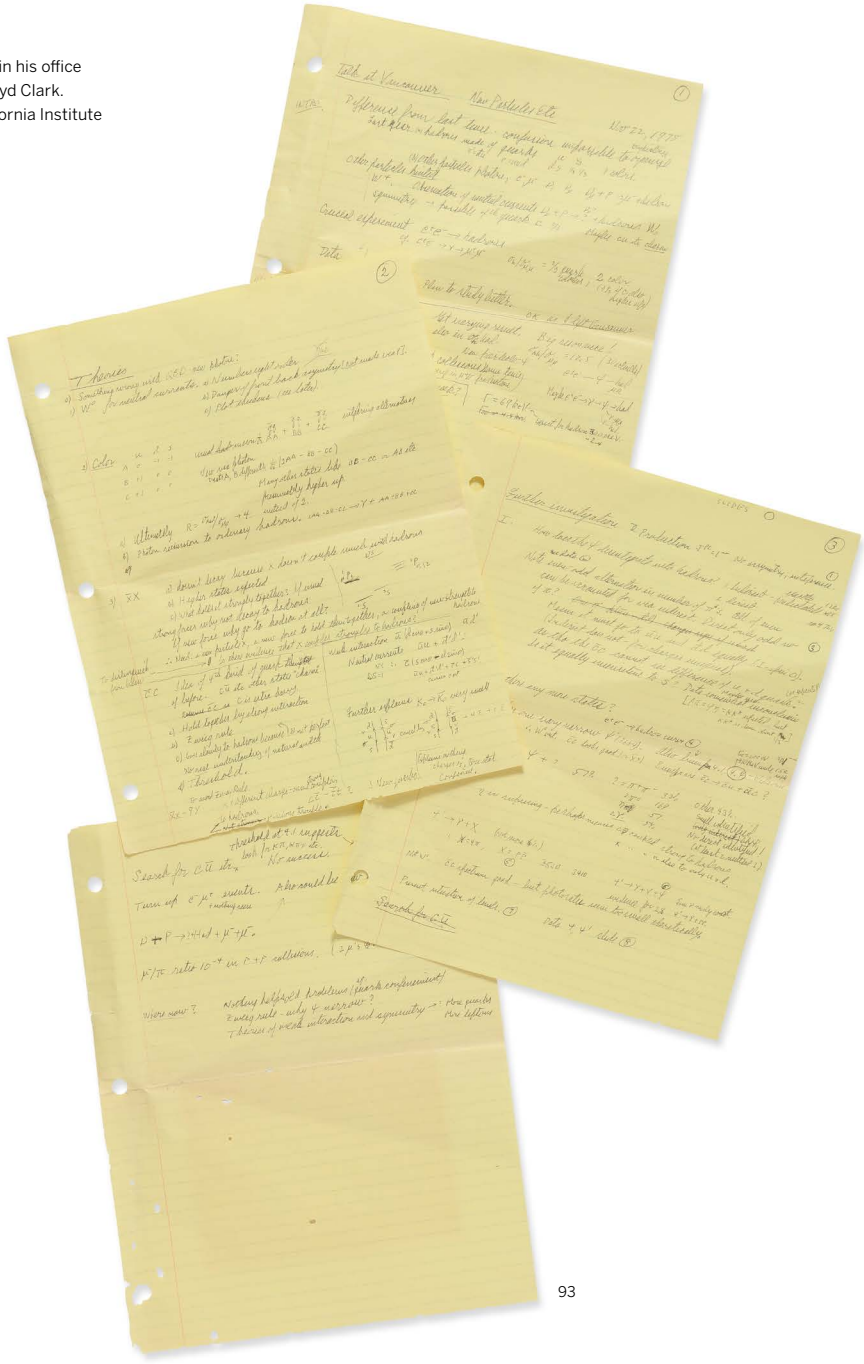
The *Advanced Research Projects Agency Network* (ARPANET) was an early packet switching network. Originally funded by the *Advanced Research Projects Agency* (ARPA) of the *United States Department of Defense*, it was the first network to implement the TCP/IP protocol suite.

Feynman accessed ARPANET using the IMP at the Augmentation Research Center at Stanford Research Institute (now SRI International). His activity includes "*PLEASE SEND AN APE MANUAL TO PROF. R. P. FEYNMAN, PHYSICS DEPT. CALTECH, PASAS|SD|ENA, CALIF...*" and "*PLEASE MAKE RICHARD FEYNMAN A USER WITH INITIALS RPF*", entering in twice his password "*BAGELS.*" It seems that his requests were not successful, and his request to be made a user was denied. In the blank margin of the printout he made some notes, which read:

"*1) Use language that is visible. 2) Evade info retrieval problem (by telling it what to remember) so as to concentrate on problem of how to put together what it knows.*"

$ 2,000-3,000

Opposite: Richard P. Feynman in his office at Caltech, 1974. (Photo by Floyd Clark. Courtesy of the Archives, California Institute of Technology)



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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"*Talk at Vancouver New Particles Etc.*"
Vancouver, Canada, 22 November, 1975.

Autograph manuscript, 4 pp (8½ x 11 in), in black ballpoint pen on yellow lined paper, creases where previously folded, being a detailed draft for a talk given to the Canadian Association of Physics Students, in Vancouver, Canada, on new developments relating to QED. The talk is clearly geared towards those with at least a graduate level understand of Physics.

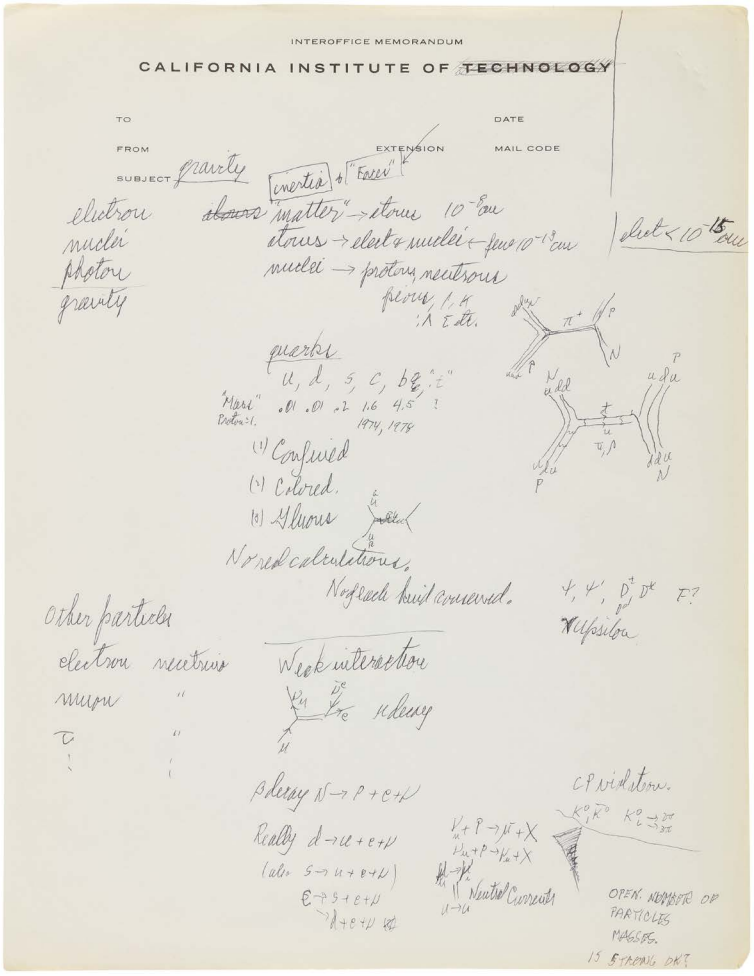
As James Gleick notes in his excellent biography of Feynman, *Genius: The Life and Science of Richard Feynman,* nearly all of Feynman's work originated in the spoken word. While Gleick provides a bibliography of some of Feynman's work in *Genius*, it is known that there is no one authoritative bibliography of his work. The present paper, as is often the case, is not recorded in Glieck's bibliography or elsewhere that we can see, however, Feynman does mention the talk briefly in "*Surely You're Joking Mr. Feynman!":*

"In Canada they have a big association of physics students. They have meetings; they give papers, and so on. One time the Vancouver chapter wanted to have me come and talk to them. The girl in charge of it arranged with my secretary to fly all the way to Los Angeles without telling me. She just walked into my office. She was really cute, a beautiful blonde. (That helped; it's not supposed to, but it did.) And I was impressed that the students in Vancouver had financed the whole thing. They treated me so nicely in Vancouver that now I know the secret of how to really be entertained and give talks: Wait for the students to ask you." (Richard Feynman, "*Surely You're Joking Mr. Feynman!*" p. 343).

REFERENCES

The transparencies prepared for this talk are located in the Richard Phillips Feynman archive at the California Institute of Technology.

$ 20,000-30,000



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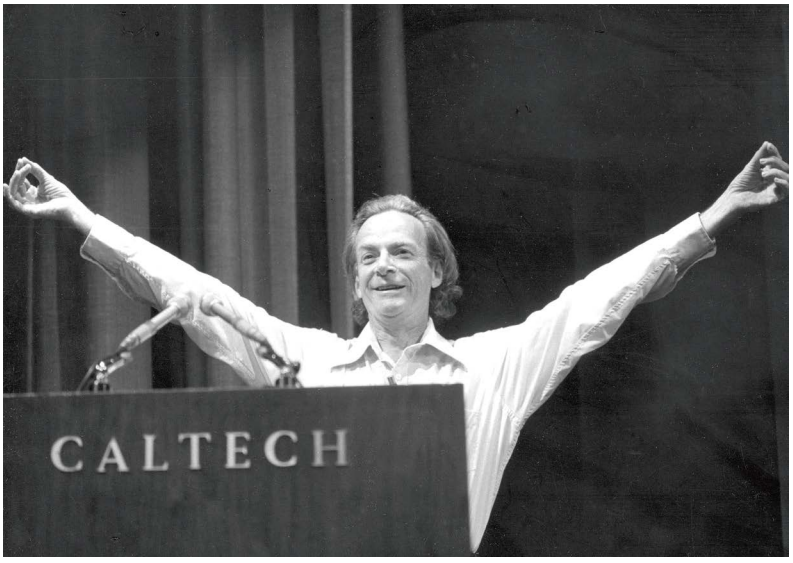


Richard P. Feynman lecturing at Caltech Seminar Day, 1978. (Courtesy of the Archives, California Institute of Technology)

94

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"*GRAVITY... QUARKS... weak interaction...*", post 1978.

Autograph manuscript, 1 page (8½ x 11 in), in black pen on sheet of California Institute of Technology Interoffice Memorandum letterhead, post 1978.

FEYNMAN DIAGRAMS DRAWN BY FEYNMAN HIMSELF — A WONDERFULLY VISUAL SHEET OF NOTES ADDRESSING THE FUNDAMENTAL FORCES OF NATURE: GRAVITY, THE STRONG INTERACTIONS (QUANTUM CHROMODYNAMICS) & ELECTROWEAK INTERACTIONS, WHICH ARE RESPONSIBLE FOR THE RADIOACTIVE DECAY OF ELEMENTARY PARTICLES.

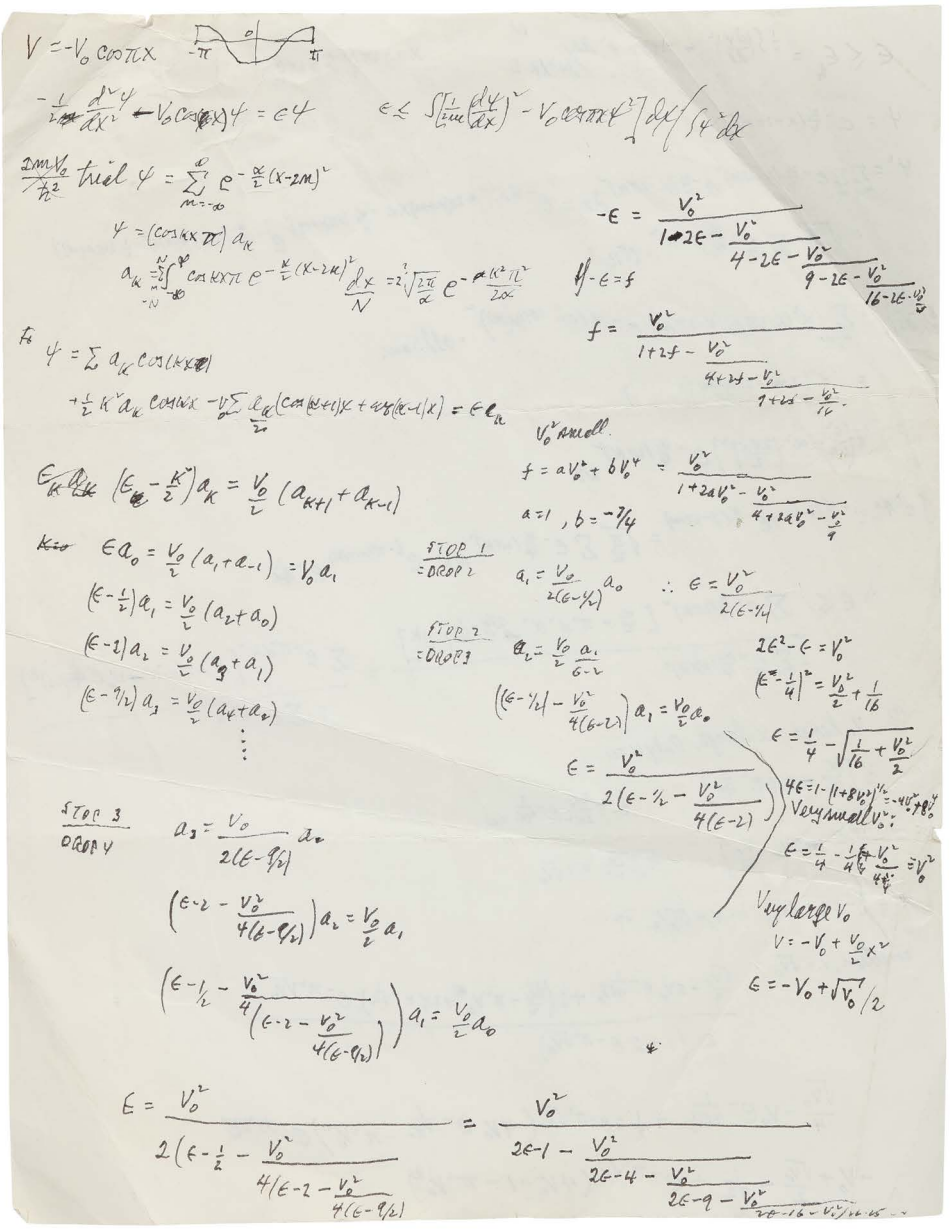
Quantum Chromodynamics, or QCD, is the theory of strong interactions between quarks and gluons, which taken together with Weinberg-Salam Gauge Theory of the Electroweak Interactions (1979 Physics Nobel), constitute the very successful "Standard Model" of present day elementary particle physics. Feynman argued that high-energy experiments showed that quarks are real particles, which he called *partons.* Feynman's younger Caltech colleague, Murray Gell-Mann, who won the 1969 Nobel Prize, himself, had coined the term *quark* for these constituents. While Gell-Mann and Feynman did important work together at Caltech in 1957 regarding an early theory of the weak interactions (Gleick, pp. 330-9), their ideas began to diverge later in life, and their differences in approach regarding QCD reflected a deep, but temporary rift in the theoretical physics community.

The pair of Feynman diagrams, upper right, illustrate the nuclear scattering of a proton (P) and a neutron (N). In the old Yukawa theory of the WWII era, this strong interaction was mediated by a pion, here indicated by the pi+. Within the later context of QCD, this scattering event is understood at a deeper level— Here the proton (uud), consisting of two "up" quarks, each of charge +2/3, and a "down" quark of charge -1/3, interacts with a neutron (ddu), which being two downs & an up is electrically neutral, via the exchange of the positively charged pion, made of an up quark (u) & down antiquark (d bar).

In Feynman's list of quarks, 1974 and 1978 refer to the dates that the "charm" and "bottom/beauty" quarks were discovered at SLAC/BNL and Fermilab, respectively. The 6th quark, indicated here as "t" by Feynman refers to the "top", sometimes called "truth", and was not discovered until 1995, well after Feynman's passing, though had been predicted, along with the bottom quark, in 1973 by Kobayashi & Maskawa, for which they were awarded the 2008 Nobel.

The lower Weak interaction diagram shows the decay of a negatively charge muon (mu) into an electron (e), a muon neutrino and an electron anti-neutrino, the neutrinos (n), appropriately sub or superscripted, with an overbar indicating anti-matter, which travels backward in space-time.

$ 10,000-15,000



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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"*V=-V$_0$ cosπx...*", ca 1987.

Autograph manuscript, 2 pp (8½ x 11 in) in black ink on plain white laid paper. Creases where previously folded, a couple of small marginal closed tears.

FEYNMAN WORKS OUT A QUIRKY QUANTUM PROBLEM WITH THE SINUSOIDAL POTENTIAL, USING THE VARIATIONAL METHOD, A FAVORITE EARLY TRICK OF HIS, TO WHICH HE OFTEN RETURNED IN HIS RESEARCH.

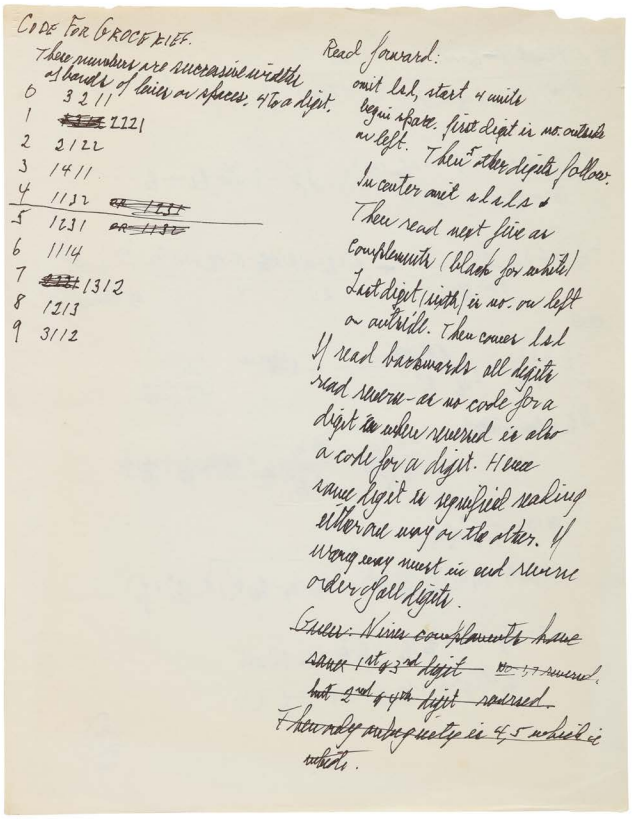
In early September 1987, Feynman presented gave a talk entitled "*Difficulties in Applying the Variational Principle to Quantum Field Theories*" at the International Workshop on Variational Calculations in Quantum Field Theory in West Germany. The present manuscript is likely notes made while preparing for his talk. The printed proceedings of the International Workshop were dedicated to the memory of Feynman who died just 5 short months after the workshop took place.

In the calculation, Feynman considers a trial wavefunction consisting of Gaussians centered in the valleys of the given sinusoidal confining potential; he then Fourier expands this periodic waveform in term of cosine harmonics, obtaining a recursion relation connecting Fourier coefficients a_k in successive rungs of the ladder. This gains him a nested, continued fraction representation for the energy e as it relates to amplitude, V_0, of the confining potential.

REFERENCES

FEYNMAN, RICHARD. "Difficulties in Applying the Variational Principle to Quantum Field Theories." pp. 28-40 IN: *Proceedings of the International Workshop on Variational Calculations.* (L. Polley and D.E.L. Pottinger, eds.) Singapore: World Scientific Publishing, 1988.

$ 6,000-9,000



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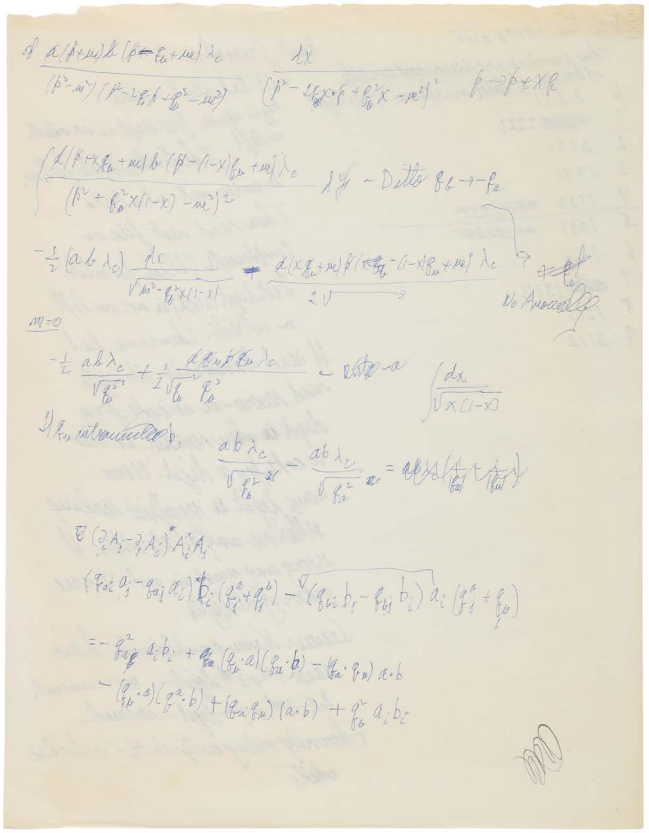

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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"Code for Groceries", ca 1978.

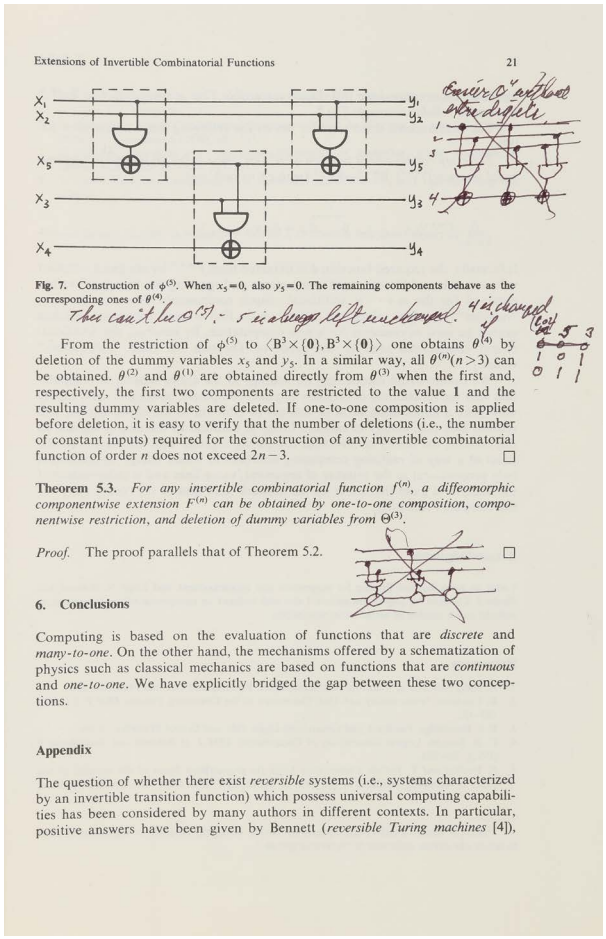
Autograph manuscript, 2 pp (8½ x 11 inches) recto in black ink and verso in blue ink, on plain white wove paper.

"CODE FOR GROCERIES." On the recto in black ink is playful manuscript by Feynman done late in life beginning: "*Code for Groceries. These numbers are successive width of bands of lines or spaces. 4 to a digit. Read forward: omit lsl, start 4 units. begin space. first digit is no. outside on left. Then 5 other digits folow. In center omit slsls*...." On the verso, in blue ink, is a full page of equations.

Feynman had a lifelong love of puzzles and codes. He and his first wife Arline would exchange encoded letters while he was working on the Atom Bomb at Los Alamos and she was at a sanatorium in Albequerque, sick with tuberculosis.

The present manuscript brings to mind the notorious "Feynman Challenge Ciphers," a series of three mysterious messages that according to Chris Cole, a graduate student of Feynman's at Caltech, were given to Feynman as a challenge by a fellow scientist at Los Alamos, and which Feynman had been unable to crack. The first of the three challenge ciphers was solved by Jack C. Morrison of JPL, after determining that it was written using a 5 x 76 transposition cipher. The other two challenges remain unsolved.

$ 5,000-8,000



Extensions of Invertible Combinatorial Functions 21

Fig. 7. Construction of $\phi^{(5)}$. When $x_5=0$, also $y_5=0$. The remaining components behave as the corresponding ones of $\theta^{(4)}$

From the restriction of $\phi^{(5)}$ to $\langle B^3\times\{0\},B^3\times\{0\}\rangle$ one obtains $\theta^{(4)}$ by deletion of the dummy variables x_5 and y_5. In a similar way, all $\theta^{(n)}(n>3)$ can be obtained. $\theta^{(2)}$ and $\theta^{(1)}$ are obtained directly from $\theta^{(3)}$ when the first and, respectively, the first two components are restricted to the value **1** and the resulting dummy variables are deleted. If one-to-one composition is applied before deletion, it is easy to verify that the number of deletions (i.e., the number of constant inputs) required for the construction of any invertible combinatorial function of order n does not exceed $2n-3$. □

Theorem 5.3. *For any invertible combinatorial function $f^{(n)}$, a diffeomorphic componentwise extension $F^{(n)}$ can be obtained by one-to-one composition, componentwise restriction, and deletion of dummy variables from $\Theta^{(3)}$.*

Proof. The proof parallels that of Theorem 5.2. □

6. Conclusions

Computing is based on the evaluation of functions that are *discrete* and *many-to-one*. On the other hand, the mechanisms offered by a schematization of physics such as classical mechanics are based on functions that are *continuous* and *one-to-one*. We have explicitly bridged the gap between these two conceptions.

Appendix

The question of whether there exist *reversible* systems (i.e., systems characterized by an invertible transition function) which possess universal computing capabilities has been considered by many authors in different contexts. In particular, positive answers have been given by Bennett (*reversible Turing machines* [4]),

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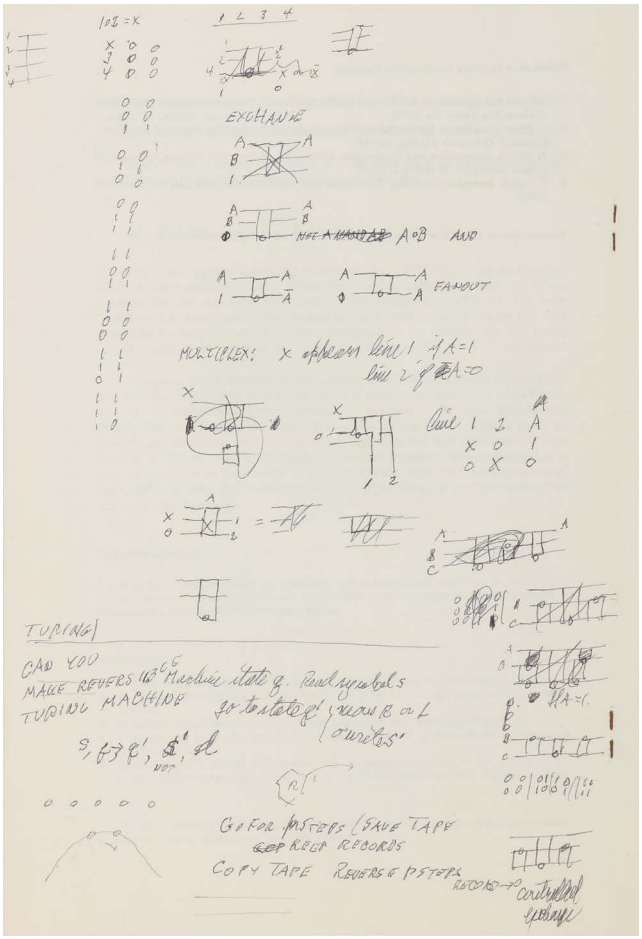

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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.; [TURING, ALAN M.]

"*Can you make reversible Turing machine*[?]", ca late summer/early fall 1981.

Autograph manuscript, 1½ pp, in black ink, consisting of detailed notes written on:

TOFFOLI, TOMMASO. "Bicontinuous Extensions of Invertible Combinatorial Functions." Offprint from: *Mathematical Systems Theory*, pp 13-23, 14, 1981. (6½ x 9½ in). Stapled into original paper wrapper. First page inscribed by Toffoli "*You may be interested in Section 2; those considerations must apply also to a Q.M. computer. T.T.*"

A GIANT OF PHYSICS ON A GIANT OF COMPUTING.

Feynman & Toffoli both attended the *Physics of Computation* Conference at MIT on May 6-8, 1981, and it is likely that Toffoli sent this offprint to Feynman in response to a conversation that the two had while there. Feynman evidently was interested in section 2 of the present offprint, as he sketches several diagrams in response to those found in the offprint, adding several annotations, and on the last page, further sketches out some detailed diagrams. Under the heading TURING he writes "*CAN YOU MAKE REVERSIBLE TURING MACHINE. Machine state q. Read symbols. go to state q'.... GO FOR P STEPS (SAVE TAPE) KEEP RECORDS COPY TAPE REVERSE P STEPS RECORD...". A FANTASTIC ITEM, LINKING TOGETHER TWO OF THE MOST CELEBRATED MINDS OF THE 20TH CENTURY.*

$ 6,000-9,000

98

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

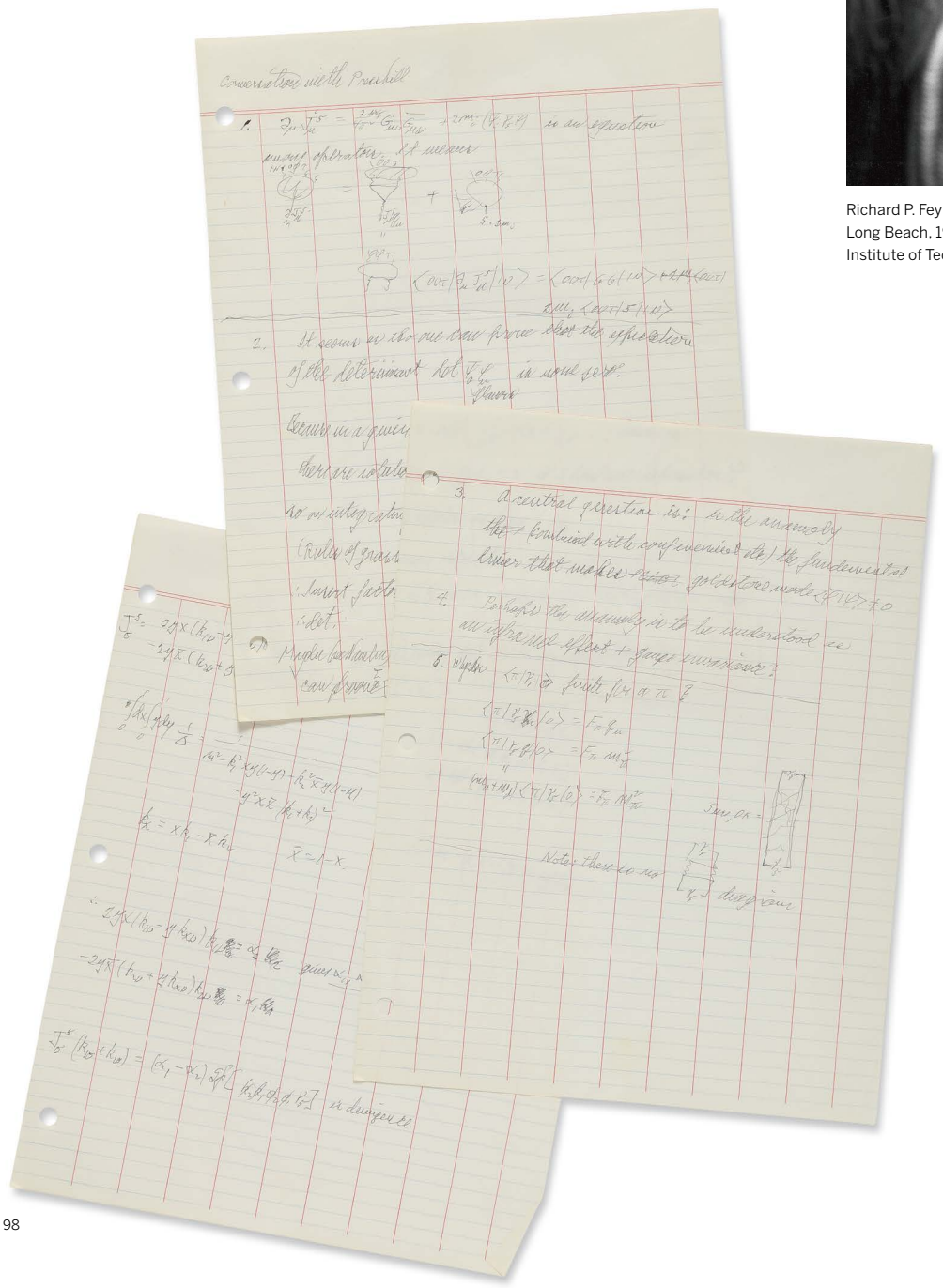
"*Conversation with Preskill*", ca late 1983 to early 1984.

Autograph manuscript, 3 pp (8½ x 11 in) in black ink on grid-ruled hole-punched paper.

A CONVERSATION ON THEORETICAL PHYSICS. Evidently, the conversation was of great interest to Feynman, as he jotted down three pages of detailed technical notes about it. John Preskill is the Richard P. Feynman Professor of Theoretical Physics at the California Institute of Technology, where he became a faculty member in 1983, just five years before Richard Feynman's death.

$ 4,000-6,000

Richard P. Feynman speaking with a student at Cal State Long Beach, 1979. (Courtesy of the Archives, California Institute of Technology)



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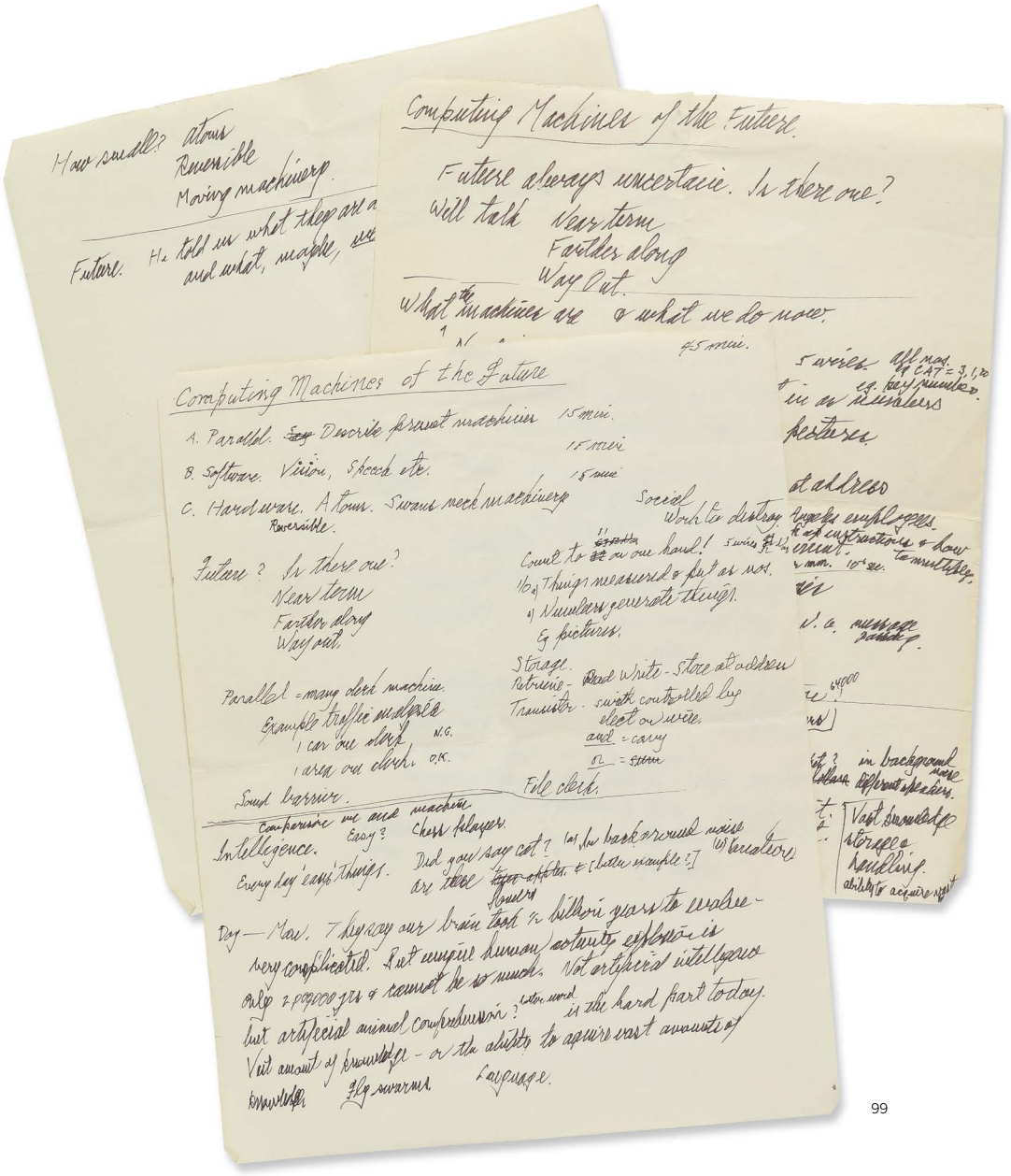


99

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.

"*Computing Machines of the Future*," ca 1985.

Autograph manuscript, 2 pp, in black felt-tip pen on unlined white paper, (8½ x 11 in), creases where previously folded, being a draft for his address "The Computing Machines in the Future", delivered as the Nishina Memorial Lecture at Gakushuin University in Tokyo on August 9, 1985.

"*FUTURE? IS THERE ONE?*" —AN IMPORTANT PAPER ON COMPUTING, DELIVERED IN JAPAN IN 1985 AS A MEMORIAL TO THE JAPANESE PHYSICIST YOSHIO NISHINA, MENTOR TO SIN-ITIRO TOMONAGA (WHO SHARED THE 1965 NOBEL PRIZE IN PHYSICS WITH FEYNMAN AND JULIAN SCHWINGER). In this paper, Feynman discusses some technical possibilities for making machines, covering three topics; Parallel computing, including discussions of the Cray supercomputer, the Cosmic Cube, and MIT's "Connection Machine"; the possibilities of reduction of energy loss, including the problems of cooling associated with large computers; and the possibilities in reducing the size of computing elements. The present draft is an excellent example of why this sort of material, rather than a nearly finished draft, is so interesting, as we get a nice look into how Feynman's work evolved from early drafts to the finished product; the first few lines of the manuscript show for example, that the original three sections of the paper were "*A. Parallel. Describe present machines*", "*B. Software. Vision, Speech etc.*", and "*C. Hardware. Atoms. Swan neck machinery. Reversible.*"

The published version of the talk begins "*It's a great pleasure and honor to be here as a speaker in memorial for a scientist that I have respected and admired as much as Prof. Nishina. To come to Japan and talk about computers is like giving a sermon to Buddha. But I have been thinking about computers and this is the only subject I could think of when invited to talk.*"

REFERENCES

"The Computing Machines in the Future" In: *Selected Papers of Richard Feynman with Commentary*. Ed. Laurie Brown. Singapore: World Scientific Publishing Co., 2000, pp 947-967; see Tony Hey, "Richard Feynman and Computation," in: *Contemporary Physics*, 1999, column 40, number 4, pp 257-265

$ 20,000-30,000

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

[FEYNMAN, RICHARD P.]; DIRAC, P[AUL] A. M.

The Principles of Quantum Mechanics. Oxford: Clarendon Press, 1935.

8vo. 300 pp. Blue publisher's cloth, spine titled in gilt. Some light wear and bubbling to cloth, hinges cracked. Second edition. Signed "*R.P. FEYNMAN*" in blue ink to fly-leaf, MARGINAL PENCILED ANNOTATIONS, DIAGRAMS, AND FORMULAE IN FEYNMAN'S HAND.

"*IT SEEMS THAT SOME ESSENTIALLY NEW PHYSICAL IDEAS ARE HERE NEEDED*".

FEYNMAN'S OWN UNDERGRADUATE COPY — SIGNED AND ANNOTATED BY HIM — OF HIS IDOL'S MAGNUM OPUS — THE BOOK THAT WOULD INSPIRE HIM TO DO THE WORK FOR WHICH HE WOULD WIN THE 1965 NOBEL PRIZE IN PHYSICS.

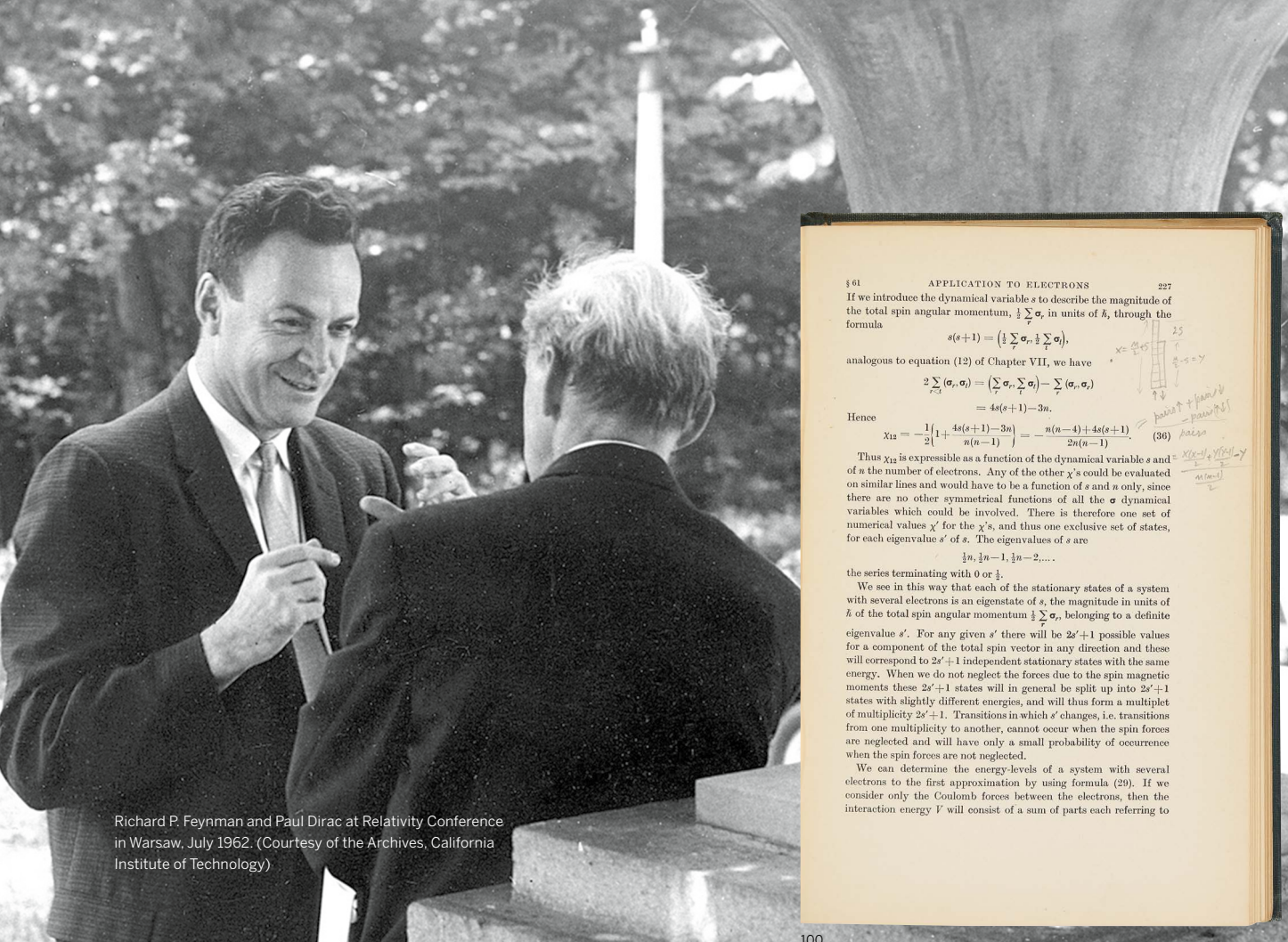
"'He is a second Dirac," Wigner said, 'only this time human.'" (Princeton physicist, & brother-in-law of Dirac, Referring to Feynman, in *Genius*, p. 184)

Dirac's masterpiece was first printed in 1930, when Feynman was only 12 years old, and the second, much improved edition published when he was 17. Knowing that Feynman had read the book for the first time before his sophomore year at MIT, "The Far Rockaway Sophomore announced that he had already learned quantum mechanics from a book by someone called Dirac." (*Genius*, p. 56), he would have then acquired this copy sometime between his senior year in high school (1935) and his freshman year.

"*The beginning of the thing was at the Massachusetts Institute of Technology, when I was an undergraduate student reading about the known physics, learning slowly about all these things that people were worrying about, and realizing ultimately that the fundamental problem of the day was that the quantum theory of electricity and magnetism was not completely satisfactory. This I gathered from books like those of Heitler and Dirac. I was inspired by the remarks in these books; not by the parts in which everything was proved and demonstrated carefully and calculated, because I couldn't understand those very well. At the young age what I could understand were the remarks about the fact that this doesn't make any sense, AND THE LAST SENTENCE OF THE BOOK OF DIRAC I CAN STILL REMEMBER, 'IT SEEMS THAT SOME ESSENTIALLY NEW PHYSICAL IDEAS ARE HERE NEEDED.'*" (Feynman, "The Development of the Space-Time View of Quantum Electrodynamics", *Nobel Lecture*, December 11, 1965.

FEYNMAN'S MARGINAL NOTES GIVE US A VALUABLE GLIMPSE INTO THE INFANCY OF HIS NOBEL PRIZE WINNING WORK. PARTICULARLY STRIKING IS THE SIMPLE NOTE: "*ANALYZE THIS SOME DAY*" IN REFERENCE TO A SECTION ON THE POLARIZATION OF PHOTONS.

$ 5,000-7,000



Richard P. Feynman and Paul Dirac at Relativity Conference in Warsaw, July 1962. (Courtesy of the Archives, California Institute of Technology)

§ 61 APPLICATION TO ELECTRONS 227

If we introduce the dynamical variable s to describe the magnitude of the total spin angular momentum, $\frac{1}{2}\sum_r \boldsymbol{\sigma}_r$ in units of $\hbar$, through the formula

$$s(s+1) = \left(\tfrac{1}{2}\sum_r \boldsymbol{\sigma}_r, \tfrac{1}{2}\sum_l \boldsymbol{\sigma}_l\right),$$

analogous to equation (12) of Chapter VII, we have

$$2\sum_{r<l}(\boldsymbol{\sigma}_r, \boldsymbol{\sigma}_l) = \left(\sum_r \boldsymbol{\sigma}_r, \sum_l \boldsymbol{\sigma}_l\right) - \sum_r (\boldsymbol{\sigma}_r, \boldsymbol{\sigma}_r)$$
$$= 4s(s+1) - 3n.$$

Hence

$$\chi_{12} = -\frac{1}{2}\left(1 + \frac{4s(s+1)-3n}{n(n-1)}\right) = -\frac{n(n-4)+4s(s+1)}{2n(n-1)}. \quad (36)$$

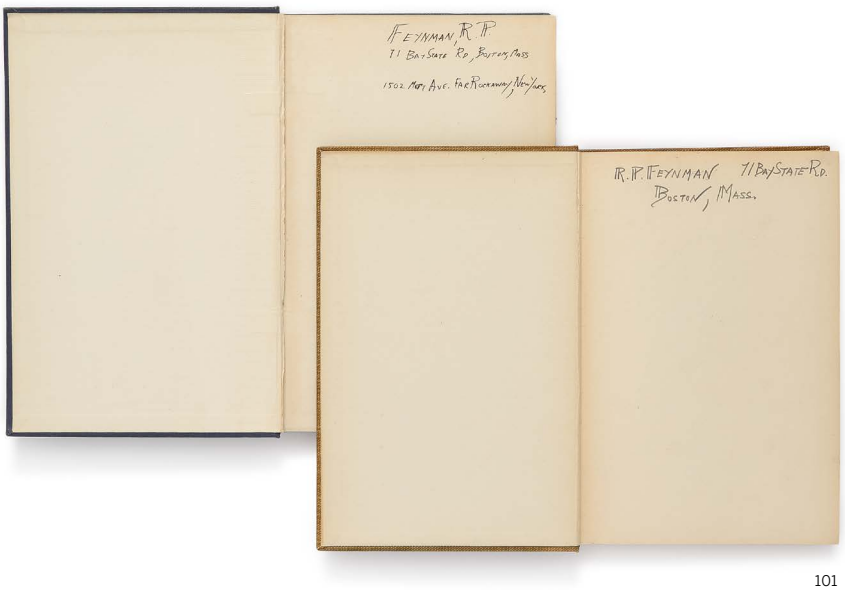
Thus χ_{12} is expressible as a function of the dynamical variable s and of n the number of electrons. Any of the other χ's could be evaluated on similar lines and would have to be a function of s and n only, since there are no other symmetrical functions of all the $\boldsymbol{\sigma}$ dynamical variables which could be involved. There is therefore one set of numerical values χ' for the χ's, and thus one exclusive set of states, for each eigenvalue s' of s. The eigenvalues of s are

$$\tfrac{1}{2}n, \tfrac{1}{2}n-1, \tfrac{1}{2}n-2, \ldots.$$

the series terminating with 0 or $\frac{1}{2}$.

We see in this way that each of the stationary states of a system with several electrons is an eigenstate of s, the magnitude in units of $\hbar$ of the total spin angular momentum $\frac{1}{2}\sum_r \boldsymbol{\sigma}_r$, belonging to a definite eigenvalue s'. For any given s' there will be $2s'+1$ possible values for a component of the total spin vector in any direction and these will correspond to $2s'+1$ independent stationary states with the same energy. When we do not neglect the forces due to the spin magnetic moments these $2s'+1$ states will in general be split up into $2s'+1$ states with slightly different energies, and will thus form a multiplet of multiplicity $2s'+1$. Transitions in which s' changes, i.e. transitions from one multiplicity to another, cannot occur when the spin forces are neglected and will have only a small probability of occurrence when the spin forces are not neglected.

We can determine the energy-levels of a system with several electrons to the first approximation by using formula (29). If we consider only the Coulomb forces between the electrons, then the interaction energy V will consist of a sum of parts each referring to



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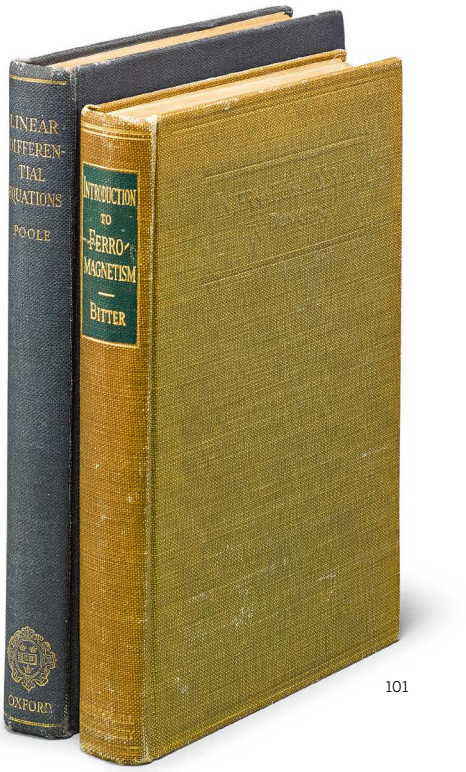


101

101

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

[FEYNMAN, RICHARD P.]

POOLE, E.G.C. *Introduction to the Theory of Linear Differential Equations.* Oxford: At the Clarendon Press, 1936.

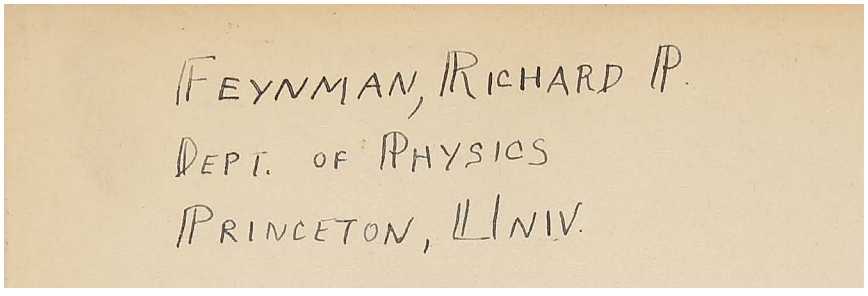
8vo. 202 pp. Blue publisher's cloth; worn. FIRST EDITION, SIGNED IN PEN ON FLYLEAF WITH THE CAPITALS LETTERS WRITTEN WITH DOUBLE LINES *"FEYNMAN, R.P./ 71 BAY STATE RD, BOSTON, MASS/ 1502 MOTT AVE. FAR ROCKAWAY, NEW YORK."*

AND: BITTER, FRANCIS. *Introduction to Ferromagnetism.* New York and London: McGraw-Hill Book Company Inc., 1937. 8vo. 314 pp. Mustard publisher's cloth; worn. FIRST EDITION. SIGNED IN PENCIL ON FLYLEAF WITH THE CAPITAL LETTERS IN HIS NAME WRITTEN WITH DOUBLE LINES *"R.P. FEYNMAN 71 BAY STATE RD. / BOSTON, MASS."*

FIRST EDITIONS OF TWO BOOKS BOUGHT BY FEYNMAN AT MIT DURING HIS SOPHOMORE YEAR, BOTH SIGNED BY HIM IN A STYLE FAVORED IN HIS YOUTH.

A wonderful pair of books which give us a glimpse into Feynman's earliest influences. The books were both clearly important to him, as not only did he sign them both with his name, but he also wrote in his home address, that of the Pi Lambda Phi Fraternity, which Feynman joined in his Sophomore year at MIT, in both. The copy of Poole, published in 1936, bears not only the address of the Fraternity, but also his address back home in Far Rockaway, New York. Bitter, published in 1937, and likely purchased later, only bears the address of the fraternity house, a telling sign of a young man who had left home and struck out on his own in the world.

$ 2,000-3,000



102 (DETAIL)

102

PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

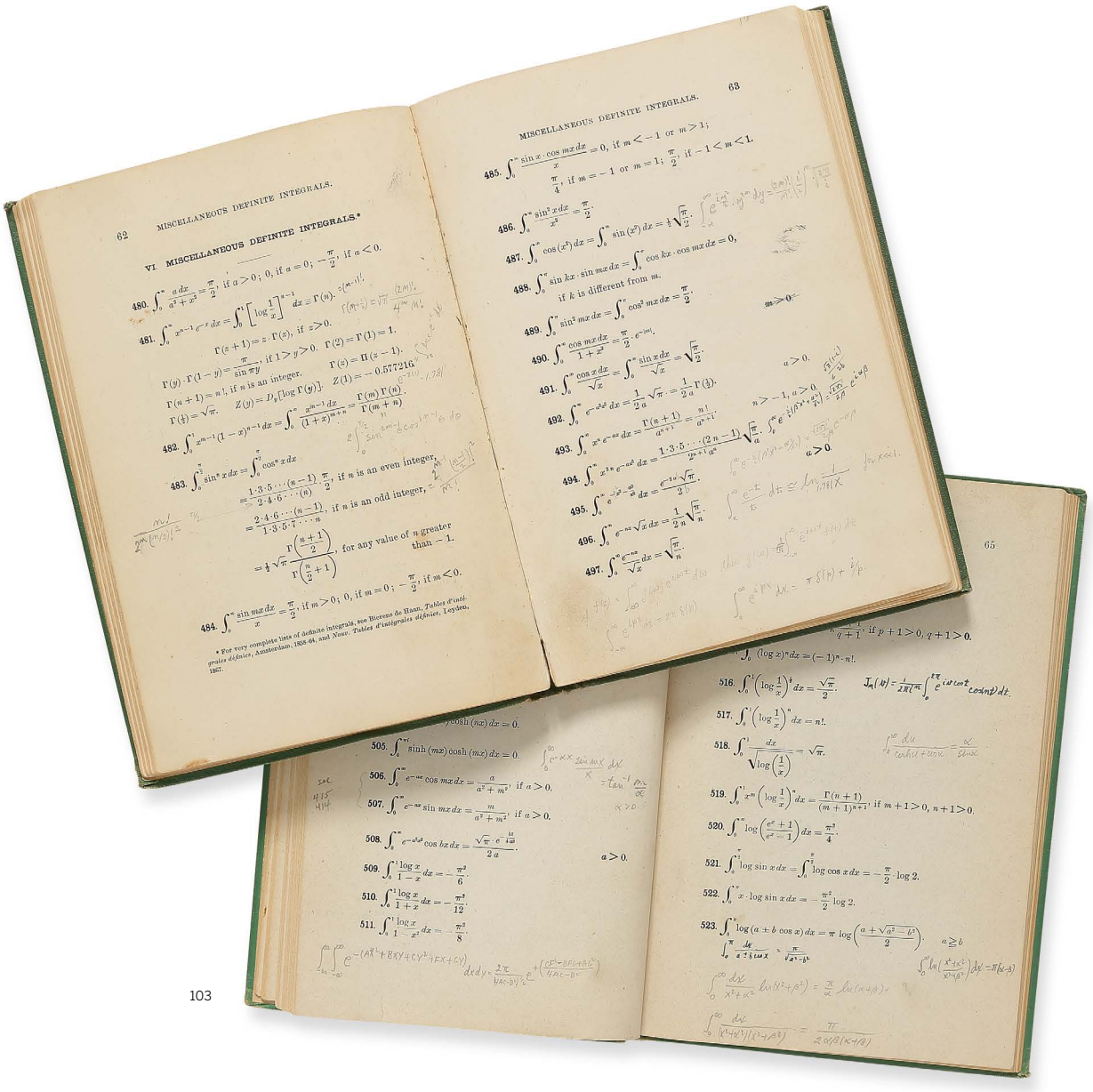
[FEYNMAN, RICHARD P.]; MONK, GEORGE S.

Light Principles and Experiments. New York and London: McGraw-Hill Book Company, Inc., 1937.

8vo. 477 pp. Blue publisher's cloth; worn. SIGNED IN BLUE INK ON FLYLEAF, WITH THE CAPITAL LETTERS WRITTEN IN DOUBLE LINES *"FEYNMAN, RICHARD P. / DEPT. OF PHYSICS / PRINCETON, UNIV."* With a handful of text annotations and diagrams in his hand in pencil.

FIRST EDITION OF THIS EARLY WORK, LIKELY USED BY FEYNMAN TO TEACH AT CORNELL. Twenty-seven year old Feynman joined the faculty at Cornell in 1945, in order to be close to his dear friend Hans Bethe, whom he met while working on the atom bomb at Los Alamos. In the three years that transpired between obtaining his Ph.D. from Princeton, and joining Cornell, the young Feynman had experienced a great deal, spending an intense three years developing the atom bomb, with the first detonation of the bomb, the Trinity Test, occurring exactly one month after Feynman lost his beloved first wife Arline to tuberculosis. He had experienced a lifetime's-worth of stress and heartache in a short amount of time, and yet, as the style of hand-writing in this book would suggest, was still very much an innocent young man.

$ 1,500-2,500



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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

[FEYNMAN, RICHARD P.]; PIERCE, B.O.

A Short Table of Integrals. Boston: Ginn & Company, 1929.

8vo. 156 pp. Green publisher's cloth, rubbed. SIGNED ON FRONT FLY-LEAF "*FEYNMAN, RICHARD P. / DEPT. OF PHYSICS/ PRINCETON, N.J.*" AND ANNOTATED BY FEYNMAN IN PENCIL AND BLACK INK.

AND: *Another copy.* 8vo. 156 pp. Green publisher's cloth, rubbed. SIGNED ON FRONT FLY-LEAF "*R.P. FEYNMAN. DEPT. PHYSICS, CORNELL UNIV.*" AND ANNOTATED BY HIM IN PENCIL, AND BLACK, BLUE, AND RED INK.

WITH: *A Short Table of Integrals. Abridged Edition.* Boston: Ginn and Company, 1942. 8vo. 32 pp. Original cloth-backed printed wrappers. SIGNED "FEYNMAN" ON FRONT COVER IN PENCIL.

FEYNMAN'S LOVE OF INTEGRALS. An extraordinary lot, pairing Feynman's two heavily annotated personal copies (the first from his graduate student days at Princeton, the second as a young professor at Cornell) of this deceptively slim, but densely packed fin-de-siècle collection of elusive integrals, bookending Feynman's years at Los Alamos, 1943-45. One certainly imagines the Princeton copy to have been on his desk & well-within reach during the Manhattan Project, long before the advent of high speed computers permitted simple numerical evaluation of intractable integrals. Both volumes are heavily annotated (in fact, nearly, but not quite identically so...) with Feynman's own favorite mathematical exotica & personal predilections. An abridged version of Pierce, focused on the barest essentials, complements the Cornell copy. As an ensemble, they speak eloquently to Feynman's mathematical toolbox being well-stocked, and interestingly, also already well-formed by 1942. In this regard, possession of Pierce would be characteristic of any pre-WWII physicist; a bit of contrast to the iconic figure known to later generations. While Feynman famously embraced the big picture view of science, he nevertheless always relished the calculational aspects of the craft; his 40's-era desktop editions of Pierce attest heartily to that....

$ 4,000-6,000

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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

[FEYNMAN, RICHARD P.]; SCHIFF, LEONARD; DAVID BOHM

SCHIFF, LEONARD. *Quantum Mechanics.* New York: McGraw-Hill Book Company Inc., 1949.

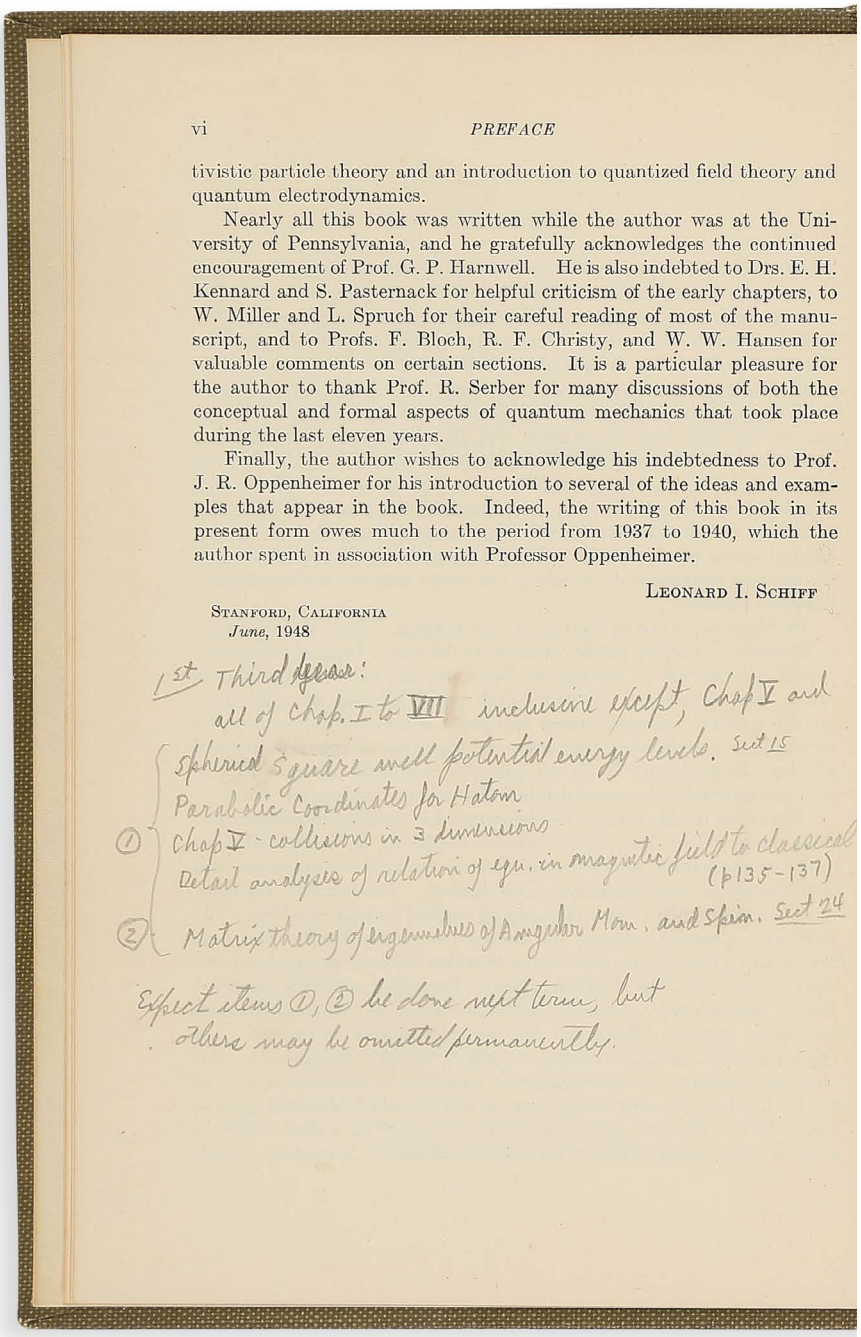
8vo. Publisher's cloth. FIRST EDITION. SIGNED *"R.P. FEYNMAN / CALTECH"* ON FLY-LEAF.

AND: BOHM, DAVID. *Quantum Theory.* New York: Prentice-Hall, Inc., 1951. 8vo. Publisher's cloth. FIRST EDITION. SIGNED "*R.P. FEYNMAN*", AND WITH EQUATION IN HIS HAND TO FLY-LEAF.

FEYNMAN'S DESK-TOP QUANTUM MECHANICS TEXTS, EVIDENTLY USED BY HIM TO TEACH WITH UPON ARRIVING AT CALTECH.

Of the two books, it is clear the Feynman relied more heavily on Schiff's text — a detailed note at the end of the preface lays out a draft for a syllabus for a third year course on Physics using the book, beginning "*1ST Third year: all of Chapt. I to VIII, inclusive except Chap V and ...*" with marking next to the chapters to be used. Text annotations include one correction to an equation, and markings next to various paragraphs such as "*YES*", "*NO*", "*?*", "*NOT YET*", "*OMIT*" clearly referring to topics to be taught in the course.

$ 2,000-3,000



vi *PREFACE*

tivistic particle theory and an introduction to quantized field theory and quantum electrodynamics.

Nearly all this book was written while the author was at the University of Pennsylvania, and he gratefully acknowledges the continued encouragement of Prof. G. P. Harnwell. He is also indebted to Drs. E. H. Kennard and S. Pasternack for helpful criticism of the early chapters, to W. Miller and L. Spruch for their careful reading of most of the manuscript, and to Profs. F. Bloch, R. F. Christy, and W. W. Hansen for valuable comments on certain sections. It is a particular pleasure for the author to thank Prof. R. Serber for many discussions of both the conceptual and formal aspects of quantum mechanics that took place during the last eleven years.

Finally, the author wishes to acknowledge his indebtedness to Prof. J. R. Oppenheimer for his introduction to several of the ideas and examples that appear in the book. Indeed, the writing of this book in its present form owes much to the period from 1937 to 1940, which the author spent in association with Professor Oppenheimer.

LEONARD I. SCHIFF

STANFORD, CALIFORNIA
June, 1948

1st Third year:
all of Chap. I to VII inclusive except, Chap V and
Spherical Square well potential energy levels. Sect 15
Parabolic Coordinates for Hatom
① Chap V - collisions in 3 dimensions
Detail analysis of relation of eqn. in magnetic field to classical (p 135-137)
② Matrix theory of eigenvalues of Angular Mom. and Spin. Sect 24
Expect items ①, ② be done next term, but
others may be omitted permanently.

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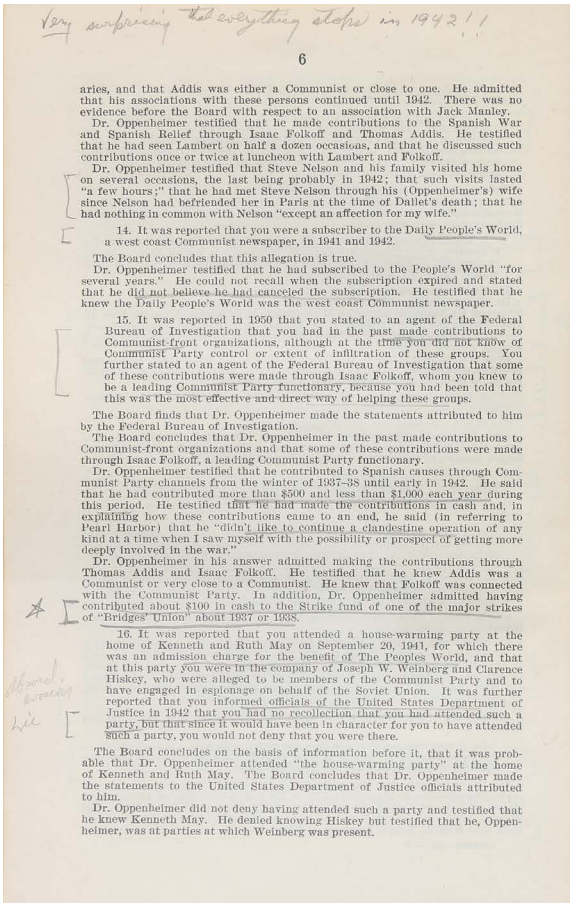

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aries, and that Addis was either a Communist or close to one. He admitted that his associations with these persons continued until 1942. There was no evidence before the Board with respect to an association with Jack Manley.

Dr. Oppenheimer testified that he made contributions to the Spanish War and Spanish Relief through Isaac Folkoff and Thomas Addis. He testified that he had seen Lambert on half a dozen occasions, and that he discussed such contributions once or twice at luncheon with Lambert and Folkoff.

Dr. Oppenheimer testified that Steve Nelson and his family visited his home on several occasions, the last being probably in 1942; that such visits lasted "a few hours;" that he had met Steve Nelson through his (Oppenheimer's) wife since Nelson had befriended her in Paris at the time of Dallet's death; that he had nothing in common with Nelson "except an affection for my wife."

14. It was reported that you were a subscriber to the Daily People's World, a west coast Communist newspaper, in 1941 and 1942.

The Board concludes that this allegation is true.

Dr. Oppenheimer testified that he had subscribed to the People's World "for several years." He could not recall when the subscription expired and stated that he did not believe he had canceled the subscription. He testified that he knew the Daily People's World was the west coast Communist newspaper.

15. It was reported in 1950 that you stated to an agent of the Federal Bureau of Investigation that you had in the past made contributions to Communist-front organizations, although at the time you did not know of Communist Party control or extent of infiltration of these groups. You further stated to an agent of the Federal Bureau of Investigation that some of these contributions were made through Isaac Folkoff, whom you knew to be a leading Communist Party functionary, because you had been told that this was the most effective and direct way of helping these groups.

The Board finds that Dr. Oppenheimer made the statements attributed to him by the Federal Bureau of Investigation.

The Board concludes that Dr. Oppenheimer in the past made contributions to Communist-front organizations and that some of these contributions were made through Isaac Folkoff, a leading Communist Party functionary.

Dr. Oppenheimer testified that he contributed to Spanish causes through Communist Party channels from the winter of 1937–38 until early in 1942. He said that he had contributed more than $500 and less than $1,000 each year during this period. He testified that he had made the contributions in cash and, in explaining how these contributions came to an end, he said (in referring to Pearl Harbor) that he "didn't like to continue a clandestine operation of any kind at a time when I saw myself with the possibility or prospect of getting more deeply involved in the war."

Dr. Oppenheimer in his answer admitted making the contributions through Thomas Addis and Isaac Folkoff. He testified that he knew Addis was a Communist or very close to a Communist. He knew that Folkoff was connected with the Communist Party. In addition, Dr. Oppenheimer admitted having contributed about $100 in cash to the Strike fund of one of the major strikes of "Bridges" Union" about 1937 or 1938.

16. It was reported that you attended a house-warming party at the home of Kenneth and Ruth May on September 20, 1941, for which there was an admission charge for the benefit of The Peoples World, and that at this party you were in the company of Joseph W. Weinberg and Clarence Hiskey, who were alleged to be members of the Communist Party and to have engaged in espionage on behalf of the Soviet Union. It was further reported that you informed officials of the United States Department of Justice in 1942 that you had no recollection that you had attended such a party, but that since it would have been in character for you to have attended such a party, you would not deny that you were there.

The Board concludes on the basis of information before it, that it was probable that Dr. Oppenheimer attended "the house-warming party" at the home of Kenneth and Ruth May. The Board concludes that Dr. Oppenheimer made the statements to the United States Department of Justice officials attributed to him.

Dr. Oppenheimer did not deny having attended such a party and testified that he knew Kenneth May. He denied knowing Hiskey but testified that he, Oppenheimer, was at parties at which Weinberg was present.

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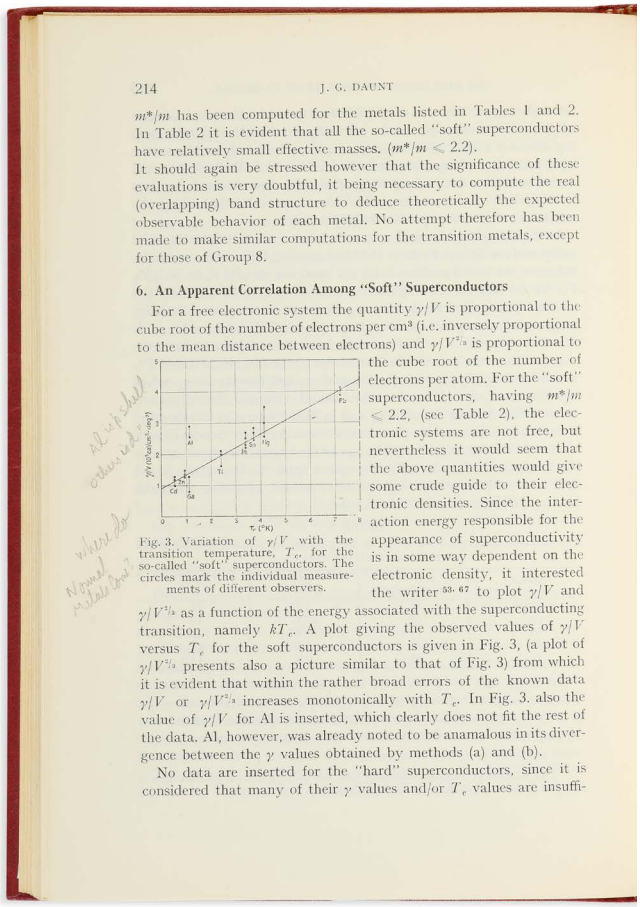

214 J. G. DAUNT

m^*/m has been computed for the metals listed in Tables 1 and 2. In Table 2 it is evident that all the so-called "soft" superconductors have relatively small effective masses, ($m^*/m \leqslant 2.2$). It should again be stressed however that the significance of these evaluations is very doubtful, it being necessary to compute the real (overlapping) band structure to deduce theoretically the expected observable behavior of each metal. No attempt therefore has been made to make similar computations for the transition metals, except for those of Group 8.

6. An Apparent Correlation Among "Soft" Superconductors

For a free electronic system the quantity γ/V is proportional to the cube root of the number of electrons per cm³ (i.e. inversely proportional to the mean distance between electrons) and $\gamma/V^{2/3}$ is proportional to the cube root of the number of electrons per atom. For the "soft" superconductors, having $m^*/m \leqslant 2.2$, (see Table 2), the electronic systems are not free, but nevertheless it would seem that the above quantities would give some crude guide to their electronic densities. Since the interaction energy responsible for the appearance of superconductivity is in some way dependent on the electronic density, it interested the writer [53, 67] to plot γ/V and $\gamma/V^{2/3}$ as a function of the energy associated with the superconducting transition, namely kT_c. A plot giving the observed values of γ/V versus T_c for the soft superconductors is given in Fig. 3, (a plot of $\gamma/V^{2/3}$ presents also a picture similar to that of Fig. 3) from which it is evident that within the rather broad errors of the known data γ/V or $\gamma/V^{2/3}$ increases monotonically with T_c. In Fig. 3. also the value of γ/V for Al is inserted, which clearly does not fit the rest of the data. Al, however, was already noted to be anamalous in its divergence between the γ values obtained by methods (a) and (b).

Fig. 3. Variation of γ/V with the transition temperature, T_c, for the so-called "soft" superconductors. The circles mark the individual measurements of different observers.

No data are inserted for the "hard" superconductors, since it is considered that many of their γ values and/or T_c values are insuffi-

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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

[FEYNMAN, RICHARD P. & J. ROBERT OPPENHEIMER]

United States Atomic Energy Commission. In the Matter of J. Robert Oppenheimer. Transcript of Hearing Before Personnel Security Board; Texts of Principal Documents and Letters of Personnel Security Board General Manager Commissioners. Washington, D.C.: United States Government Printing Office, 1954.

Two volumes. 8vo. 991; 67 pp. Original printed wrappers; edges toned, lower cover of vol 1 with large closed tear. "*Oppy*" written in pencil to spine in Feynman's hand, heavy underlining and annotations in Feynman's hand to vol 2.

FEYNMAN'S COPY OF THE OPPENHEIMER SECURITY HEARING TRANSCRIPTS, VOL 2 (TEXTS OF PRINCIPAL DOCUMENTS) HEAVILY UNDERLINED AND ANNOTATED BY HIM.

In 1954, the United States Atomic Energy Commission held security hearing proceedings to investigate J. Robert Oppenheimer, the head of the Los Alamos laboratory, where the atom bomb was developed as part of the Manhattan Project. Feynman joined the Manhattan Project while still a graduate student at Princeton, and worked with Oppenheimer, as well as with several of the people who gave statements during the hearing, including Enrico Fermi and Hans Bethe, who testified in support of Oppenheimer, and Edward Teller, who initially was opposed to the hearing, but who at the same time, had long-time grievances against Oppenheimer. Teller, when asked whether Oppenheimer should be granted a security clearance, said that it would be wiser not to do so. After the trial, Oppenheimer's clearance was revoked. Teller's testimony against him led to outrage in the scientific community, leading Teller to be ostracized.

Feynman's notations give us a fascinating insider's look at the hearing, with numerous sections marked as "*Lies!*", "*Not true*", and "*I wonder.*"

$ 2,500-3,500

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[FEYNMAN, RICHARD P.]

LONDON, FRITZ. *Superfluids. Volume II. Macroscopic Theory of Superfluid Helium.* New York: John Wiley & Sons, Inc., 1954.

8vo. 217 pp. Blue publisher's cloth, in original jacket. FIRST EDITION, SIGNED ON FLYLEAF IN BLUE INK "*R.P. FEYNMAN / CAL. TECH*"

WITH: GORTER, C.J. *Progress in Low Temperature Physics.* Amsterdam: North-Holland Publishing Company, 1955. 8vo. 418 pp. Brick-red publisher's cloth. FIRST EDITION, SIGNED ON FLYLEAF "R.P. FEYNMAN." WITH PENCIL ANNOTATIONS IN FEYNMAN'S HAND TO ONE PAGE.

FEYNMAN'S COPIES OF TWO KEY TEXTS IN SUPERFLUID AND LOW-TEMPERATURE PHYSICS.

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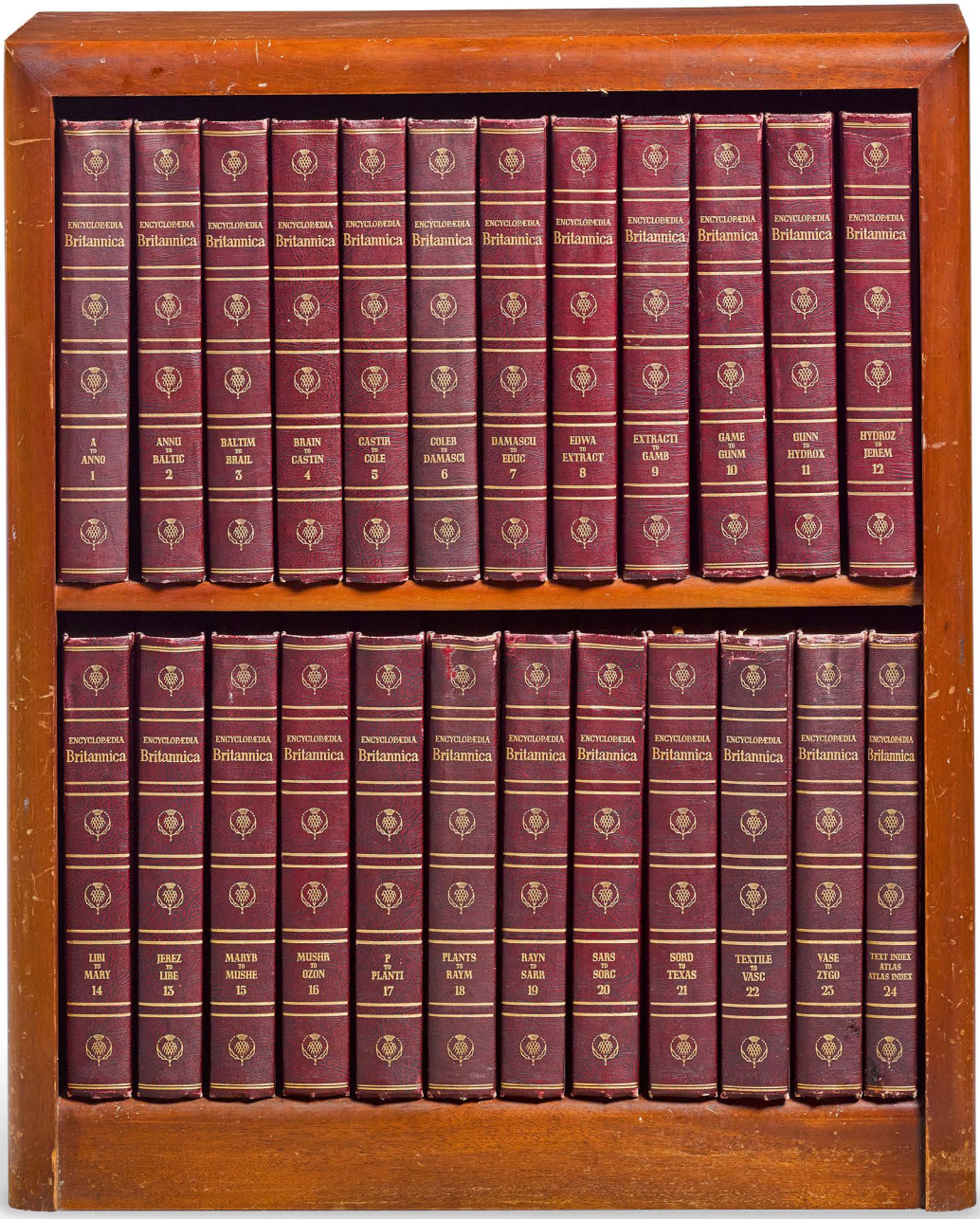

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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

[FEYNMAN, RICHARD P.]

Encyclopedia Britannica. London & New York: Encyclopedia Britannica Ltd., 1957.

Quarto. 24 volumes. Publisher's red leatherette cloth, covers with gilt thistle devices. Housed in the original oak case (24½ x 24 x 9 inches).

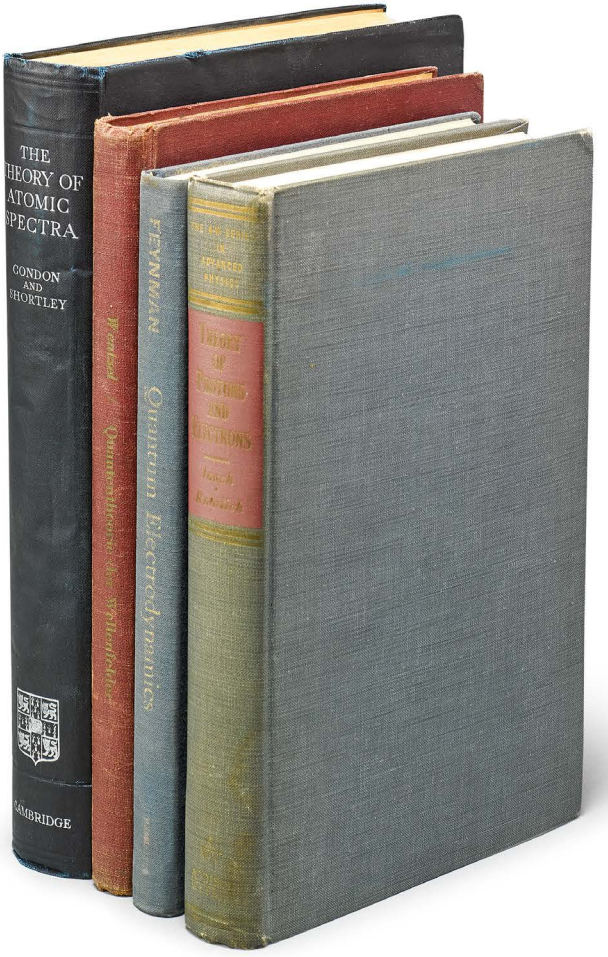
FEYNMAN'S OWN COPY OF ONE OF THE MUCH REFERENCED BOOKS OF HIS CHILDHOOD.

Feynman mentions the *Encyclopedia Britannica* several times in "*Surely You're Joking Mr. Feynman!*", and his biographer Gleick mentions it several times as well, noting that Feynman's father first bought him a copy when he was a small child and "Richard devoured it." (*Genius*, p. 25). Gleick notes again on page 38 of *Genius* that "Richard read and reread in the Feynman's *Encyclopedia Britannica* that...". It was not just a book that Feynman enjoyed as a child; it even figured into games played by him with his long time revel Julian Schwinger when they were old, as Gleick notes on p 49 of *Genius*

"Long afterward, when they were old men, after they had shared a Nobel Prize for work done as rivals, they amazed a dinner party by competing to see who could most quickly recite from memory the alphabetical headings on the spines of their half-century-old edition of the *Encyclopedia Britannica*." Perhaps Feynman's most famous mention of the *EB* is in his famous talk, *Plenty of Room at the Bottom* in which he poses the challenge of printing the entire *EB* on the head of a pin, offering $1,000 to whomever could do it.

$ 2,000-3,000

108 (DETAIL)



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[FEYNMAN, RICHARD P.]

FOUR BOOKS ON OR RELATING TO QED. 1935-1961.

1. CONDON, E.U & G.H. SHORTLEY. *The Theory of Atomic Spectra.* Cambridge: At the University Press, 1935. 8vo. 441 pp. Publisher's blue cloth, lettered in silver. FIRST EDITION. SIGNED ON FLY-LEAF *"R.P. FEYNMAN CORNELL UNIVERSITY DEPT. OF PHYSICS.",* WITH NOTE IN FEYNMAN'S HAND *"IT IS ON PAGE 76"* (referring to tables of Angular momentum), WITH ANNOTATIONS IN BLUE AND BLACK INK IN FEYNMAN'S HAND.

2. WENTZEL, GREGOR. *Einführung in die Quantentheorie der Wellenfelder.* Vienna: Franz Deuticke, 1943. 8vo. 209 pp. Publisher's brick-red cloth. FIRST EDITION. SIGNED ON FRONT FREE ENDPAPER "R.P. FEYNMAN / CORNELL UNIV." WITH PENCIL ANNOTATION IN FEYNMAN'S HAND.

3. JAUCH, J.M. & F. ROHRLICH. *The Theory of Photons and Electrons. The Relativistic Quantum Field Theory of Charged Particles with Spin One-half.* Cambridge, Mass: Addison-Wesley Publishing Company, Inc., 1955. 8vo. 488 pp. Publisher's gray cloth. FIRST EDITION, WITH SEVERAL PENCIL ANNOTATIONS IN FEYNMAN'S HAND.

4. FEYNMAN, RICHARD. *Quantum Electrodynamics. A Lecture Note and Reprint Volume.* New York: W.A. Benjamin Inc., 1961. 8vo. 198 pp. Publisher's blue cloth.

$ 2,000-3,000

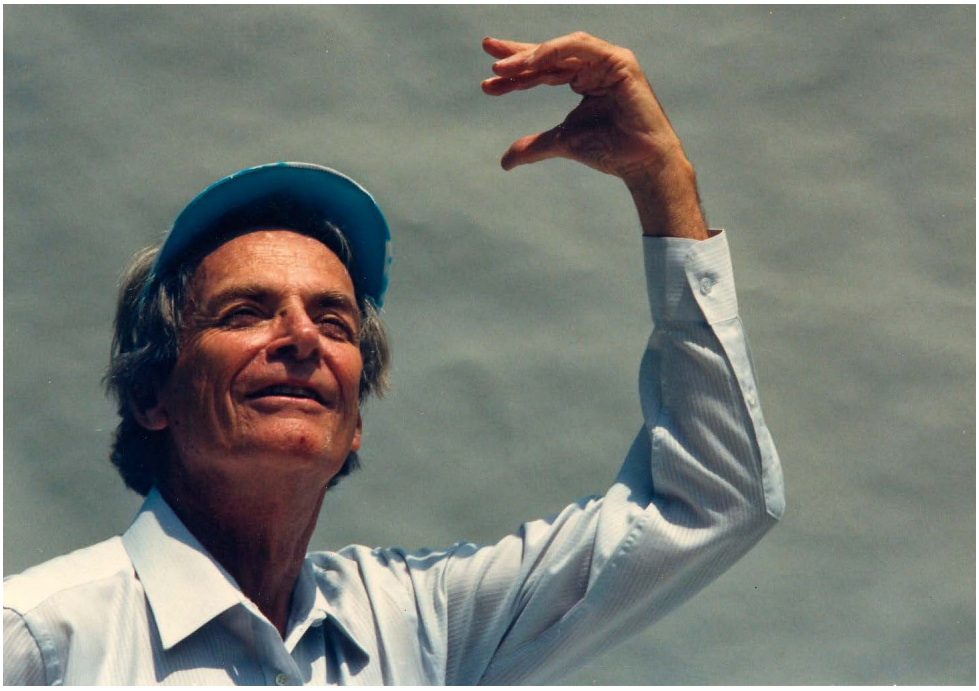
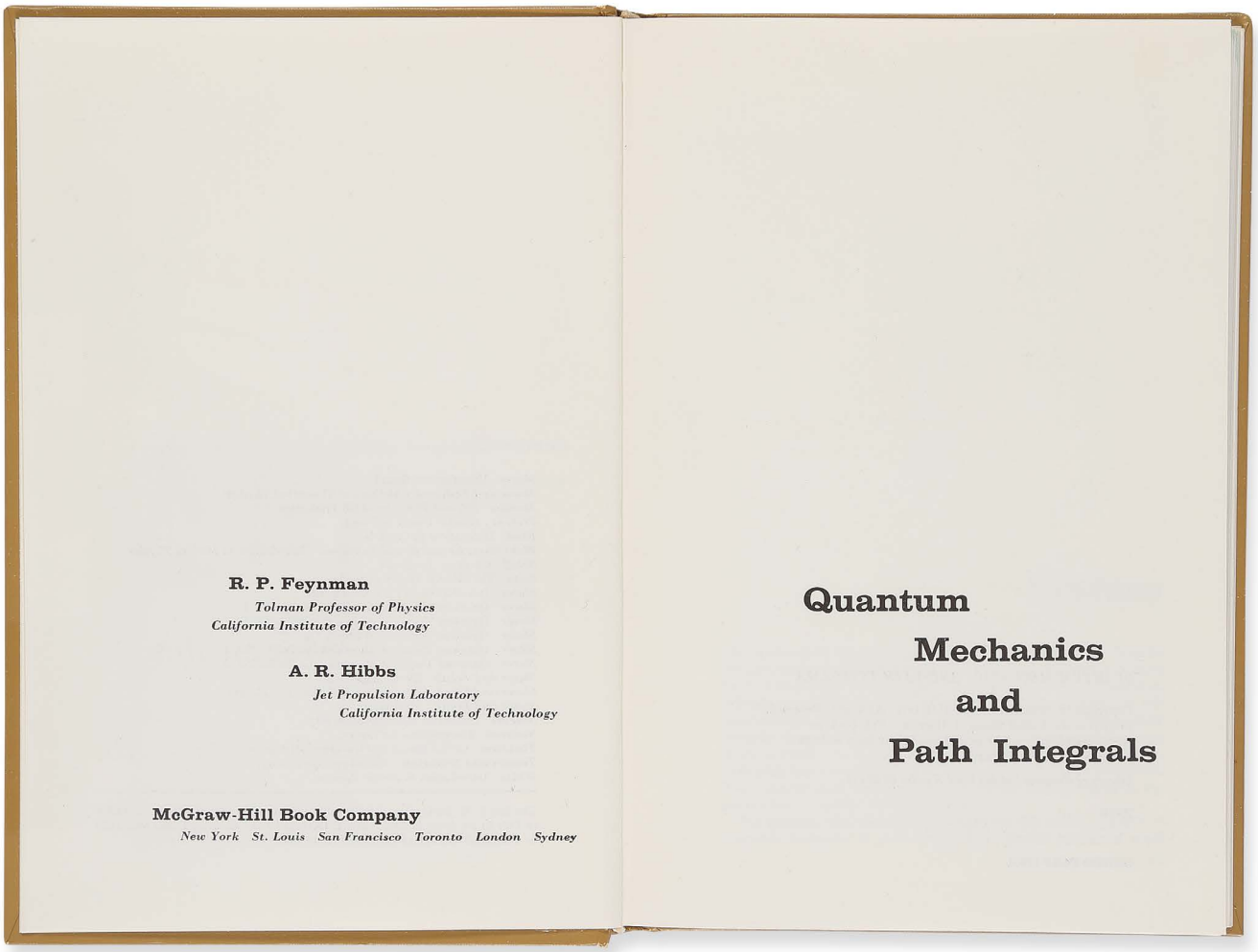


Photo by Michelle Feynman, courtesy of Michelle Feynman



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PROPERTY FROM THE FAMILY OF RICHARD P. FEYNMAN

FEYNMAN, RICHARD P.; HIBBS, A[LBERT]

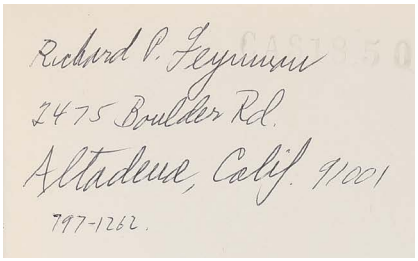
Quantum Mechanics & Path Integrals. New York: McGraw Hill, 1965.

8vo. 365 pp. Publisher's mustard cloth with green spine-label, lettered in silver. Spine & extremities rubbed. Original price of $18.50 stamped to front fly-leaf.

FIRST EDITION, FEYNMAN'S OWN COPY, SIGNED BY HIM ON FLYLEAF "*RICHARD P. FEYNMAN/ 2475 BOULDER RD./ ALTADENA, CALIF. 91001./ 797-1262.*" The only book signed by Feynman in his library that he also authored.

The textbook published by Feynman and his former graduate student and dear friend Al Hibbs, based on Feynman's teaching of graduate-level quantum mechanics courses at Caltech. Feynman developed his unconventional path-integral formulation of quantum mechanics while still a graduate student himself, and often used the method while teaching graduate courses in quantum mechanics at Caltech. McGraw Hill publishing company had approached Feynman about publishing a textbook on the subject, but Feynman, who hated the process of publishing his work, declined to do so. It was only at the urging of Hibbs that Feynman changed his mind, and only because Hibbs promised to do handle all of the burdensome details. Hibbs was a noted mathematician who was known the world over as "The Voice of JPL," the Jet Propulsion Laboratory in Pasadena, CA. Hibbs transcribed and edited Feynman's lectures in quantum electrodynamics, and in 1967, was chosen to be an astronaut on the cancelled Apollo 25 lunar mission.

$ 5,000-7,000



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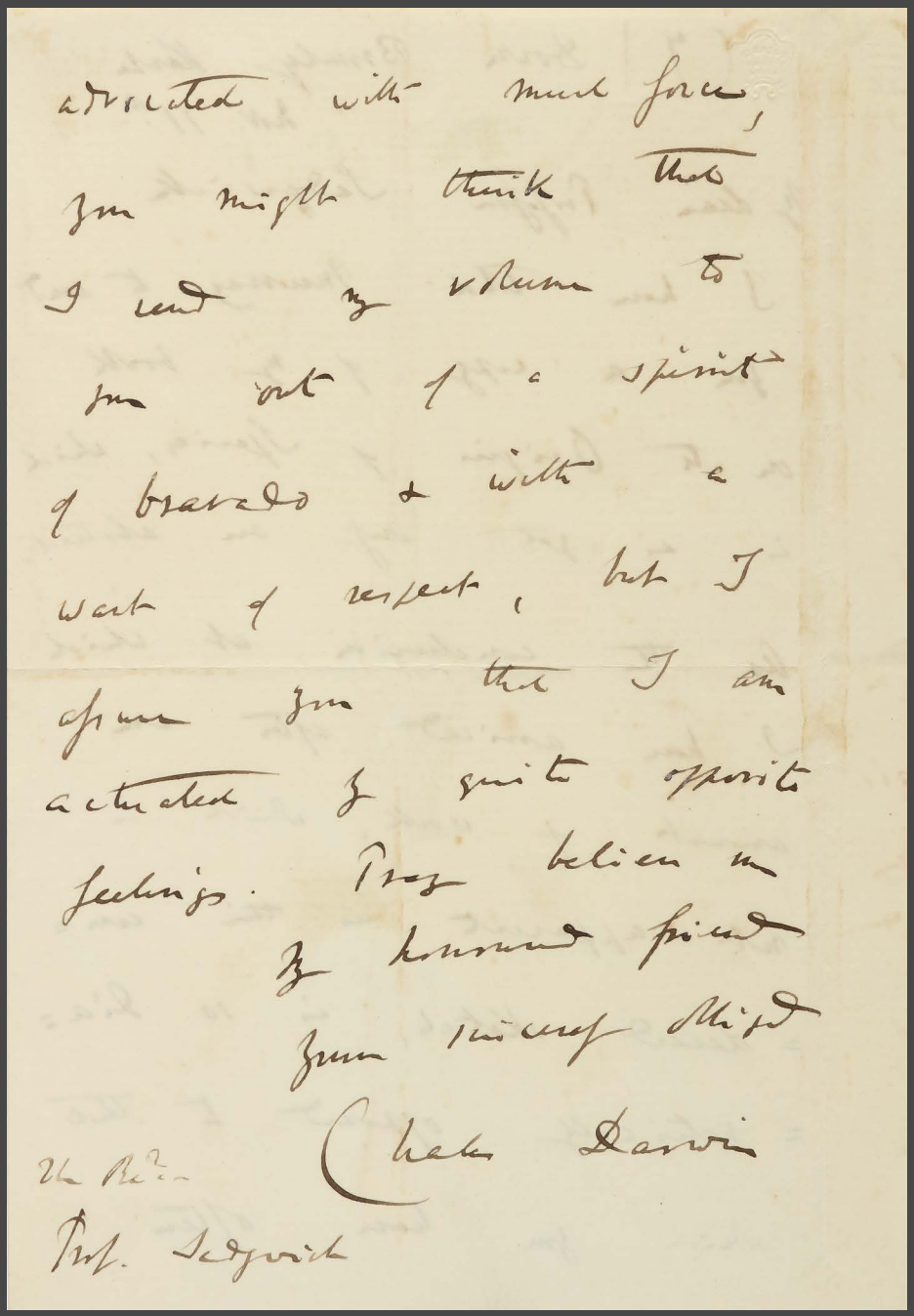

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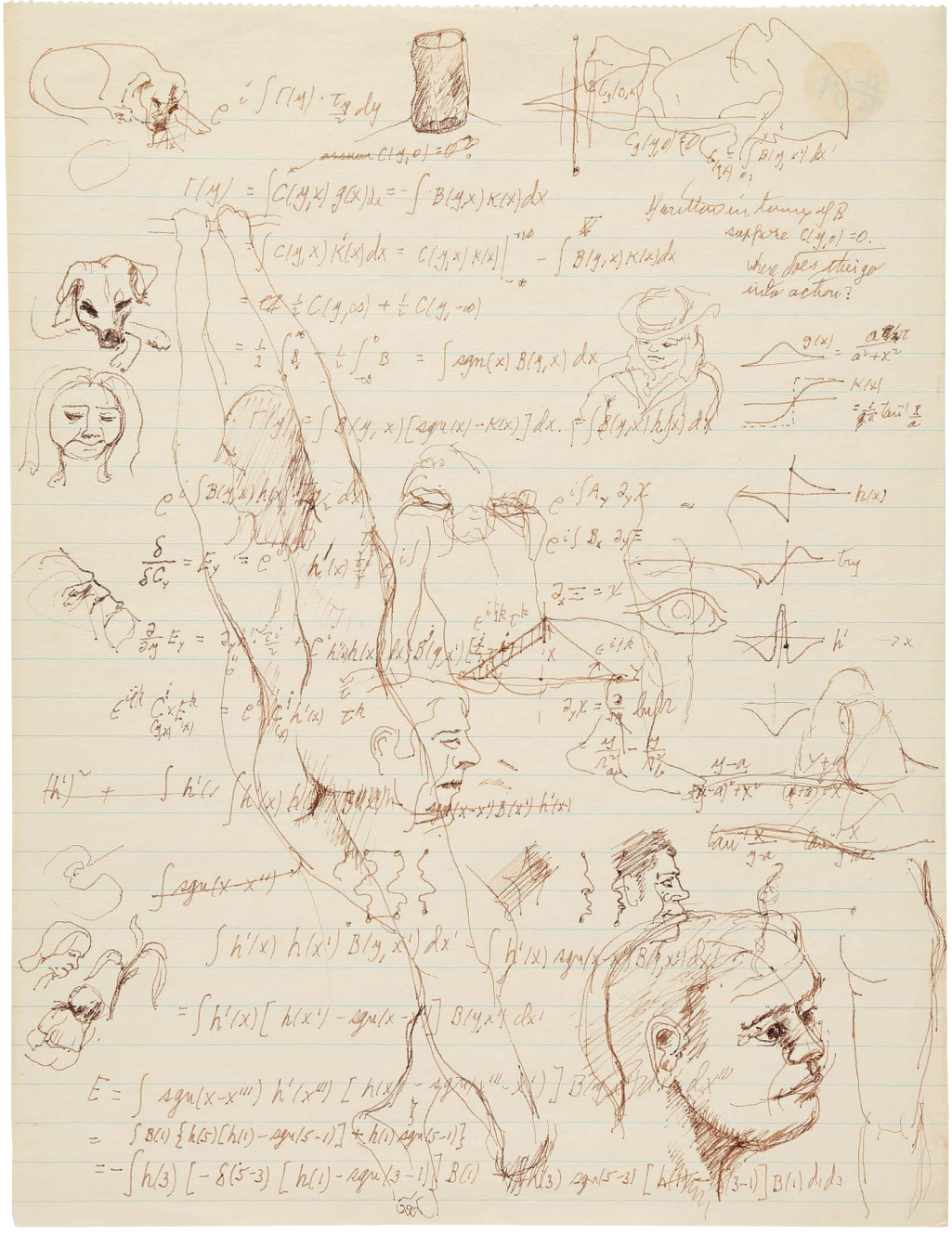

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If the client provides Sotheby's with information that is defined by European data protection laws as "sensitive", the client agrees that it may be used for the purposes set out above.

In the course of these disclosures, personal data collected in the European Economic Area may be disclosed to countries outside the European Economic Area. Although such countries may not have legislation that protects a client's personal information, Sotheby's shall take great care to keep such information secure and in accordance with European data protection principles. By agreeing to these Conditions of Business, the client is agreeing to such disclosure.

Please be aware that Sotheby's may film auctions or other activities on Sotheby's premises and that such recordings may be transmitted over the Internet via Sotheby's website, the eBay website and other Online Platforms. Telephone bids may be recorded.

Under European data protection laws, a client may object, by request and free of charge, to the processing of their information for certain purposes, including direct marketing, and may access and rectify personal data relating to them and may obtain more information about Sotheby's data protection policies by writing to Sotheby's, 34-35 New Bond Street, London W1A 2AA, or 1334 York Avenue, New York, NY 10021, Attn: Compliance, or emailing enquiries@sothebys.com. Sotheby's use of information collected about eBay users may differ and is governed by the terms of the eBay Privacy Policy and Sotheby's on eBay Live Auction Platform Privacy Policy, which can be found on the Sotheby's on eBay Live Auction Website.

Important

Please note that the execution of written and telephone bids is offered as an additional service for no extra charge, and at the bidder's risk. It is undertaken subject to Sotheby's other commitments at the time of the auction. Sotheby's therefore cannot accept liability for failure to place such bids, whether through negligence or otherwise. All bids will be executed and are accepted subject to the "Conditions of Sale" and "Terms of Guarantee" printed in the catalogue for the sale. Please note that a buyer's premium in the amount stated in paragraph 3 of the "Conditions of Sale" in the back of the sale catalogue will be added to the hammer price as part of the total purchase price, plus any applicable sales tax.

New Clients

Please note that we may contact you to request a bank reference. In addition Sotheby's requires a copy of government issued photo ID in order to generate a new account. If you have opened a new account with Sotheby's since 1 December, 2002, and have not already done so, you will be asked to present appropriate documentation confirming your identity before your lots or sale proceeds can be released to you.

For Written/Fixed Bids

- Bids will be executed for the lowest price as is permitted by other bids or reserves.
- "Buy" or unlimited bids will not be accepted and we do not accept "plus one" bids. Please place bids in the same order as in the catalogue.
- Always indicate a "top limit" — the amount up to which you would bid if you were attending the auction yourself.
- Alternative bids can be placed by using the word "or" between lot numbers.
- Where appropriate your written bids will be rounded down to the nearest amount consistent with the auctioneer's bidding increments.

For Telephone Bids

Please clearly specify the telephone number on which you may be reached at the time of the sale, including the country code. We will call you from the saleroom shortly before your lot is offered.

CONDITIONS OF SALE

The following Conditions of Sale and Terms of Guarantee are Sotheby's, Inc. and the Consignor's entire agreement with the purchaser and any bidders relative to the property listed in this catalogue.

The Conditions of Sale, Terms of Guarantee, the glossary, if any, and all other contents of this catalogue are subject to amendment by us by the posting of notices or by oral announcements made during the sale. The property will be offered by us as agent for the Consignor, unless the catalogue indicates otherwise.

By participating in any sale, you acknowledge that you are bound by these terms and conditions.

1. **As Is** Goods auctioned are often of some age. The authenticity of the Authorship (as defined below) of property listed in the catalogue is guaranteed as stated in the Terms of Guarantee and except for the Limited Warranty contained therein, all property is sold "AS IS" without any representations or warranties by us or the Consignor as to merchantability, fitness for a particular purpose, the correctness of the catalogue or other description of the physical condition, size, quality, rarity, importance, medium, frame, provenance, exhibitions, literature or historical relevance of any property and no statement anywhere, whether oral or written, whether made in the catalogue, an advertisement, a bill of sale, a salesroom posting or announcement, or elsewhere, shall be deemed such a warranty, representation or assumption of liability. We and the Consignor make no representations and warranties, express or implied, as to whether the purchaser acquires any copyrights, including but not limited to, any reproduction rights in any property. We and the Consignor are not responsible for errors and omissions in the catalogue, glossary, or any supplemental material. Sotheby's will not be responsible or liable for damage to frames and glass coverings, regardless of the cause.

2. **Inspection** Prospective bidders should inspect the property before bidding to determine its condition, size, and whether or not it has been repaired or restored.

3. **Buyer's Premium** A buyer's premium will be added to the hammer price and is payable by the purchaser as part of the total purchase price. The buyer's premium is 25% of the hammer price up to and including $300,000, 20% of any amount in excess of $300,000 up to and including $4,000,000, and 12.9% of any amount in excess of $4,000,000.

4. **Withdrawal** We reserve the right to withdraw any property before the sale and shall have no liability whatsoever for such withdrawal.

5. **Per Lot** Unless otherwise announced by the auctioneer, all bids are per lot as numbered in the catalogue.

6. **Bidding** We reserve the right to reject any bid. The highest bidder acknowledged by the auctioneer will be the purchaser. The auctioneer has absolute and sole discretion in the case of error or dispute with respect to bidding, and whether during or after the sale, to determine the successful bidder, to re-open the bidding, to cancel the sale or to re-offer and re-sell the item in dispute. If any dispute arises after the sale, our sale record is conclusive. In our discretion we will execute order or absentee bids and accept telephone bids and online bids via BIDnow, eBay, Invaluable or other online platforms as a convenience to clients who are not present at auctions; Sotheby's is not responsible for any errors or omissions in connection therewith. Prospective bidders should also consult sothebys.com for the most up to date cataloguing of the property in this catalogue.

By participating in the sale, you represent and warrant that any bids placed by you, or on your behalf, are not the product of any collusive or other anti-competitive agreement and are otherwise consistent with federal and state antitrust law.

In order to bid on "Premium Lots" you must complete the required Premium Lot pre-registration application. Sotheby's decision whether to accept any pre-registration application shall be final. You must arrange for Sotheby's to receive your pre-registration application at least three working days before the sale. Please bear in mind that we are unable to obtain financial references over weekends or public holidays.

Sotheby's may require such necessary financial references, guarantees, deposits and/or such other security, in its absolute discretion, as security for your bid(s).

7. **Online Bids via BIDnow or other Online Platforms:** Sotheby's may offer clients the opportunity to bid online via BIDnow, eBay, Invaluable or other Online Platforms for selected sales. By participating in a sale via any of these Online Platforms, you acknowledge that you are bound by these Conditions of Sale as well as the Additional Terms and Conditions for Live Online Bidding ("Online Terms"). By participating in a sale via any Online Platform, Bidders accept the Online Terms, as well as the relevant Conditions of Sale. Online bidding may not be available for Premium Lots.

8. **Bids Below Reserve** If the auctioneer determines that any opening bid is below the reserve of the article offered, he may reject the same and withdraw the article from sale, and if, having acknowledged an opening bid, he determines that any advance thereafter is insufficient, he may reject the advance.

9. **Purchaser's Responsibility** Subject to fulfillment of all of the conditions set forth herein, on the fall of the auctioneer's hammer, the contract between the consignor and the purchaser is concluded, and the winning bidder thereupon will immediately pay the full purchase price or such part as we may require. Title in a purchased lot will not pass until Sotheby's has received the full purchase price in cleared funds. The purchaser's obligation to immediately pay the full purchase price or such part as we may require is absolute and unconditional and is not subject to any defenses, setoffs or counterclaims of any kind whatsoever. Sotheby's is not obligated to release a lot to the purchaser until title to the lot has passed and any earlier release does not affect the passing of title or the purchaser's unconditional obligation to pay the full purchase price. In addition to other remedies available to us by law, we reserve the right to impose from the date of sale a late charge of the annual percentage rate of Prime + 6% of the total purchase price if payment is not made in accordance with the conditions set forth herein. Please note Sotheby's reserves the right to refuse to accept payment from a source other than the buyer of record.

Unless otherwise agreed by Sotheby's, all property must be removed from our premises by the purchaser at his expense not later than 30 calendar days following its sale. Purchasers are reminded that Sotheby's liability for loss of or damage to sold property shall cease upon the earlier of (a) 30 calendar days after the date of the auction and (b) our release of the property to the purchaser or the purchaser's designated agent. Upon the expiration of such 30 calendar day period or upon such earlier release, as applicable: (i) the purchaser bears full liability for any and all loss of or damage to the property; (ii) the purchaser releases Sotheby's, its affiliates, agents and warehouses from any and all liability and claims for loss of or damage to the property; and (iii) the purchaser agrees to indemnify and hold Sotheby's, its affiliates, agents and warehouses harmless from and against any and all liability for loss of or damage to property and any all claims related to loss of or damage to the property as of and from and after the time Sotheby's liability for loss or damage to the property ceases in accordance with this paragraph. If any applicable conditions herein are not complied with by the purchaser, the purchaser will be in default and in addition to any and all other remedies available to us and the Consignor by law, including, without limitation, the right to hold the purchaser liable for the total purchase price, including all fees, charges and expenses more fully set forth herein, we, at our option, may (x) cancel the sale of that, or any other lot or lots sold to the defaulting purchaser at the same or any other auction, retaining as liquidated damages all payments made by the purchaser, or (y) resell the purchased property, whether at public auction or by private sale, or (z) effect any combination thereof. In any case, the purchaser will be liable for any deficiency, any and all costs, handling charges, late charges, expenses of both sales, our commissions on both sales at our regular rates, legal fees and expenses, collection fees and incidental damages. We may, in our sole discretion, apply any proceeds of sale then due or thereafter becoming due to the purchaser from us or any affiliated company, or any payment made by the purchaser to us or any affiliated company, whether or not intended to reduce the purchaser's obligations with respect to the unpaid lot or lots, to the deficiency and any other amounts due to us or any affiliated companies. In addition, a defaulting purchaser will be deemed to have granted and assigned to us and our affiliated companies, a continuing security interest of first priority in any property or money of or owing to such purchaser in our possession, custody or control or in the possession, custody or control of any of our affiliated companies, in each case whether at the time of the auction, the default or if acquired at any time thereafter, and we may retain and apply such property or money as collateral security for the obligations due to us or to any affiliated company of ours. We shall have all of the rights accorded a secured party under the New York Uniform Commercial Code. You hereby agree that Sotheby's may file financing statements under the New York Uniform Commercial Code without your signature. Payment will not be deemed to have been made in full until we have collected good funds. Any claims relating to any purchase, including any claims under the Conditions of Sale or Terms of Guarantee, must be presented directly to Sotheby's. In the event the purchaser fails to pay any or all of the total purchase price for any lot and Sotheby's nonetheless elects to pay the Consignor any portion of the sale proceeds, the purchaser acknowledges that Sotheby's shall have all of the rights of the Consignor to pursue the purchaser for any amounts paid to the Consignor, whether at law, in equity, or under these Conditions of Sale.

10. **Reserve** All lots in this catalogue are offered subject to a reserve, which is the confidential minimum hammer price at which a lot will be sold. No reserve will exceed the low presale estimate stated in the catalogue, or as amended by oral or posted notices. We may implement such reserve by opening the bidding on behalf of the Consignor and may bid up to the amount of the reserve, by placing successive or consecutive bids for a lot, or bids in response to other bidders. In instances where we have an interest in the lot other than our commission, we may bid up to the reserve to protect such interest. In certain instances, the Consignor may pay us less than the standard commission rate where a lot is "bought-in" to protect its reserve.

11. **Tax** Unless exempted by law, the purchaser will be required to pay the combined New York State and local sales tax, any applicable compensating use tax of another state, and if applicable, any federal luxury or other tax, on the total purchase price. The rate of such combined tax is 8.875% in New York City and ranges from 7% to 8.625% elsewhere in New York.

12. **Export and Permits** It is the purchaser's sole responsibility to identify and obtain any necessary export, import, firearm, endangered species or other permit for the lot. Any symbols or notices in the sale catalogue reflect Sotheby's reasonable opinion at the time of cataloguing and are for bidders' general guidance only; Sotheby's and the Consignor make no representations or warranties as to whether any lot is or is not subject to export or import restrictions or any embargoes.

13. **Governing Law and Jurisdiction** These Conditions of Sale and Terms of Guarantee, as well as bidders', the purchaser's and our respective rights and obligations hereunder, shall be governed by and construed and enforced in accordance with the laws of the State of New York. By bidding at an auction, whether present in person or by agent, order bid, telephone, online or other means, all bidders including the purchaser, shall be deemed to have consented to the exclusive jurisdiction of the state courts of, and the federal courts sitting in, the State of New York. All parties agree, however, that Sotheby's shall retain the right to bring proceedings in a court other than the state and federal courts sitting in the State of New York.

14. **Packing and Shipping** We are not responsible for the acts or omissions in our packing or shipping of purchased lots or of other carriers or packers of purchased lots, whether or not recommended by us. Packing and handling of purchased lots is at the entire risk of the purchaser.

15. **Limitation of Liability** In no event will the aggregate liability of Sotheby's and the consignor to a purchaser exceed the purchase price actually paid.

16. **Data Protection** Sotheby's will use information provided by its clients (or which Sotheby's otherwise obtains from eBay, Invaluable or other sources relating to its clients) for the provision of auction and other art-related services, loan services, client administration, marketing and otherwise to manage and operate its business, or as required by law, in accordance with Sotheby's Privacy Policy. This will include information such as the client's name and contact details, proof of identity, financial information, records of the client's transactions, and preferences. Some gathering of information about Sotheby's clients will take place using technical means to identify their preferences in order to provide a higher quality of service to them. Sotheby's may also disclose the client information to other Sotheby's Companies and/or third parties acting on their behalf to provide services for these purposes.

Sometimes, Sotheby's may also disclose this information to carefully selected third parties for their own marketing purposes. If you do not wish your details to be used for this purpose, please email enquiries@sothebys.com.

If the client provides Sotheby's with information that is defined by European data protection laws as "sensitive", the client agrees that it may be used for the purposes set out above.

In the course of these disclosures, personal data collected in the European Economic Area may be disclosed to countries outside the European Economic Area. Although such countries may not have legislation that protects a client's personal information, Sotheby's shall take great care to keep such information secure and in accordance with European data protection principles. By agreeing to these Conditions of Sale, the client is agreeing to such disclosure.

Please be aware that Sotheby's may film auctions or other activities on Sotheby's premises and that such recordings may be transmitted over the Internet via Sotheby's website, the eBay website, the Invaluable website and other Online Platforms. Telephone bids may be recorded.

Under European data protection laws, a client may object, by request and free of charge, to the processing of their information for certain purposes, including direct marketing, and may access and rectify personal data relating to them and may obtain more information about Sotheby's data protection policies by writing to Sotheby's, 34-35 New Bond Street, London W1A 2AA, or 1334 York Avenue, New York, NY 10021, Attn: Compliance, or emailing enquiries@sothebys.com. Sotheby's use of information collected about eBay users may differ and is governed by the terms of the eBay Privacy Policy and Sotheby's on eBay Live Auction Platform Privacy Policy, which can be found on the Sotheby's on eBay Live Auction Website. Sotheby's use of information collected about Invaluable users may differ and is governed by the terms of the Invaluable Privacy Policy and Sotheby's on Invaluable Online Platform Privacy Policy, which can be found on the Sotheby's on Invaluable Live Auction Website.

TERMS OF GUARANTEE

As set forth below and in the Conditions of Sale, for all lots Sotheby's guarantees that the authorship, period, culture or origin (collectively, "Authorship") of each lot in this catalogue is as set out in the BOLD or CAPITALIZED type heading in the catalogue description of the lot, as amended by oral or written salesroom notes or announcements. Purchasers should refer to the Glossary of Terms, if any, for an explanation of the terminology used in the Bold or Capitalized type heading and the extent of the Guarantee. Sotheby's makes no warranties whatsoever, whether express or implied, with respect to any material in the catalogue other than that appearing in the Bold or Capitalized heading and subject to the exclusions below.

In the event Sotheby's in its reasonable opinion deems that the conditions of the Guarantee have been satisfied, it shall refund to the original purchaser of record the hammer price and applicable Buyer's Premium paid for the lot by the original purchaser of record.

This Guarantee is provided for a period of five (5) years from the date of the relevant auction, is solely for the benefit of the original purchaser of record at the auction and may not be transferred to any third party. To be able to claim under this Guarantee of Authorship, the original purchaser of record must: (i) notify Sotheby's in writing within three (3) months of receiving any information that causes the original purchaser of record to question the accuracy of the Bold or Capitalized type heading, specifying the lot number, date of the auction at which it was purchased and the reasons for such question; and (ii) return the Lot to Sotheby's at the original selling location in the same condition as at the date of sale to the original purchaser of record and be able to transfer good title to the Lot, free from any third party claims arising after the date of such sale.

Sotheby's has discretion to waive any of the above requirements. Sotheby's may require the original purchaser of record to obtain at the original purchaser of record's cost the reports of two independent and recognized experts in the field, mutually acceptable to Sotheby's and the original purchaser of record. Sotheby's shall not be bound by any reports produced by the original purchaser of record, and reserves the right to seek additional expert advice at its own expense. It is specifically understood and agreed that the rescission of a sale and the refund of the original purchase price paid (the successful hammer price, plus the buyer's premium) is exclusive and in lieu of any other remedy which might otherwise be available as a matter of law, or in equity. Sotheby's and the Consignor shall not be liable for any incidental or consequential damages incurred or claimed, including without limitation, loss of profits or interest.

ADDITIONAL TERMS AND CONDITIONS FOR LIVE ONLINE BIDDING

The following terms and conditions (the "Online Terms") provide important information related to live online bidding via BIDnow, eBay, Invaluable, and any other Online Platform through which bidding is made available ("Online Platforms").

These Conditions are in addition to and subject to the same law and our standard terms and conditions of sale, including the authenticity guarantee and any other terms and are not intended in any way to replace them. By participating in this sale via any Online Platform, you acknowledge that you are bound by the Conditions of Sale applicable in the relevant sale and by these additional Conditions.

1. The procedure for placing bids via Online Platforms is a one-step process; as soon as the "Bid Now" button is clicked, a bid is submitted. By placing a bid via any Online Platform, you accept and agree that bids submitted in this way are final and that you will not under any circumstances be permitted to amend or retract your bid. If a successful bid is sent to Sotheby's from your computer, phone, tablet, or any other device, you irrevocably agree to pay the full purchase price, including buyer's premium and all applicable taxes and other applicable charges.

2. If you have the leading bid, it will be indicated on the screen with the statement "Bid with you" (on BIDNow) or "You're the highest bidder" (on eBay) or "Bid with you" (on Invaluable). If a bid is placed online simultaneously with a bid placed by a bidder in the room or on the telephone (a "floor" bid), the "floor" bid generally will take precedence; the auctioneer will have the final discretion to determine the successful bidder or to reopen bidding. The auctioneer's decision is final.

3. The next bidding increment is shown on the screen for your convenience. The auctioneer has discretion to vary bidding increments for bidders in the auction room and on the telephones, but bidders using Online Platforms may not be able to place a bid in an amount other than a whole bidding increment. All bidding for this sale will be in the domestic currency of the sale location, and online bidders will not be able to see the currency conversion board that may be displayed in the auction room.

4. The record of sale kept by Sotheby's will be taken as absolute and final in all disputes. In the event of a discrepancy between any online records or messages provided to you and the record of sale kept by Sotheby's, the record of sale will govern.

5. Online bidders are responsible for making themselves aware of all salesroom notices and announcements. All saleroom notices will be read by the auctioneer at the beginning, where appropriate, or during the sale prior to a relevant lot being offered for sale. Sotheby's recommends that online bidders log on at least ten minutes before the scheduled start of the auction to ensure that you have heard all announcements made by the auctioneer at the beginning of the sale.

6. Sotheby's reserves the right to refuse or revoke permission to bid via Online Platforms and to remove bidding privileges during a sale.

7. Purchase information shown in the "Account Activity" section of BIDnow, the "Purchase History" section of the "My eBay" page on eBay and the "Account Activity" section of the "My Invaluable" page on Invaluable is provided for your convenience only. Successful bidders will be notified and invoiced by Sotheby's after the sale. In the event of any discrepancy between any online purchase information and the invoice sent to you by Sotheby's following the respective sale, the invoice prevails. Terms and conditions for payment and collection of property remain the same regardless of how the winning bid was submitted.

8. Sotheby's offers online bidding as a convenience to our clients. Sotheby's will not be responsible for any errors or failures to execute bids placed via Online Platforms, including, without limitation, errors or failures caused by (i) a loss of connection to the internet or to the BIDnow, eBay, Invaluable or other Online Platform software by either Sotheby's or the client; (ii) a breakdown or problem with the BIDnow, eBay, Invaluable or other Online Platform software; or (iii) a breakdown or problem with a client's internet connection, mobile network or computer. Sotheby's is not responsible for any failure to execute an online bid or for any errors or omissions in connection therewith.

9. Live online bidding via all Online Platforms will be recorded.

10. In the event of any conflict between these Online Terms and Sotheby's Conditions of Sale and Terms of Guarantee, Sotheby's Conditions of Sale and Terms of Guarantee will control.

11. In the event of any conflict between these Online Terms and any term in any agreement between the User and eBay, these Online Terms will control for purposes of all Sotheby's auctions.

12. In the event of any conflict between these Online Terms and any term in any agreement between the User and Invaluable, these Online Terms will control for purposes of all Sotheby's auctions.

BUYING AT AUCTION

The following will help in understanding the auction buying process as well as some of the terms and symbols commonly used in an auction catalogue. All bidders should read the Conditions of Sale and Terms of Guarantee in this catalogue, as well as the Glossary or any other notices. By bidding at auction, bidders are bound by the Conditions of Sale and Terms of Guarantee, as amended by any oral announcement or posted notices, which together form the sale contract among Sotheby's, the seller (consignor) of the lot and any bidders, including the successful bidder (purchaser).

1. SYMBOL KEY

☐ Reserves
Unless indicated by a box (☐), all lots in this catalogue are offered subject to a reserve. A reserve is the confidential minimum hammer price at which a lot will be sold. The reserve is generally set at a percentage of the low estimate and will not exceed the low estimate of the lot. If any lots in the catalogue are offered without reserve, such lots will be designated by a box (☐). If every lot in a catalogue is offered without a reserve, the Conditions of Sale will so state and this symbol will not be used for each lot.

○ Guaranteed Property
The seller of lots with this symbol has been guaranteed a minimum price from one auction or a series of auctions. This guarantee may be provided by Sotheby's or jointly by Sotheby's and a third party. Sotheby's and any third parties providing a guarantee jointly with Sotheby's benefit financially if a guaranteed lot is sold successfully and may incur a loss if the sale is not successful. If the Guaranteed Property symbol for a lot is not included in the printing of the auction catalogue, a pre-sale or pre-lot announcement will be made indicating that there is a guarantee on the lot.

△ Property in which Sotheby's has an Ownership Interest
Lots with this symbol indicate that Sotheby's owns the lot in whole or in part or has an economic interest in the lot equivalent to an ownership interest.

∋ Irrevocable Bids
Lots with this symbol indicate that a party has provided Sotheby's with an irrevocable bid on the lot that will be executed during the sale at a value that ensures that the lot will sell. The irrevocable bidder, who may bid in excess of the irrevocable bid, may be compensated for providing the irrevocable bid by receiving a contingent fee, a fixed fee or both. If the irrevocable bidder is the successful bidder, any contingent fee, fixed fee or both (as applicable) for providing the irrevocable bid may be netted against the irrevocable bidder's obligation to pay the full purchase price for the lot and the purchase price reported for the lot shall be net of any such fees. From time to time, Sotheby's may enter into irrevocable bid agreements that cover multiple lots. In such instances, the compensation Sotheby's will pay the irrevocable bidder is allocated to the lots for which the irrevocable bidder is not the successful purchaser. Under such circumstances, the total compensation to the irrevocable bidder will not exceed the total buyer's premium and other amounts paid to Sotheby's in respect of any lots for which the irrevocable bidder is not the successful bidder. If the irrevocable bid is not secured until after the printing of the auction catalogue, Sotheby's will notify bidders that there is an irrevocable bid on the lot by one or more of the following means: a pre-sale or pre-lot announcement, by written notice at the auction or by including an irrevocable bid symbol in the e-catalogue for the sale prior to the auction. From time to time, Sotheby's or any affiliated company may provide the irrevocable bidder with financing related to the irrevocable bid. If the irrevocable bidder is advising anyone with respect to the lot, Sotheby's requires the irrevocable bidder to disclose his or her financial interest in the lot. If an agent is advising you or bidding on your behalf with respect to a lot identified as being subject to an irrevocable bid, you should request that the agent disclose whether or not he or she has a financial interest in the lot.

⊻ Interested Parties
Lots with this symbol indicate that parties with a direct or indirect interest in the lot may be bidding on the lot, including (i) the beneficiary of an estate selling the lot, or (ii) the joint owner of a lot. If the interested party is the successful bidder, they will be required to pay the full Buyer's Premium. In certain instances, interested parties may have knowledge of the reserve. In the event the interested party's possible participation in the sale is not known until after the printing of the auction catalogue, a pre-sale or pre-lot announcement will be made indicating that interested parties may be bidding on the lot.

◉ Restricted Materials
Lots with this symbol have been identified at the time of cataloguing as containing organic material which may be subject to restrictions regarding import or export. The information is made available for the convenience of bidders and the absence of the symbol is not a warranty that there are no restrictions regarding import or export of the Lot; bidders should refer to Condition 12 of the Conditions of Sale. Please also refer to the section on Endangered Species in the information on Buying at Auction.

∏ Monumental
Lots with this symbol may, in our opinion, require special handling or shipping services due to size or other physical considerations. Bidders are advised to inspect the lot and to contact Sotheby's prior to the sale to discuss any specific shipping requirements.

♧ Premium Lot
In order to bid on "Premium Lots" (♧ in print catalogue or ✧ in eCatalogue) you must complete the required Premium Lot pre-registration application. You must arrange for Sotheby's to receive your pre-registration application at least three working days before the sale. Please bear in mind that we are unable to obtain financial references over weekends or public holidays. Sotheby's decision whether to accept any pre-registration application shall be final. If your application is accepted, you will be provided with a special paddle number. If all lots in the catalogue are "Premium Lots", a Special Notice will be included to this effect and this symbol will not be used.

2. BEFORE THE AUCTION

The Catalogue A catalogue prepared by Sotheby's is published for every scheduled live auction and is available prior to the sale date. The catalogue will help familiarize you with property being offered at the designated auction. Catalogues may be purchased at Sotheby's or by subscription in any categories. For information, please call +1 212 606 7000 or visit sothebys.com. Prospective bidders should also consult sothebys.com for the most up to date cataloguing of the property in this catalogue.

Estimates Each lot in the catalogue is given a low and high estimate, indicating to a prospective buyer a range in which the lot might sell at auction. When possible, the estimate is based on previous auction records of comparable pieces. The estimates are determined several months before a sale and are therefore subject to change upon further research of the property, or to reflect market conditions or currency fluctuations. Estimates should not be relied upon as a representation or prediction of actual selling prices.

Provenance In certain circumstances, Sotheby's may print in the catalogue the history of ownership of a work of art if such information contributes to scholarship or is otherwise well known and assists in distinguishing the work of art. However, the identity of the seller or previous owners may not be disclosed for a variety of reasons. For example, such information may be excluded to accommodate a seller's request for confidentiality or because the identity of prior owners is unknown given the age of the work of art.

Specialist Advice Prospective bidders may be interested in specific information not included in the catalogue description of a lot. For additional information, please contact either a Sotheby's specialist in charge of the sale (all of whom are listed in the front of the catalogue), or Sotheby's Client Services Department. You may also request a condition report from the specialist in charge.

The Exhibition An exhibition of the auction property will be held the week prior to the auction on the days listed in the front of the catalogue. There you will have the opportunity to view, inspect and evaluate the property yourself, or with the help of a Sotheby's specialist.

Salesroom Notices Salesroom notices amend the catalogue description of a lot after our catalogue has gone to press. They are posted in the viewing galleries and salesroom or are announced by the auctioneer. Please take note of them.

Registration Sotheby's may require such necessary financial references, guarantees, deposits and/or such other security, in its absolute discretion, as security for your bid. If you are not successful on any lot, Sotheby's will arrange for a refund (subject to any right of set off) of the deposit amount paid by you without interest within 14 working days of the date of the sale. Any exchange losses or fees associated with the refund shall be borne by you. Registration to bid on Premium Lots must be done at least 3 business days prior to the sale.

3. DURING THE AUCTION

The Auction Auctions are open to the public without any admission fee or obligation to bid. The auctioneer introduces the objects for sale — known as "lots" — in numerical order as listed in the catalogue. Unless otherwise noted in the catalogue or by an announcement at the auction, Sotheby's acts as agent on behalf of the seller and does not permit the seller to bid on his or her own property. It is important for all bidders to know that the auctioneer may open the bidding on any lot by placing a bid on behalf of the seller. The auctioneer may further bid on behalf of the seller, up to the amount of the reserve, by placing responsive or consecutive bids for a lot. The auctioneer will not place consecutive bids on behalf of the seller above the reserve.

Bidding in Person If you would like to bid, you must register for a paddle upon entering the salesroom. The paddle is numbered so as to identify you to the auctioneer. To register, you will need a form of identification such as a driver's license, a passport or some other type of government issued identification. If you are a first-time bidder, you will also be asked for your address, phone number and signature in order to create your account. If you are bidding for someone else, you will need to provide a letter from that person authorizing you to bid on that person's behalf. Issuance of a bid paddle is in Sotheby's sole discretion.

Once the first bid has been placed, the auctioneer asks for higher bids, in increments determined by the auctioneer. To place your bid, simply raise your paddle until the auctioneer acknowledges you. You will know when your bid has been acknowledged; the auctioneer will not mistake a random gesture for a bid.

If you wish to register to bid on a Premium Lot, please see the paragraph above.

All lots sold will be invoiced to the name and address in which the paddle has been registered and cannot be transferred to other names and addresses. Sotheby's reserves the right to refuse to accept payment from a source other than the buyer of record.

Absentee Bidding If it is not possible for you to attend the auction in person, you may place your bid ahead of time. In the back of every catalogue there is an absentee bid form, which you can use to indicate the item you wish to bid on and the maximum bid you are willing to make. Return the completed absentee bid form to Sotheby's either by mail or fax. When the lot that you are interested in comes up for sale, a Sotheby's representative will execute the bid on your behalf, making every effort to purchase the item for as little as possible and never exceeding your limit. This service is free and confidential. For detailed instructions and information, please see the Absentee Bid Form and Guide for Absentee Bidders instructions at the back of this catalogue.

Telephone Bidding In some circumstances, we offer the ability to place bids by telephone live to a Sotheby's representative on the auction floor. Please contact the Bid Department prior to the sale to make arrangements or to answer any questions you may have. Telephone bids are accepted only at Sotheby's discretion and at the caller's risk. Calls may also be recorded at Sotheby's discretion. By bidding on the telephone, prospective buyers consent thereto.

Online Bidding If you cannot attend the auction, it may be possible to bid online via BIDnow, eBay, Invaluable or other Online Platforms for selected sales. This service is free and confidential. For information about registering to bid via BIDnow, please see www.sothebys.com. For information about registering to bid on eBay, please see www.ebay.com/sothebys. For information about registering to bid on Invaluable, please see www.invaluable.com/invaluable/help.cfm. Bidders utilizing any online platform are subject to the Online Terms as well as the relevant Conditions of Sale. Online bidding may not be available for Premium Lots.

Employee Bidding Sotheby's employees may bid in a Sotheby's auction only if the employee does not know the reserve and if the employee fully complies with Sotheby's internal rules governing employee bidding.

US Economic Sanctions The United States maintains economic and trade sanctions against targeted foreign countries, groups and organizations. There may be restrictions on the import into the United States of certain items originating in sanctioned countries, including Burma, Cuba, Iran, North Korea and Sudan. The purchaser's inability to import any item into the US or any other country as a result of these or other restrictions shall not justify cancellation or rescission of the sale or any delay in payment. Please check with the specialist department if you are uncertain as to whether a lot is subject to these import restrictions, or any other restrictions on importation or exportation.

Hammer Price and the Buyer's Premium For lots which are sold, the last price for a lot as announced by the auctioneer is the hammer price. A buyer's premium will be added to the hammer price and is payable by the purchaser as part of the total purchase price. The buyer's premium will be the amount stated in the Conditions of Sale.

Currency Board As a courtesy to bidders, a currency board is operated in many salesrooms. It displays the lot number and current bid in both U.S. dollars and foreign currencies. Exchange rates are approximations based on recent exchange rate information and should not be relied upon as a precise invoice amount. Sotheby's assumes no responsibility for any error or omission in foreign or United States currency amounts shown.

Results Successful absentee bidders will be notified after the sale. Absentee bidders will receive a list of sale results if they enclose a stamped self-addressed envelope with their absentee bid form. Printed lists of auction prices are available at our galleries approximately three weeks following each auction and are sent on request to catalogue purchasers and subscribers. Results may also be obtained online at sothebys.com.

International Auctions If you need assistance placing bids, obtaining condition reports or receiving auction results for a Sotheby's sale outside the United States, please contact our International Client Services Department.

4. AFTER THE AUCTION

Payment If your bid is successful, you can go directly to Post Sale Services to make payment arrangements. Otherwise, your invoice will be mailed to you. The final price is determined by adding the buyer's premium to the hammer price on a per-lot basis. Sales tax, where applicable, will be charged on the entire amount. Payment is due in full immediately after the sale. However, under certain circumstances, Sotheby's may, in its sole discretion, offer bidders an extended payment plan. Such a payment plan may provide an economic benefit to the bidder. Credit terms should be requested at least one business day before the sale. However, there is no assurance that an extended payment plan will be offered. Please contact Post Sale Services or the specialist in charge of the sale for information on credit arrangements for a particular lot. Please note that Sotheby's will not accept payments for purchased lots from any party other than the purchaser, unless otherwise agreed between the purchaser and Sotheby's prior to the sale.

Payment by Cash It is against Sotheby's general policy to accept single or multiple related payments in the form of cash or cash equivalents in excess of the local currency equivalent of US $10,000. It is Sotheby's policy to request any new clients or purchasers preferring to make a cash payment to provide: verification of identity (by providing some form of government issued identification containing a photograph, such as a passport, identity card or driver's license), confirmation of permanent address and identification of the source of the funds.

Payment by Credit Cards Sotheby's accepts payment by credit card for Visa, MasterCard, and American Express only. Credit card payments may not exceed $50,000 per sale. Payment by credit card may be made (a) online at https://www.sothebys.com/en/invoice-payment.html, (b) by calling in to Post Sale Services at +1 212 606 7444, or (c) in person at Sotheby's premises at the address noted in the catalogue.

Payment by Check Sotheby's accepts personal, certified, banker's draft and cashier's checks drawn in US Dollars (made payable to Sotheby's). While personal and company checks are accepted, property will not be released until such checks have cleared, unless you have a pre-arranged check acceptance agreement. Application for check clearance can be made through the Post Sale Services.

Certified checks, banker's drafts and cashier's checks are accepted at Sotheby's discretion and provided they are issued by a reputable financial institution governed by anti-money laundering laws. Instruments not meeting these requirements will be treated as "cash equivalents" and subject to the constraints noted in the prior paragraph titled "Payment By Cash".

Payment by Wire Transfer To pay for a purchase by wire transfer, please refer to the payment instructions on the invoice provided by Sotheby's or contact Post Sale Services to request instructions.

Sales and Use Tax New York sales tax is charged on the hammer price, buyer's premium and any other applicable charges on any property picked up or delivered in New York State, regardless of the state or country in which the purchaser resides or does business. Purchasers who wish to use their own shipper who is not a considered a "common carrier" by the New York Department of Taxation and Finance will be charged New York sales tax on the entire charge regardless of the destination of the property. Please refer to "Information on Sales and Use Tax Related to Purchases at Auction" in the back of the catalogue.

Collection and Delivery
Post Sale Services
+ 1 212 606 7444
FAX: + 1 212 606 7043
uspostsaleservices@sothebys.com

Once your payment has been received and cleared, property may be released. Unless otherwise agreed by Sotheby's, all purchases must be removed by the 30th calendar day following a sale.

Shipping Services Sotheby's offers a comprehensive shipping service to meet all of your requirements. If you received a shipping quotation or have any questions about the services we offer please contact us.

Collecting your Property As a courtesy to purchasers who come to Sotheby's to collect property, Sotheby's will assist in the packing of lots, although Sotheby's may, in the case of fragile articles, choose not to pack or otherwise handle a purchase.

If you are using your own shipper to collect property from Sotheby's, please provide a letter of authorization and kindly instruct your shipper that they must provide a Bill of Lading prior to collection. Both documents must be sent to Post Sale Services prior to collection.

The Bill of Lading must include: the purchaser's full name, the full delivery address including the street name and number, city and state or city and country, the sale and lot number.

Sotheby's will contact your shipper within 24 hours of receipt of the Bill of Lading to confirm the date and time that your property can be collected. Property will not be released without this confirmation and your shipper must bring the same Bill of Lading that was faxed to Sotheby's when collecting. All property releases are subject to the receipt of cleared funds.

Please see the Conditions of Sale for further details.

Endangered Species Certain property sold at auction, for example, items made of or incorporating plant or animal materials such as coral, crocodile, ivory, whalebone, tortoiseshell, rhinoceros horn, rosewood, etc., irrespective of age or value, may require a license or certificate prior to exportation and additional licenses or certificates upon importation to another country. Sotheby's suggests that buyers check on their government wildlife import requirements prior to placing a bid. Please note that the ability to obtain an export license or certificate does not ensure the ability to obtain an import license or certificate in another country, and vice versa. It is the purchaser's responsibility to obtain any export or import licenses and/or certificates as well as any other required documentation. In the case of denial of any export or import license or of delay in the obtaining of such licenses, the purchaser is still responsible for making on-time payment of the total purchase price for the lot.

Although licenses can be obtained to export some types of endangered species, other types may not be exported at all, and other types may not be resold in the United States. Upon request, Sotheby's is willing to assist the purchaser in attempting to obtain the appropriate licenses and/or certificates. However, there is no assurance that an export license or certificate can be obtained. Please check with the specialist department or the Shipping Department if you are uncertain as to whether a lot is subject to these export/import license and certificate requirements, or any other restrictions on exportation.

The Art Loss Register As part of Sotheby's efforts to support only the legitimate art market and to combat the illegitimate market in stolen property, Sotheby's has retained the Art Loss Register to check all uniquely identifiable items offered for sale in this catalogue that are estimated at more than the equivalent of US$1,500 against the Art Loss Register's computerized database of objects reported as stolen or lost. The Art Loss Register is pleased to provide purchasers with a certificate confirming that a search has been made. All inquiries regarding search certificates should be directed to The Art Loss Register, First Floor, 63-66 Hatten Garden, London EC1N 8LE or by email at artloss@artloss.com. The Art Loss Register does not guarantee the provenance or title of any catalogued item against which they search, and will not be liable for any direct or consequential losses of any nature howsoever arising. This statement and the ALR's service do not affect your rights and obligations under the Conditions of Sale applicable to the sale.

SELLING AT AUCTION

If you have property you wish to sell, Sotheby's team of specialists and client services representatives will assist you through the entire process. Simply contact the appropriate specialist (specialist departments are listed in the back of this catalogue), General Inquiries Department or a Sotheby's regional office representative for suggestions on how best to arrange for evaluation of your property.

Property Evaluation There are three general ways evaluation of property can be conducted:

(1) In our galleries
You may bring your property directly to our galleries where our specialists will give you auction estimates and advice. There is no charge for this service, but we request that you telephone ahead for an appointment. Inspection hours are 9:30 am to 5 pm, Monday through Friday.

(2) By photograph
If your property is not portable, or if you are not able to visit our galleries, you may bring in or send a clear photograph of each item. If you have a large collection, a representative selection of photographs will do. Please be sure to include the dimensions, artist's signature or maker's mark, medium, physical condition and any other relevant information. Our specialists will provide a free preliminary auction estimate subject to a final estimate upon first-hand inspection.

(3) In your home
Evaluations of property can also be made in your home. The fees for such visits are based on the scope and diversity of property, with travel expenses additional. These fees may be rebated if you consign your property for sale at Sotheby's. If there is considerable property in question, we can arrange for an informal "walkthrough."

Once your property has been evaluated, Sotheby's representatives can then help you determine how to proceed should you wish to continue with the auction process. They will provide information regarding sellers' commission rates and other charges, auction venue, shipping and any further services you may require.

SOTHEBY'S SERVICES

Sotheby's also offers a range of other services to our clients beyond buying and selling at auction. These services are summarized below. Further information on any of the services described below can be found at sothebys.com.

Valuations and Appraisals Sotheby's Valuations and Appraisals Services offers advice regarding personal property assets to trusts, estates, and private clients in order to help fiduciaries, executors, advisors, and collectors meet their goals. We provide efficient and confidential advice and assistance for all appraisal and auction services. Sotheby's can prepare appraisals to suit a variety of needs, including estate tax and planning, insurance, charitable contribution and collateral loan. Our appraisals are widely accepted by the Internal Revenue Service, tax and estate planning professionals, and insurance firms. In the event that a sale is considered, we are pleased to provide auction estimates, sales proposals and marketing plans. When sales are underway, the group works closely with the appropriate specialist departments to ensure that clients' needs are met promptly and efficiently.

Financial Services Sotheby's offers a wide range of financial services including advances on consignments, as well as loans secured by art collections not intended for sale.

Museum Services Tailored to meet the unique needs of museums and nonprofits in the marketplace, Museum Services offers personal, professional assistance and advice in areas including appraisals, deaccessions, acquisitions and special events.

Corporate Art Services Devoted to servicing corporations, Sotheby's Corporate Art Services Department can prepare appraisal reports, advise on acquisitions and deaccessions, manage all aspects of consignment, assist in developing arts-management strategies and create events catering to a corporation's needs.

INFORMATION ON SALES AND USE TAX RELATED TO PURCHASES AT AUCTION

To better assist our clients, we have prepared the following information on Sales and Use Tax related to property purchased at auction.

Why Sotheby's Collects Sales Tax
Virtually all State Sales Tax Laws require a corporation to register with the State's Tax Authorities and collect and remit sales tax if the corporation either establishes or maintains physical or economic presence within the state. In the states that impose sales tax, Tax Laws require an auction house, with such presence in the state, to register as a sales tax collector, and remit sales tax collected to the state. New York sales tax is charged on the hammer price, buyer's premium and any other applicable charges on any property picked up or delivered in New York, regardless of the state or country in which the purchaser resides or does business.

Where Sotheby's Collects Sales Tax
Sotheby's is currently registered to collect sales tax in the following states: Alabama, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Illinois, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nevada, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Texas, Vermont, Washington and Wisconsin. For any property collected or received by the purchaser in New York City, such property is subject to sales tax at the existing New York State and City rate of 8.875%.

Sotheby's Arranged Shipping If the property is delivered into any state in which Sotheby's is registered, Sotheby's is required by law to collect and remit the appropriate sales tax in effect in the state where the property is delivered.

Client Arranged Shipping Property collected from Sotheby's New York premises by a common carrier hired by the purchaser for delivery at an address outside of New York is not subject to New York Sales Tax, but if the property is delivered into any state in which Sotheby's is registered, Sotheby's is required by law to collect and remit the appropriate sales tax in effect in the state where the property is delivered. New York State recognizes shippers such as the United States Postal Service, United Parcel Service, FedEx, or the like as "common carriers". If a purchaser hires a shipper other than a common carrier to pick up property, Sotheby's will collect New York sales tax at a rate of 8.875% regardless of the ultimate destination of the goods. If a purchaser utilizes a freight-forwarder who is registered with the Transportation Security Administration ("TSA") to deliver property outside of the United States, no sales tax would be due on this transaction.

Where Sotheby's is Not Required to Collect Sales Tax Sotheby's is not required to collect sales tax on property delivered to states other than those listed above. If the property is delivered to a state where Sotheby's is not required to collect sales tax, it is the responsibility of the purchaser to self-assess any sales or use tax and remit it to taxing authorities in that state.

Sotheby's is not required to collect sales tax for property delivered to the purchaser outside of the United States.

Restoration and Other Services
Regardless of where the property is subsequently transported, if any framing or restoration services are performed on the property in New York, it is considered to be a delivery of the property to the purchaser in New York, and Sotheby's will be required to collect the 8.875% New York sales tax.

Certain Exemptions Most states that impose sales taxes allow for specified exemptions to the tax. For example, a registered re-seller such as a registered art dealer may purchase without incurring a tax liability, and Sotheby's is not required to collect sales tax from such re-seller. The art dealer, when re-selling the property, may be required to charge sales tax to its client, or the client may be required to self-assess sales or use tax upon acquiring the property.

Local Tax Advisors As sales tax laws vary from state to state, Sotheby's recommends that clients with questions regarding the application of sales or use taxes to property purchased at auction seek tax advice from their local tax advisors.

IMPORTANT NOTICES

Property Collection As of March 19, 2018, property that is sold, has bought in, or is to be returned to the consignor will be moved to our temporary offsite location at Crozier Fine Arts at One Star Ledger Plaza, 69 Court Street, Newark, NJ (SLP Warehouse). Certain items of property, including jewelry, watches, silver, works on panel and items valued $10 million or more will remain at 1334 York Avenue. All other property will be moved to our temporary offsite location on the day the applicable sale concludes and is available for pickup after two business days. Invoices and statements will indicate your property's location.

Property Payment All property must be paid in full before collection or release from any Sotheby's location. Payment must be made through Sotheby's New York Post Sale Services by way of our acceptable forms of payment methods mentioned on your invoice. To arrange for payment, please contact Post Sale Services at +1 212 606 7444 or USPostSaleServices@sothebys.com. Payment will not be accepted at the offsite facility. Dealers and resale clients should fill out the appropriate forms where applicable or contact Post Sale Services with any questions.

Loss and Liability Unless otherwise agreed by Sotheby's, all sold property must be removed from any of our premises (including the SLP Warehouse) by the buyer at their expense no later than 30 calendar days following its sale. Buyers are reminded that Sotheby's liability for loss or damage to sold property shall cease no later than 30 calendar days after the date of the auction.

Collection & Shipping The SLP Warehouse requires 24 hours advanced notice for collection of property. Please arrange this through our Post Sale Services team at +1 212 606 7444 or USPostSaleServices@sothebys.com.

For in-person collections at our offsite location, please alert Post Sale Services of your proposed collection date, ensure that all outstanding invoices have been paid for, and that you or your agent have the appropriate photo identification upon arrival.

If you are using your own shipper to collect property, please provide a letter of authorization and instruct your shipper to email their bill of lading to billsoflading@sothebys.com and ensure the correct collection location is specified.

Sotheby's can arrange for delivery of your property through one of our contracted vendors or can coordinate pick up at our offsite location with you or your shipper directly. Please contact Post Sale Services at +1 212 606 7444 or USPostSaleServices@sothebys.com to start your collection process.

Photography:

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Elliot Perez
Paulette Tavormina

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For a full listing of our offices and salerooms worldwide with detailed information on all of Sotheby's services, visit sothebys.com

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FORTHCOMING AUCTIONS

A comprehensive calendar of international auctions, in addition to all sale results, can be viewed at sothebys.com

ENGLISH LITERATURE, HISTORY, CHILDREN'S BOOKS AND ILLUSTRATIONS ONLINE AUCTION
November 30 - December 10
London

FINE BOOKS AND MANUSCRIPTS ONLINE AUCTION
3-17 December
New York

MUSIC, MEDIEVAL AND RENAISSANCE MANUSCRIPTS AND CONTINENTAL BOOKS
4 December
London

FINE AUTOGRAPH LETTERS AND MANUSCRIPTS FROM A DISTINGUISHED PRIVATE COLLECTION: PART II MUSIC, AMERICANA, ENGLISH AND CONTINENTAL LITERATURE
13 December
New York

OPPOSITE PAGE
LOT 50 (DETAIL)

What I cannot create,
I do not understand.

Why const × sort. POM

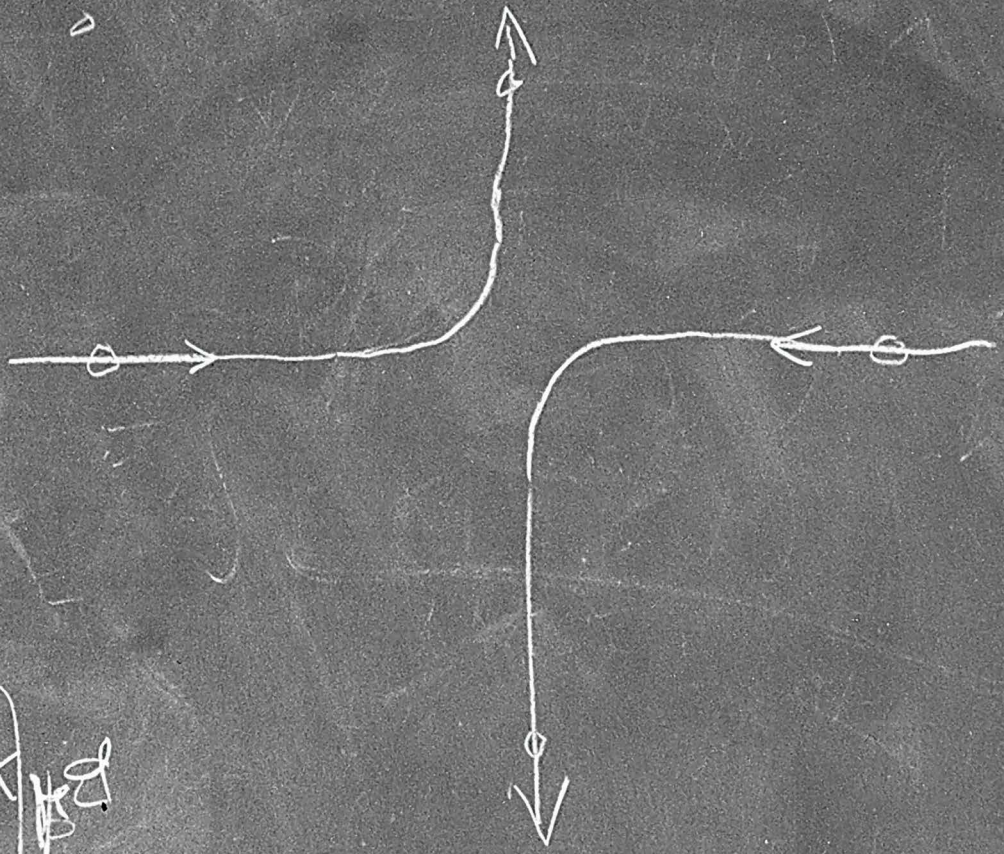
TO LEARN:
Bethe Ansatz Probs.
Kondo
2-D Hall
accel. Temps
Non Linear Classical Hydro

Know how to solve every
problem that has been solved

(A) $f = U(r, a)$

$g = 4(r \cdot z)\, a(r \cdot z)$

(B) $f = 2|r \cdot a|(u \cdot a)$



(3)

$$L = \int \sqrt{g}\, g^{\alpha\beta}\, \partial_\alpha X^\mu \partial_\beta X$$