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Fundamental aspects of depreciation theory

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FUNDAMENTAL ASPECTS OF DEPRECIATION THEORY

by

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INTRODUCTION

CHAPTER I

OBJECT OF INVESTIGATION

The search for new methods whereby depreciation can be estimated has produced an extensive literature in which many of the fundamental aspects of depreciation theory are presented in an unrelated manner. The need for a complete discussion of these fundamentals is apparent and the present dissertation is an attempt to present such a discussion.

The history of the concept of charging for the use of long-lived properties reveals a division of opinion about its application even before the term "depreciation" was used. In part, the present concept of depreciation is confused because of the ambiguous terminology which permeates much of the writings. The interpretation of the meaning of the word depreciation by the courts in the regulation of public utilities has contributed its share of trouble to a clarification of the application of depreciation. The ends which can be achieved by depreciation policies have been intermingled with managerial or political ends to which depreciation has only an evanescent relationship.

The objective of this dissertation is to present a detailed discussion of the history and the elements of depreciation. Within this discussion the goals which have been set forth as ends toward which depreciation policy has been directed will be indicated. It is not the intent of the author to present a new theory; instead, the presentation of a small part of an integration of present thinking on depreciation is all that is hoped for.

CHAPTER II

ORIGIN OF THE PROBLEM

The development of the concept of depreciation arose when it was necessary to determine profits or losses, and to make monetary adjustments for periods of time which were shorter than the life of the property. The fundamental problem has been a result of relative time intervals in which the indivisible interval of property life, although it is a prime quantity, must be subdivided because of business conventions. The problem in an actual firm is complex since different properties have lives which may vary from a few seconds to a century or more. Seldom does the length of these property lives coincide with the arbitrary business intervals of a month, a year, or a production unit.

Frequently it is assumed that all property which is consumed during a business period can rightfully[1] be charged to that period. The consumption of property refers to either the physical transformation of materials or the economic transformation of a long-lived property

[1]The basis for deciding whether this is right must await an examination of the ends to be achieved by depreciation.

into the subsequent products. Overtly these charges refer only to the fact that when a ton of steel is consumed it may be charged as "one-ton-of-steel." This assumption does not state what the relative pecuniary charge is. Herein lies another question. Whenever the price of a ton of steel varies during the business period, what should be the price used for accounting purposes? According to the recent accounting procedures the steel could be charged at the latest purchase price. This is the last-in-first-out, LIFO, method of calculating the cost of consumable materials. It would be just as feasible to use a first-in-first-out method, or an average. The choice between these methods depends upon the ends to be attained,[1] i.e., whether costs should reflect the current market, be based on the actual money outlay, or rely upon an average or standard price.

The cost of a property which is long lived relative to the business period should be allocated over several periods. Thus, the additional problem of allocating a portion of the property to a specific period is added to the previous pricing problem encountered with

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[1]A good discussion of the LIFO, FIFO, and weighted average methods of valuing inventories is presented by W. A. Paton. Advanced accounting. New York, The Macmillan Company. 1941. pp. 138-169.

consumable supplies. The basis of allocation may be time or production. It may be on a cost or value basis. Since allocations will be distributed throughout time, interest may enter the problem. Long-lived property which is partly consumed during a period retains the pricing problem and in addition propounds many additional problems. The choice between the various alternatives still depends upon the end in view. Therefore, it may be helpful to examine the possible goals which allocation and pricing methods can be expected to achieve.

CHAPTER III

THREEFOLD[1] CONCEPT OF DEPRECIATION

Ambiguity in the use of the word "depreciation" is one of the major errors which must be rectified before any discussion of depreciation can be intelligible. Depreciation may represent entirely different ideas when used with reference to "cost", to "value", or to physical condition. Cost as used hereinafter is the actual cash outlay or its equivalent necessary to purchase or fabricate the property and place it in operating condition. Value is the monetary equivalent at any instant of the anticipated future benefits to be received from the ownership of the property. Physical condition is the ratio of the observed condition[2] of the property to

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[1]A fourth concept of replacement cost of the service minus present value of the property is sometimes included but is actually a combination of the cost and value concepts.

[2]The ratio of observed conditions may be the result of a qualitative inspection of the property. However, it is also the ratio of physical characteristics which can be measured, e.g., the ratio of the depth of pitting in a cast iron pipe to the maximum permissible depth, the decrease in the maximum pressure in an internal combustion engine cylinder to the maximum allowable decrease.

that of new property of the same kind. Cost is based upon recorded transactions. Value is based upon anticipated returns. Physical condition is based on observation.

Cost and value are equal only for the marginal purchaser. The specious interpretation of this principle is that cost and value are equal at the time of purchase.[1] Generally value is greater than cost and cannot be less than cost at the time of purchase. The specious equality of cost and value to the buyer at the time of purchase is the result of the inadequate consideration of the significance of supply and demand curves. Supply and demand curves which establish the price of any good are the composite of all of the individual's supply and demand curves.

The price, or cost to the purchaser, is determined in the market in which the demand curve represents the composite prospective bids based on anticipated returns of all purchasers, whereas the supply curve repre-

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[1] J. B. Canning. Economics of accountancy. New York, The Ronald Press. 1929. Chapter XII. M. R. Scharf, F.J. Leerburger, Joseph Jeming. Depreciation of public utility property. 285 Madison Avenue, New York, M.R. Scharf. 1940. Part III, p. 2. "If the money has been prudently spent, then we may assume that cost and value are synonymous at the time of installation. . . ."

sents the composite offerings of all sellers. Thus, the prospective bids include many which are higher than the final price. Since the price will be established which nets the seller the greatest profit,[1] many purchasers will obtain property for less than the anticipated returns. Thus for these individuals the cost is less than the value. This increment is the consumers's surplus.[2]

A simplified illustration of this situation might be as follows. Each of fifteen firms wishes to replace its present machines with a special turret lathe. One firm is willing to pay $20,000 for a lathe; two firms are willing to pay $18,000; four, $17,000; and eight, $15,000. The cost of manufacture plus a normal return is $15,000 and is constant over this range of output. If the lathes are made by a single manufacturer he should set the price at $17,000 to maximize his profit when a single price is quoted to all purchasers. However, if there are many manufacturers each attempting to underbid

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[1]Profit is used in the sense commonly employed in business in which both the risk and interest are included, not in the sense generally employed in economics wherein it is a payment for risk.

[2]Alfred Marshall. Principles of economics. London, Macmillan and Co., Ltd. 1938. pp. 124, 830.
J.R. Hicks. Value and capital. Oxford, The Clarendon Press. 1939. pp. 38-39.

his rival, the price will be $15,000. In either case several purchasers will be able to buy the machine for less than its value to them.

The meaning of the word depreciation must be clearly stated whenever it is used because it may refer either to cost, to value, or to physical condition. Hereinafter that differentiation will be made by using the terms cost-depreciation, value-depreciation, and physical condition. The only exceptions to this convention will be in direct quotations, in the general historical review of the evolution of the concept of depreciation, and in a discussion encompassing all of the meanings. The definitions of cost-depreciation and value-depreciation differ in that the former is an arbitrary allocation while the latter is a result of the change in anticipation of future benefits. Cost-depreciation is the allocation of the purchase price over the life of the equipment. Value-depreciation is the change in anticipated benefits between two points in time.

Depreciation may also connote a relative physical condition. Whereas cost and value are measurable in dollars, physical condition is an estimate of the per cent of the tangible decay of a property. It may be a factor in either of the previous concepts of cost-depreciation or value-depreciation but it is generally insufficient to attribute all of either cost or value depreciation to the physical condition. This concept has given rise to the "good as new", "plant immortality", or the "since it is 100% efficient there is no depreciation" claims in valuations.

In order to understand the significance of the three meanings of depreciation and the confusion which has resulted from the failure to recognize the distinction, it is helpful to examine the historical development of these ideas.

PART II

EVOLUTION OF THE CONCEPT OF DEPRECIATION

CHAPTER IV

GROWTH OF THE CONCEPT OF CHARGING FOR THE USE OF LONG-LIVED PROPERTY

The word depreciation was not used in accounting until about 1838. However, the recognition of the diminution of the utility of long-lived assets has been recorded in pre-Christian documents. Since most references to the early history of wasting assets are generally found in bookkeeping texts, most of the evolution of depreciation is recorded in early works on bookkeeping. The present brief account of the evolution prior to 1900 relies heavily upon A. C. Littleton's Accounting Evolution to 1900,[1] Perry Mason's "Illustrations of the Early Treatment of Depreciation,"[2] and E. A. Saliers' Depreciation Principles and Applications.[3]

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[1]A.C. Littleton. Accounting evolution to 1900. New York, American Institute Publishing Co. 1933.

[2]Perry Mason. Illustrations of the early treatment of depreciation. Accounting Review. 8:209-218. 1933.

[3]E.A. Saliers. Depreciation principles and applications. New York, The Ronald Press. 1939. pp.8-36.

The ancient peoples had little need for accurate bookkeeping. The nomadic life of many of them meant that long-lived property was rare. If long-lived property existed at all it was owned by a family or tribe. This made annual reckoning of gains or losses unnecessary. Even after these people settled in agricultural communities properties were still owned by the family. The rulers of the communities levied taxes but the calculation of income, as we think of it, was not involved since these levies were paid in kind.

Although bookkeeping was still a matter of little concern, the sale of properties presented a problem whenever joint ownership occurred. In an architectural manuscript of about 27 B.C. the following statement about the allocation of the original cost of a masonry wall is found:

> He, therefore, who is desirous of producing a lasting structure, is enabled, by what I have laid down, to choose the sort of wall that will suit his purpose. Those walls which are built of soft and smooth-looking stone, will not last long. Hence, when valuations are made of external walls, we must not put them at their original cost; but having found, from the register, the number of lettings they have gone through, we must deduct for every year of their age an eightieth part of such cost, and set down the remainder or balance as their value, inasmuch as they are not calculated to last more than eighty years. This is not the

> practice in the case of brick walls, which whilst they stand upright, are always valued at their first cost.[1]

Although the Romans of from 0-500 A.D. are reputed to have had some method of bookkeeping which resembled the double-entry method, there is little evidence that it contained any organized system of double-entry accounts.

There is very little of importance to note "From the Fall of the Western Empire until the Norman conquest of England, when the English Exchequer, with its elaborate system of finance and its famous Pipe-Rolls, first comes to notice."[2]

The development of accounting awaited the advent of writing, arithmetic, private property, money, credit, commerce, and capital. The emergence of bookkeeping as a first step toward accounting was closely allied to the development of arithmetic. The first well organized treatise on double-entry bookkeeping appeared

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[1]The architecture of Marcus Vitruvius Pollio in ten books translated from the Latin by Joseph Gwilt, F.S.A., F.R.A.S. London, Lockwood & Co. 1874. (From manuscripts dated 1552, 1649, and later.) Book the Second, Chapter VIII, p. 47.

[2]A.H. Woolf. A short history of accountants and accountancy. London, Gee and Co. 1912. p. 54.

as a small part of a much larger work on mathematics, Summa di Arithmetica Geometria Proportioni & Proportionalita (1494), by a monk, Luca Pacioli.[1]

The first reference to a charge for wear and tear appeared in a textbook, A Briefe Instruction and Maner How to Keepe Bookes of Accompts After the Order of Debitor and Creditor, written by John Mellis in 1588.[2] The following entry was made on the credit side of the ledger account "Implements of householde":

> Implements of householde here
> against is due to have xl.xs and
> is for so much as I doe finde at
> this day to be consumed and worn,
> which said xl.xs for the decay of
> the said household stuffe is borne
> to profit and losse in
> Debitor (15) 10 10 0

The profit-and loss account was debited with the following:

> More xl.xs. for so much lost by
> decay householde stuff as in
> Creditor (06) . . . . . 10 10 0[3]

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[1]Complete title from Institute of Chartered Accountants. Library Catalogue, Vol. II, The Bibliography of Bookkeeping. London, Gee & Co. 1937.

[2]Complete title from source in footnote 1. Title followed by note: "Text of the bookkeeping portion adapted by Hugh Oldcastle from L. Pacioli."

[3]A.C. Littleton, op. cit., p. 223.

A century later, 1683, in Stephen Monteague's Debtor and Creditor Made Easie the deterioration of livestock was included as a "valuation of stock unsold." Bulls were valued at 15 shillings less at the end of the accounting period than at the beginning of the period. Cows were valued the same at the end as at the beginning of the accounting period. In a later edition of the same book the illustration was changed. The entry was "To Horses impaired by a year's use -6:-:-".[1] Thus in 1683 the charge for the diminution of utility of long-lived assets was made on a value basis.

In the middle of the eighteenth century a book, The Gentlemen and Lady's Accomptant (1744, author not given), refers to the loss by "wear and tear" and to the balance as present value.

> In the journal: 'Income and Expence Debtor: To House-Furniture for Ware and Tare . . . . . 10/10/0.
> In the ledger account:
> March 25, 1742, By the Income and Expence charg'd for Ware and Tare. . .' The balance of the House Furniture account is referred to as 'the present value'.[2]

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[1] Ibid., p. 224.

[2] Perry Mason, op. cit., p. 209.

The recognition of the consumption of long-lived assets was still not universal. In 1757, the fifth edition of John Mair's Book-keeping Methodiz'd was published. Throughout the book there was no mention of any charges for the deterioration of long-lived assets. The methods of accounting for these assets were similar to those used in the merchandise accounts, i.e., the inventory was recorded and the remainder in the account was debited to profit and loss. At the same time (1764) a report of one John Smeaton on the "Canal from Forth to Clyde" recorded an estimate that the locks would need new gates in 20 years. For this purpose he set aside £4320. In William Jackson's Book-keeping in the True Italian Form (1801) a "Ship" account was credited "By Profit and Loss, for Wear, Age, etc." and the balance brought forward was called "present value." The inventory method similar to that used by Mair was prescribed as follows:

> 1. Credit the account by balance for the value of the ships or the part you own thereof.
> 2. Close the account with profit and loss for the remaining difference.[1]

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[1]Ibid., p. 211.

No mention of a charge for wear and tear appears in a book <u>The Elements of Book-keeping</u> (1805) by P. Kelley.

In 1830 the estimate of the cost of operating a ten horse power steam boat included a charge for a decrease in value.

> 30 per cent. on the cost of the boat and engine, valued at $3500, for interest, decrease in value, hazard, renewals, and repairs, allowing only 300 working days . . . . $3.50[1]

The use of interest as a factor in the calculation of the annual charge appeared in the Annual Report of the Baltimore and Ohio in 1833.

> Baltimore & Ohio Railroad, 7th Annual Report. One section was devoted to the presentation of estimates of the cost of construction and of repairs and renewals of rail way. The cost of replacing different parts was estimated in detail, the same unit costs being used as were incurred in the original construction. For instance, the total renewal cost per mile for oak sills and sleepers, and yellow pine string pieces was $3,342 and the estimated life was 12 years. The annual provision was expressed in terms of an annuity: "An annuity of equivalent value (to $3,342 due 12 years hence) to commence at the end of one year, to continue 12 years, reckoning compound interest at 5 per cent. is $209.97."[2]

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[1] Ibid., p. 211.

[2] Ibid., p. 211.

From the earliest record of the recognition of the gradual consumption of long-lived property until the early nineteenth century when the word depreciation was first used to indicate a charge for wear and tear, etc., these charges have been made on both a cost and a value basis. In the earliest reference the charge was strictly an allocation of the original cost over the life of the walls. In most of the subsequent instances until 1838 the loss in value during the accounting period has constituted the charge. Many authors have attributed this confusion of cost and value to the word depreciation. However, the concept of the charge for the consumption of the long-lived property clearly had two meanings before the term depreciation was used.

CHAPTER V

THE WORD "DEPRECIATION" USED TO SIGNIFY THE CHARGE FOR WEAR AND TEAR OR LOSS IN VALUE OF LONG-LIVED PROPERTY

Careful accounting of the charges for wear and tear on long-lived property was of little importance until the time of the industrial revolution. The consequence of the development of new sources of power and new machines to utilize the power was a new kind of business organization which required divided ownership of single enterprises.

With the invention of the reciprocating steam engine by James Watt in 1769 ample power became available to run several machines at a time. With the discovery by Abraham Darbys and Henry Cort of a process using coal, instead of charcoal, in blast furnaces, the pig iron industry expanded and more machines which had long lives could be made. These two discoveries, plus the ingenuity of men like John Kay, who invented the flying shuttle in 1733, Hargreaves, Arkwright, and Crompton, who perfected textile weaving gave rise to large investments in long-lived machines. For example, the pig iron output in England increased from 25,000 tons in 1720 to 1,396,000 tons in 1840.

Railroads rapidly grew in size so that by 1848 5,000 miles of railway line had been laid in England. The invention of the electric generator required additional investment in long-lived power generation equipment. The large expenditures of money with which to finance these new industries demanded a new kind of commercial financial structure.

Corporations were established with consequent division of ownership. The New York legislature in 1811 enacted pioneer laws enabling corporations to be formed without a special act of the legislature for each corporation charter. Soon there were many corporations owning large amounts of long-lived property. These corporations were in turn owned by many individuals who were continually buying or selling their interest in these firms. It was now necessary to reckon the profits correctly in order to provide equitable treatment of the stockholders. Although the equity of each stockholder was of concern to himself, many corporations were concerned very little about the individual stockholder and some further stimulus was necessary to spur on the study of depreciation. It was necessary to await the advent of governmental supervision and control before the depreciation issue became critical.

One of the first instances where wear and tear or loss in value was referred to as depreciation appeared in a report of "a committee to shew the prospects of a company established in London for the conducting of the inland navigation of India by steam":

> In Aug. 1835, the 'Lord Williams Bentinck,' after having been sixteen months in the water, was hauled up on the patent slip, and no marks of corrosion were visible. With this protection 20 years are confidently assumed for the duration of an iron vessel. The annual depreciation, therefore, on the vessels as well as on the engines, has been assumed at five per cent., and on the boilers, at twenty per cent.[1]

The following year the American Railroad Journal contained an analysis of some of the costs of the Reading Railroad including: "Repairs and depreciation of engine and tender estimated at 25 per cent on cost, $8000 . . . ."[2] Perry Mason cited more instances where depreciation appeared in the annual reports of various railroads

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[1]Ibid., p. 211.

[2]Ibid., p. 211.

from 1836-1867 including a series of annual reports of the Boston and Worcester Railroad from 1838 to 1848.

Government control of railroads was uncommon and vacillating. In 1846 the laws of the State of Massachusetts required railroads to submit annual reports of expenses. One section required:

> Estimated depreciation beyond renewals viz:-
> Roads and bridges
> Buildings
> Engines and Cars.[1]

Thirty years later the railroad commissioners of Massachusetts issued instructions calling for the separate reporting of "new locomotives charged to operating expense to make good original numbers," in which they failed to mention depreciation.[2]

Concurrently the additional concepts of depreciation as it related to replacement and maintenance appeared in the literature. The idea of providing a depreciation fund adequate to replace the present equipment was proclaimed by Mr. Glyn in a speech which later was published in the April 1, 1848, issue of the American Railroad Journal as an article titled "Depreciation of Railway stock." He said:

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[1] A.C. Littleton, op. cit., p. 235.

[2] Ibid., p. 235.

> . . . your directors have thought fit, not only to take the usual course in regard to the relaying of the rails . . . but conceiving that, in the course of some fifteen or twenty years, the existing rails will, from the working upon them, require necessarily to be replaced by others, they have thought it their duty to call upon you to sanction the annual appropriation of 15,000 pounds for the purpose of forming a fund to meet that contingency from time to time.[1]

The other idea that if a plant is well maintained it suffers no depreciation appeared in the "Berkshire Railroad, 12th Annual Report" which explained the omission of any depreciation by the comment "to be kept in perfect repair by lessees".[2] This same idea of the "plant immortality" or "good as new" concept of depreciation appeared in a book by Dionysius Lardner, Railway Economy (1850). He wrote, "If time has deteriorated some portions, new portions have been infused so that on the whole the value in use remains the same."[3] In addition he stated:

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[1]Perry Mason, op. cit., p. 213.

[2]Ibid., p. 213.

[3]Dionysius Lardner. Railway Economy. New York, Harper & Bros. 1850. p. 117.

> Its movable capital existence is perennial, and it is in a constant state of rejuvenescence. This point having been conclusively established, the companies very properly discontinued to set aside from revenue any fund for the future reproduction of stock; but they would have been justified, in strict equity, in going further, and in taking back from the capital, and placing to the credit of revenue, all the sums which, in previous years, they had erroneously brought to the credit of capital, to represent a deterioration which did not exist, and to pay for a future want which can never arise.[1]

The use of the sinking fund method of providing for depreciation appeared in the 1856 report of the Nashville and Chattanooga road.

> From the foregoing, you will be able to form a very correct idea of the rate our rails and machinery are wearing out; and in so doing, you cannot fail to see the propriety, and, indeed, absolute necessity of creating an adequate sinking fund to provide for this large item of depreciation.[2]

Bookkeeping texts still had not completely accepted depreciation as an important expense. A Practical System of Book-keeping by Single and Double Entry (1853)

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[1] Ibid., p. 115.

[2] Perry Mason, op. cit., p. 215.

by Ira Mayhem avoided the subject of depreciation by ignoring fixed assets. Common School Book-keeping (1861) by H. B. Bryant and others gave no specific discussion or illustration of depreciation. In the same year Book-keeping by W. Inglis illustrated depreciation expense by the entry "By Depreciation, 5% carried to Trade Expenses".[1] Later in 1871, Book-keeping and Business Manual by H. W. Ellsworth used the inventory method but did not mention depreciation.[2]

The analysis of the service life of long-lived property was an outgrowth of the controversies between the advocates of the "good as new" and those who believed in the inevitable wearing out of these properties. In 1870, there was published in the Proceedings of the Institution of Civil Engineers (England) a "thorough analysis of the life of locomotive parts". From this analysis the investigators concluded

> that even full renewals of parts did not prevent final depreciation, because a day would come when the timing of the expiration of parts having differing lengths of service life would so coincide as to leave the locomotive practically beyond repair.[3]

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[1] Ibid., p. 215.

[2] Ibid., p. 217.

[3] Littleton, op. cit., p. 223-4.

Depreciation as a replacement cost reappeared in correspondence to the Railway Gazette in 1879. The correspondents were opposed to arbitrary maintenance charges based on current income. Instead they favoured the establishment of a "renewal fund" to be debited for all repairs and renewals.

> Monthly there would be a debit to operating expense and a credit to renewal fund. The sum thus transferred is to be "the proper amount" to cover depreciation and repairs, or according to another correspondent, to cover the average depreciation and natural decay caused by the action of the weather and movement of trains.[1]

The following year, a version of the good-as-new interpretation of depreciation again appeared in an article "Value of Railroad Property".[2] The author pointed out that since the net income of the company fluctuated between 56% and 10% during the first five months of 1879 "there seems to be little basis for depreciating railroad property when it is honestly managed."

The determination of the costs of operation became a bigger problem when in 1876 the states were upheld

[1] Ibid., p. 230.

[2] Value of Railroad Property. Commercial and Financial Chronicle, 31:29-30, July 10, 1880.

in their attempt to fix maximum rates. The Granger laws and the subsequent decision of the U. S. Supreme Court upholding these laws made business "clothed with public interest" subject to state control. In the first of these decisions, Munn v. Illinois in October, 1876, Mr. Chief Justice Waite said:

> When therefore, one devotes his property to the use in which the public has an interest, he, in effect, grants to the public an interest in that use, and must submit to be controlled by the public for the common good, to the extent of the interest he has thus created.[1]

This right applied only to intrastate business. After a later decision when the same court in the case of the Wabash, St. Louis, and Pacific Railway v. Illinois,[2] in October, 1886, declared that a state could not regulate even that portion of interstate commerce which was within its borders, the Congress of the United States passed the Interstate Commerce Act of 1887.

The appointment of the five Interstate Commerce Commissioners began a new era in government regulation. Although the original duties of the Commission were prin-

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[1]Munn v. Illinois, 94 U.S. 126 (1876).

[2]Wabash, St. Louis, and Pacific Railway v. Illinois, 118 U.S. 557 (1886).

cipally those of a referee, it asked the railroads to report the costs and value of their property. Unfortunately depreciation was not mentioned in spite of previous experience of legislatures, e.g., Massachusetts, and business. Since the government was in a position to help improve the inadequate financial practices of the railroads, the omission of a requirement providing for depreciation was a costly one.

The size of this serious problem which confronted the state and federal regulatory commissions can best be judged by a report which appeared in December, 1896, in an article "The Street Railway Problem in Cleveland."

> These reports to investment houses that over $7,000,000 has actually been invested in lines and emphasize "the unusually large margin in cash investment in the plant over and above the bond issue". In view of the fact that many street railways are paid for almost entirely out of their proceeds of their bonds, this last statement is not without weight, although it may seem to come strangely from a corporation which professes to have a paid-up capital stock of $12,000,000. Seven millions represents the extreme claim of the company as to its bona fide investment. . . . But when we examine what is meant by an "actual cash investment of over $7,000,000," we shall find that this does not necessarily mean the lines are worth that sum -- it may

> mean the entire sum spent upon the line from the beginning of its history to this moment. And this sum may include vast sums which should long ago have been written off for depreciation.[1]

The right but not the basis of regulation had been decided in the Granger cases. The railroads had grown nearly sixtyfold from 1840 to 1890. When in 1893 Nebraska passed laws regulating the maximum rates to be charged by the railroads, the stockholders of the Union Pacific challenged these laws. The United States Supreme Court, Smyth v. Ames,[2] ruled that these laws were constitutional provided the rates were based on the "fair value of the property being used by it for the convenience of the public."

Although in the United States the basis for regulation of rates had been established as a fair return on the fair value of the property used, depreciation was not yet recognized as an operating cost. The Iowa Supreme Court, Cedar Rapids Water Co. v. Cedar Rapids,[3] on

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[1]W.R. Hopkins. The street railway problem in Cleveland. Economic Studies. 1(no. 5-6):318. Dec., 1896.

[2]Smyth v. Ames, 169 U.S. 466 (1898).

[3]Cedar Rapids Water Co. v. Cedar Rapids, 118 Ia. 234 (1902).

October 27, 1902, overruled an allowance for depreciation by saying:

> . . . to hold otherwise is to say that the public must not only pay the reasonable and fair value of the services rendered, but must in addition pay the company the full value of its works every forty years.

Similarly, the U. S. Supreme Court, San Diego Land and Town Co. v. Jasper,[1] on April 6, 1903, overruled the contention "of the appellant, that there should have been an allowance for depreciation, over and above the cost of repairs, when the annual rate of return was calculated."[2]

The English courts had recognized the propriety of a charge for depreciation somewhat earlier. In 1879, an injunction was granted, Davison v. Gillies,[3] to prohibit the payment of dividends before adequate charges for depreciation had been made. Ten years later in Glasier v. Rolls[4] the court said:

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[1]San Diego Land and Town Co. v. Jasper, 189 U.S. 439 (1903).

[2]For similar rulings by the U.S. Supreme Court see: Eyster v. Centennial Finance Board, 94 U.S. 500, 1876, and United States v. Kansas Pacific Railway Co., 99 U.S. 459, 1878.

[3]Davison v. Gillies, 16 Ch.D. 347 (1879).

[4]Glasier v. Rolls, 42 Ch.D. 436 (1869).

> Ought a deduction to be made for depreciation? There are two good reasons for an affirmative answer. First, profits must be deemed to be calculated as a prudent man of business would calculate them, after making a fair allowance for depreciation. Secondly, apart from mere prudential reasons an allowance is necessary because . . . there is a constant consumption of capital that ought not to enter into profits.

More detailed methods of bookkeeping were required to cope with the growing industries. John Q. Pilsen, in the Complete Reform in Book-keeping (1887), recommended the use of separate inventories for business properties. He mentioned fixtures, furniture, equipment, livestock and leases as classifications. Furthermore he advised that one should "take off a percentage rate of total cost for wear and tear."[1]

The first book to be written on the subject of depreciation was The Depreciation of Factories by Ewing Matheson in 1844. In this book he discussed the engineering aspects of depreciation as they related to the life expectancy of physical properties, the relation between maintenance and depreciation, and the relation of depreciation to sound financial management. Although his con-

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[1] Saliers, op. cit., p. 15.

cept of depreciation was based on the change in value of properties, he had a good understanding of the necessity for including depreciation as an expense. For example, his rebuttal to those who claimed that there was no need for including depreciation in the expenses incurred by municipal works was as follows:[1]

> It is sometimes argued that as all such municipal works are fully maintained out of the rates, there is no need to write down their value or accumulate funds for their renewal. It is however well known that no system of maintenance will provide for the wasting of assets which takes place from many causes or contingencies.

Protection of the shareholder in a corporation was recognized as a reason for accurate depreciation accounting. He said:

> And though, in course of years, the expenditure for repairs and renewals must almost of necessity balance the deterioration if traffic is to go on, there is room for much error in the accounts for particular years; and, in the case of constantly changing shareholders, of an unfair allotment of charges.[2]

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[1]Ewing Matheson. The depreciation of factories. 4th ed. London, E. & F.C. Spon, Ltd. 1910. p. 4.

[2]Ibid., p. 16.

Cost accountants of the same period gave little consideration to depreciation. Garcke and Fells, in <u>Factory Accounts</u>, Fourth Edition, 1893, said that in practice the amount of the depreciation charges was varied with the firm's business and that the allocation to departments or operations was rare.[1] J. S. Lewis in <u>The Commercial Organization of Factories</u> stated that sufficient funds should be set aside out of revenue to purchase new machines in a given number of years.[2]

During the period from 1838 to 1908 the concept of the charge for the use of long-lived property became more ambiguous. The contention was introduced that no depreciation was incurred if adequate maintenance was supplied. The use of the inventory method was being replaced in a few instances by the overt allocation of the cost over the life of the property. Writers were gradually substituting the word "depreciation" for "wear and tear, etc." The literature became filled with articles in which the word "depreciation" was not properly delineated with the result that different meanings were implied by the same author in a single article. The disagreements which

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[1]A.C. Littleton, op. cit., p. 239.

[2]Ibid., p. 239.

have followed have been due in part to misunderstanding of the sense in which the word was used.

Progress in the application of depreciation to operating expenses had been made but awaited additional impetus. Large quantities of long-lived assets owned by corporations whose stockholders were continually changing should have made it necessary for the corporations to calculate their profits accurately. Although the stockholders should have demanded a proper accounting for depreciation, at least two reasons existed for the ignoring of this expense. First, the early stockholders would benefit greatly if dividends were declared before depreciation was accounted for <u>if</u> they planned to sell their stock within a short time. Second, profits in many of these expanding enterprises were very high and depreciation expense was not as important to the continuance of an enterprise as it was when competition became keener.

Businesses in which profits were relatively small or closely watched by public authority were the first to realize the critical problems presented by the ownership of long-lived property. Railroads were the first of this group. Thus, much of the literature about depreciation during this period was concerned with railroads. The railroads in the United States today (1949) are still suffering from inadequate depreciation policies developed during this era.

As the period from 1838 to 1909 drew to a close the states of New Jersey and New York recognized the necessity of accounting for depreciation.[1] However, with the ambiguous concept of depreciation as it had developed it was unlikely that the court decisions which ensued could be other than reflections of past inconsistent word usage.

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[1] Whittaker v. Amwell Nat'l Bank et al, 52 N.J. Eq. 400 29 Atl. 203 (1894); Jamaica Water Supply Company v. State Board of Tax Commissioners, 112 N.Y. Supp. 392 (1908).

CHAPTER VI

DEPRECIATION BECOMES A MAJOR PROBLEM

The industrial revolution and the establishment of the corporate form of business created a need for the accurate accounting for depreciation, but the impetus to analyze it carefully awaited the time when the corporations' incomes were vitally affected by the application of depreciation to utility regulation and income taxation. The Knoxville v. Knoxville Water Co. case[1] established depreciation as a part of the costs to be considered when rates for public utility services were determined. Shortly thereafter the excise tax of 1909 and the Revenue Act of 1913 included depreciation as a deduction from gross income in the determination of taxable income.

The United States Supreme Court reversed its previous rulings on depreciation in the Knoxville case. The Court, besides recognizing the consumption of the long-lived properties, injected the concept of a charge for replacing the property. It stated:

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[1]Knoxville v. Knoxville Water Co., 212 U.S. 1 (1909).

> A water plant with all its additions begins to depreciate in value from the moment of its use. Before coming to the question of profit at all the company is entitled to earn a sufficient sum annually to provide not only for current repairs but for making good the depreciation and replacing the parts of the property when they come to the end of their life. The company is not bound to see its property gradually waste without making provision out of earnings for its replacement. It is entitled to see that from earnings the value of the property invested is kept unimpaired, so that, at the end of any given term of years, the original investment remains as it was at the beginning.[1]

The Court embodied within this statement three ideas which have caused much confusion in recent years. The quotation included a charge for depreciation previously described in this decision as the "impairment of value", a charge to maintain the original investment. The latter statement in a broad sense was consistent with the value basis of depreciation, although without qualification it could have meant the maintenance of the "dollars" invested which has been the more recent interpretation by accountants of the proper basis for depreciation.

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[1] Ibid., p. 13.

The Revenue Act of 1913 which followed the passage of the Sixteenth Amendment (February 25, 1913) provided that "a reasonable allowance for depreciation by use, wear and tear of property, if any" could be deducted from gross income. The difficulties encountered in administering the 1913 and 1916 laws caused the phrase "including a reasonable allowance for obsolescence" to be added.[1] The basis for the deduction of depreciation in this and subsequent revenue acts has been cost.

The contrast between the base upon which the courts and the Treasury Department calculated depreciation was a logical result of the development of the policies of the two groups. The Court had already established "value" as the proper basis for regulation of utilities, whereas the calculation of taxes was based on "facts", i.e., recorded transactions.

The recognition of depreciation by the courts was not confined to rate determination. The New York courts in a tax case stated:

> The net income of a corporation for dividend purposes cannot be determined until all taxes,

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[1] Saliers, op. cit., p. 25.

> depreciation, maintenance, and upkeep expenditures have been deducted.[1]

Public utilities were immediately affected by the Court rulings. Their concern over better methods for the determination of depreciation was cause for employing consulting engineers to aid in this task. As a result of experience gained in this work, Paul C. Campbell developed a depreciation method based on the present worth of future services.[2] The importance of depreciation in engineering practice was recognized by the American Society of Civil Engineers which published a major contribution to depreciation literature in the 1917 report[3] of the Society's depreciation committee. In both of these engineering contributions the valuation approach was taken.

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[1]People ex rel Jamaica Water Supply Co. v. State Board of Tax Examiners 128 App Div 13 at 17-18, 112 N.Y. Supp 392 at 395 (3d Dept 1908) from Bonbright, op. cit., p. 933.

[2]Paul C. Campbell, Depreciation by the present worth method. Unpublished M.S. Thesis. Ames, Iowa, Iowa State College Library. 1916.

[3]Final Report of the Special Committee to Formulate Principles and Methods for the Valuation of Railroad Property and other Public Utilities. American Society Civil Engineers Transactions. 81:1311-1620. 1917.

Economists were aware of the effect of depreciation on income and the vagaries of the methods of calculation. Alfred Marshall stated: "But if we look chiefly at the income of a country we must allow for the depreciation of the sources from which it is derived."[1] As for the methods of calculation, Marshall said:

> Almost every trade has its own difficulties and its own customs connected with the task of valuing the capital that has been invested in a business, and of allowing for depreciation which that capital has undergone from wear and tear, from the influence of the elements, from new inventions, and from changes in the course of trade.[2]

World War I necessitated the increase of income taxes from the 1% of 1913 and 2% of 1916 to 12% for 1918 and 10% for 1919, 1920, and 1921. As a result of this rise in tax rates more interest in the subject should have occurred. However, the number of publications on depreciation listed in two technical indexes[3] did not in-

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[1]Alfred E. Marshall. Principles of economics. 8th ed. London, MacMillan and Co. Ltd. 1920, reprinted 1938. p. 81.

[2]Ibid., p. 354.

[3]Engineering Index. New York, Engineering Index Inc. 1913 to 1922; Industrial Arts Index. New York, H. W. Wilson Company. 1912 to 1922.

crease significantly between 1913 and 1922. Apparently the impact of these taxes was insufficient to warrant great concern by those affected.

Accountants no longer omitted depreciation from their manuscripts but confusion stemming from the previous usage of the word depreciation was still evident. Bennett, in Advanced Accounting, confused depreciation, replacement, and efficiency. For example, he wrote: "As a matter of practice no asset should be kept when its condition drops below 75 to 65 per cent . . . repairs and renewals become excessive."[1]

P. D. Leake, in Depreciation and Wasting Assets (1924), confused value and cost in his definition of depreciation.

> In its true commercial sense, the word "Depreciation" means fall in exchangeable value of wasting assets, computed on the basis of cost expired during the period of their use in seeking profits, increase of value or other advantages.[2]

Hatfield, in Modern Accounting (1922), in an oft quoted remark aptly set forth the reason why depre-

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[1]George E. Bennett. Advanced accounting. New York, McGraw-Hill Book Company. 1922. p. 229.

[2]P.D. Leake. Depreciation and wasting assets. 4th ed. London, Sir Isaac Pitman and Sons Ltd. 1924. p. 1.

ciation must be considered. He said: "All machinery is on an irrestible march to the junk heap, and its progress while it may be delayed cannot be prevented by repairs."[1] He also used the word value when later his calculations were based on cost, e.g.,

> Depreciation should cover all decline in value due to the use of productive assets. . . . Depreciation itself means that there has been a decline in the value of certain assets.[2]

A previous statement that the purpose of depreciation was a part of a plan for the equalization[3] of annual expenses would apparently justify either the use of the straight line method or retirement accounting, e.g., the recommendation of the National Association of Railroad and Utilities Commissioners (hereinafter called NARUC).

The conflict of ideas was not confined to textbooks or courts. The two organizations responsible for the promulgation of depreciation policies for the railroads and public utilities were also advocating divergent

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[1]R.H. Hatfield. Modern accounting. New York, D. Appleton and Company. 1922. p. 121.

[2]Ibid., p. 137.

[3]Ibid., p. 134.

methods for the accounting for depreciation. In 1920 the Interstate Commerce Commission was required by Congress to determine "the classes of property for which depreciation charges may properly be included under operating expenses and the percentages of depreciation which shall be charged with respect to each such classes of property." (Section 20, paragraph 5)[1] In 1922, NARUC in its standard classification of accounts approved retirement reserve accounting. It stated:

> An account is provided in which to include charges made in order that corporations may, through the creation of adequate reserves, equalize from year to year as nearly as is practicable the losses incident to important retirements of buildings, dams, lines, or of definitely identifiable units of plant or equipment.[2]

The inclusion of the word "losses" connoted a financial hardship which did not exist. This concept of the burden of long-lived properties further beclouded the significance of the allocation of charges for these properties.

Confronted with these various interpretations of depreciation, the United States Supreme Court essentially approved the "observed" or physical-depreciation

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[1]G.O. May. Financial accounting. New York, Macmillan Company. 1943. p. 131.

[2]Ibid., p. 131.

concept. An example of this idea is found in the Pacific Gas and Electric Co. v. City and County of San Francisco, in 1924. Mr. Justice Reynolds said:

> Appellant objects to the application of this method [modified sinking fund] and insists that depreciation should have been ascertained upon a full consideration of the definite testimony given by competent experts who examined the structural units, spoke concerning observed conditions and made estimates therefor. . . We think the criticism is not without merit. Facts shown by reliable evidence were preferable to averages based on assumed probabilities.[1]

<u>Studies in the Economics of Overhead Costs</u> by J. M. Clark provided one of the first discussions of the broad concepts of overhead costs in which depreciation consisted of only one phase of the total problem. It was an integration of the studies of the various overhead costs to show their effect upon business profits and the consequent policies of both business and government. His observations on value and cost were significant in light of the confusion of the terms at that time. He said:

> The back bone of the science of economics is the balancing of value against cost. . . . Economic efficiency consists of making things that are worth more than they cost,

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[1]Pacific Gas and Electric Co. v. City and County of San Francisco, 265 U.S. 403 (1924).

> and it is a peculiar characteristic of private business, under a competitive system to seize and exploit any opportunity to achieve this desirable end.[1]

Of depreciation he said:

> The physical deterioration of a plant goes on whether it is made good or not; and obsolescence reduces its value whether it is provided for or not. It is not the cost, but the making of it good, that is really postponable.[2]

Despite these clear statements of the nature of depreciation and the relation between value and cost, the muddled writings continued. However, now and then statisticians interested in economics applied their methods to depreciation studies.

A synthesis of the many variables which influence depreciation awaited the development of mathe-

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[1] J. Maurice Clark. Studies in the economics of overhead costs. Chicago, The University of Chicago Press. 1923. p. 17.

[2] Ibid., p. 55.

matical theories by Taylor,[1] Hotelling,[2] and Roos.[3] These theories were able to explain many of the reasons for the conflicts which existed by showing how depreciation, profits, interest, original "value", and scrap "value" were interrelated and what assumptions had to be made in order to reach a particular conclusion. It was unfortunate that the advanced mathematics which was necessary to understand the theories relegated them to obscurity for many years.

For some time the settlement of fire insurance claims had included the determination of the physical condition or the usefulness of the property.[4] Frequently it was held that "the measure of the cash value under

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[1]J.S. Taylor. A statistical theory of depreciation. Journal of the American Statistical Association. 18:1010-1023. 1923.

[2]Harold Hotelling. A general mathematical theory of depreciation. Journal of the American Statistical Association. 20:340-353. 1925.

[3]C.F. Roos. The mathematical theory of depreciation and replacement. American Journal of mathematics. 50:147-157. 1928; and The problem of depreciation in the calculus of variations. Bulletin of the American Mathematical Society. 34:218-228. 1928.

[4]Brinley v. National Insurance Co., 11 Metc. 195 (Mass. 1846); Aetna Insurance Co. v. Johnson, 74 Ky. 587 (1875) from Bonbright, op. cit., p. 385.

standard policy was replacement cost minus physical depreciation". However, in a later case a New York court reversed a lower court for not considering obsolescence. The case involved the settlement for a brewery which was damaged by fire after the passage of the National Prohibition Act.[1] Speaking for a unanimous court the judge said:

> In the case at bar the trier of fact, in considering cost of reproduction was required by the policy to make proper "deductions for depreciation". The word (depreciation) means by derivation and common usage "a fall in value, reduction of worth" . . . It includes obsolescence. . . . An obsolete thing is a thing no longer in use. In determining the extent to which these buildings had suffered from depreciation the trier of fact should have been permitted to consider that, owing to the passage of the National Prohibition Act, they were no longer useful for the purposes to serve which they were erected. It should have been permitted to consider their adaptability or inadaptability to other commercial purposes.[2]

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[1]Smith v. Allemania Fire Insurance, 219 Ill. App 506 (1920) from Bonbright, op. cit., p. 387.

[2]McAnarney v. Newark Fire Insurance Co. 247 N.Y. 176 at 183 from Bonbright, op. cit., p. 391.

Even the United States Supreme Court in its decisions fluctuated between cost and value. Whereas for years annual depreciation had been based upon cost, the Court wavered in 1929. In the United Railways case it held that annual depreciation should be based on value; i.e.,

> The allowance for annual depreciation made by the commission was based on cost. The Court of Appeal held that this was erroneous and that it should have been based upon present value. The court's view of the matter was plainly right.[1]

Life expectancy of physical properties occupied a strategic place in the proper determination of depreciation credits during the preparation of income tax calculations. In an effort to aid the businessman in his tax preparation the Treasury issued Bulletin "F" in 1928 and revised it in 1931 and in 1942. This publication of estimated lives of hundreds of kinds of properties has had a vital part in the determination of individual business depreciation policies.[2] Since relatively few

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[1]United Railways and Electric Company of Baltimore v. West, 280 U.S. 234 (1929).

[2]U.S. Treasury Department. Bulletin "F", Income tax depreciation and obsolescence estimated useful lives and depreciation rates. Wash., U.S. Government Printing Office, 1942.

statistical studies of property lives had been made, and no supporting evidence was included in Bulletin "F", it is probable that many of the life expectancies were based on the opinions of either the men in the Bureau or on lists of properties published by various authors. It is unfortunate that these same figures were later to be used as a factual basis for the administration of income taxes.[1]

The application of statistical methods to the determination of the life expectancy of long-lived properties developed from studies of individual kinds of properties into general methods applicable to all properties. An early statistical study was made by Alvord in 1903 on the mortality characteristics of water pumps. It was not until the advent of three publications in 1928, 1930, and 1931 that the general theories were available to everyone desiring the information. In 1928, the testimony of the American Telephone and Telegraph Company before the Interstate Commerce Commission, Docket No. 14700, included a discussion of the Gompertz-Makeham method of curve fitting as it was used to determine the average life of the company's equipment. In 1930, Kurtz,

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[1]United States Treasury Decision 4422. 1934.

in *Life Expectancy of Physical Property*,[1] collected a number of previous mortality studies of properties and classified them into seven "type survivor curves." In 1931 the Iowa Engineering Experiment Station published *Life Characteristics of Physical Properties*[2] by Winfrey and Kurtz. In this study more data was availahle and the type curves were increased to 13. A continuation of this project resulted in what is probably one of the most authoritative publication on the subject of physical property mortality characteristics, *Statistical Analyses of Industrial Property Retirements*.[3] The latest publication in this series extended the previous work to include the depreciation analysis of group properties.[4]

Kester, who had written a monograph on the subject of depreciation, later included most of it in his

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[1]Edwin B. Kurtz. Life expectancy of physical property. New York, Ronald Press. 1930.

[2]R. Winfrey and E.B. Kurtz. Life characteristics of physical property. Iowa State College Eng. Exp. Sta. Bul. 103. 1931.

[3]Robley Winfrey. Statistical analysis of industrial property retirements. Iowa State College Eng. Exp. Sta. Bul. 125. 1935.

[4]Robley Winfrey. Depreciation of group properties. Iowa State College Eng. Exp. Sta. Bul. 155. 1942.

accounting textbooks. He explained the inconsistent treatment of the subject in the following way:

> The subject of depreciation has been greatly misrepresented, because depreciation, which is a financial result, has been confused with obsolescence which is an economic process, and with deterioration which is a physical condition. Either of the latter brings about depreciation and the physical process happens to be more rapid than the economic one.[1]

A definition of depreciation which has become a classic was stated by Mr. Chief Justice Hughes in the United States Supreme Court decision Lindenheimer et al v. Illinois Bell Telephone[2] in April, 1934. He said:

> Broadly speaking depreciation is the loss, not restored by current maintenance which is due to all factors causing the ultimate retirement of the property.

The significant point in this definition is that the word "loss" was unqualified. The same objection, as previously noted, to the connotation of the word loss was applicable here but in addition the vagueness as to whether it referred to value, cost, or physical condition has contributed to the conflict over the meaning of depreciation.

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[1]Roy B. Kester. Accounting theory and practice. New York, The Ronald Press. 1933. p. 218.

[2]Lindenheimer et al v. Illinois Bell Telephone, 292 U.S. 151 (1934).

In the same year the Treasury Department issued T.D. 4422 which, coupled with the subsequent tax increases, has had a marked effect upon the importance of depreciation. This decision reversed the previous position of the Treasury Department wherein the individual had the privilege of choosing his own depreciation rates with little restraint from the government. Under T.D. 4422 he was required to prove all depreciation rates which he claimed or accept those specified by the department in Bulletin "F". Compare the following:

> From Article 205 of Regulation 77 - While the burden of proof must rest upon the taxpayer to sustain the deduction taken by him, <u>such deduction will not be disallowed unless shown by clear and convincing evidence to be unreasonable</u>. (Underlining supplied.)
>
> From T.D. 4422 - The burden of proof will rest upon the taxpayer to sustain the deduction claimed. [Note the omission of the qualifying phrase.]

This ruling was issued during the depression in an effort to increase the tax collections.

> It was the belief of the Treasury Department that by changing the administration of the law, an additional $85,000,000 of revenue could be secured.[1]

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[1] E.A. Saliers, op. cit., p. 201.

> It is still an open question to what extent the previous practice of the tax department as to allowances for depreciation will be modified under a "new policy," announced by Treasury Decision 4422 (approved February 28, 1934) and elaborated in the revised Treasury regulations (Reg. 86, Art.23). Under pressure from Congress to secure more revenue from the income tax, the Treasury promised to make drastic cuts in its depreciation allowances, which it conceded to have been overgenerous in many instances. With this object in mind, it declared its intention to take much more seriously the rule that the burden of proving depreciation must fall on the taxpayer. It apparently proposed to make it more difficult for a taxpayer to offset an inadequate deduction in prior years by an accelerated rate of depreciation in subsequent years.[1]

The continuation of the policies started under T.D. 4422 coupled with the large increase in profits during the war years has made the depreciation problem one of primary importance. Thus, the high profits taxed on a graduated tax scale with these profits subject to tax rates which increased from 20 to 36 percent of the national income between 1940 and 1944[2] made businessmen

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[1] James C. Bonbright. Valuation of property. New York, McGraw-Hill Book Co. 1937. p. 1006.

[2] R.A. Musgrave and H.L. Seligman. The wartime tax effort. Federal Reserve Bulletin. 30:16-27. Jan. 1944. p. 19.

depreciation conscious. It has been estimated that in 1949 a dollar of allowable depreciation results in a savings of from 38 to 40 cents for many public utilities. Since the lives recommended by Bulletin "F" were overall averages probably based on opinions, many companies have made meticulous studies to prove shorter lives and higher depreciation rates. Other companies and business organizations have suggested substitute methods for the straight-line method now used by the Bureau of Internal Revenue. Most of these suggestions were an attempt to accelerate depreciation charges to permit larger deductions during the early life of the equipment.[1]

Fluctuating prices and consequent devaluation of the dollar presented an important problem in the calculation of depreciation. The "dollar", which was the basis upon which investment was recorded and depreciation calculated, was not a constant but a variable quantity. H.W. Sweeney recommended a system of stabilized accounting in a book by the same name. In this book he described the method of determining depreciation as follows:

> . . . stabilized accounting values the fixed asset at its replacement cost. But because stabilized

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[1]Burnham Finney. Needed: a sensible depreciation policy. American Machinist. 90:111-118. 1946.

> accounting is primarily concerned with the maintenance of capital on the basis of general purchasing power, it depreciates original cost adjusted for any intervening change in the general price level instead of depreciating cost of replacement.[1]

Engineers were more concerned with the valuation of and depreciation of public utility properties. In 1936, Marston and Agg, in Engineering Valuation, stated that:

> Depreciation is negative value; its fundamental basis, also, is prevailing opinion as to the probable future operation returns yet to be earned by physical property units during their probable future service lives.[2]

One of the most searching and comprehensive books on the subject of valuation was published in 1937. The Valuation of Property by James C. Bonbright contained a critical review of many different situations in which depreciation was a problem. His critical analysis of the controversies was a milestone in depreciation literature. He classified the four basic concepts of depreciation as follows:

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[1] Henry W. Sweeney. Stabilized accounting. New York, Harper Brothers Publishers. 1936. p. 51.

[2] Anson Marston and T.R. Agg. Engineering valuation. New York, McGraw-Hill Book Co. 1936. p. 77.

> . . . (a) impaired serviceableness, (b) fall in value, (c) difference in value [between the present value of the old property and the present value of a hypothetical, new property], and (d) amortized cost.[1]

Another important contribution to the depreciation literature was made by G.A.D. Preinreich in a number of articles and notes which appeared in Econometrica. The first of these was "The Theory of Depreciation."[2] This article contained the mathematical approach begun by Taylor and Hotelling.

The following year, 1939, Walter Rautenstrauch, professor of industrial engineering at Columbia University, wrote: "The term depreciation is now generally used to express the decline in value of an asset due to all causes, . . ."[3] This statement was made in spite of the excellent discussion by Bonbright, also of Columbia University.

A recent (1941) intermediate economics text by Boulding presented the same interpretation: "The value

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[1]Bonbright, op. cit., p. 183.

[2]G.A.D. Preinreich. Annual survey of economic theory: the theory of depreciation. Econometrica. 6:219-241. 1938.

[3]Walter Rautenstrauch. The economics of business enterprise. New York, John Wiley and Sons, Inc. 1939. p. 136.

evidently declines . . ., and the problem of depreciation is that of constructing a formula to show how this decline occurs."[1] In his defense it should be noted that he presented this as an application of the theory of valuation but he did not present any other discussion or qualification of the statement.

The NARUC committee on depreciation reversed its stand in the 1938 Report, and in the 1943 Report presented a distillation of five years of work, trying to clarify the use of depreciation in public utility rate cases. This report was not adopted by the Association, but nevertheless has been the target for many criticisms by many of the professional and business organizations affected by its suggestions. The committee introduced a slightly different definition by saying: "Depreciation is the expiration or consumption in whole or in part, of the service life or utility of property. . ."[2] This definition based on consumption of service life was contrary to previous ideas. Actually this definition was a derivative of other definitions when they were qualified

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[1]Kenneth E. Boulding. Economic analysis. New York, Harper and Brothers. 1941. p. 714.

[2]Report of the Committee on Depreciation - 1943. National Association of Railway and Utility Commissioners. State Law Publishing Co. 1943. p. 30.

by an assumption that service capacity was directly related to service life.

Other modern writers are still adding to the confusion by defending concepts which were discarded at least a decade ago. Men who have been eminent consulting engineers or utility executives continue to publish books and articles based on biased viewpoints. For example, a recent book, The Anatomy of Depreciation by L. R. Nash,[1] is an instance in which public utility propaganda on depreciation can be found. The book denied the validity of adequate reserves solely on the basis of numerical quantities, i.e., a reserve was too large because it contained several million dollars. The book deprecated the use of mortality statistics by saying they were little used but did not mention the trend toward increased usage by the telephone companies, railroads, Bureau of Internal Revenue, electric utilities and some private competitive enterprises.

Other examples of recent statements which portray a similar attitude are those of Ferguson and Dorau. Samuel Ferguson, a utility executive, wrote:

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[1]L.R. Nash. Anatomy of depreciation. Washington, D.C., Public Utilities Reports. 1947.

This pronouncement [by the Court, 271 U.S. 23-31, 1925 that customers have an equity in the depreciation reserve] would seem to fully justify the stand of such companies as have resisted all claims for any customer equity in depreciation reserves. . . . However, such companies forget one essential fact that the building up of such reserves is possible only because the regulatory bodies which have control over earnings see fit to permit inclusion in the costs of the companies of certain annual charges for depreciation in excess of retirements actually made, just as though these charges were actual expenditures.[1]

H. B. Dorau, professor of economics, wrote:

"The problem is dual and aggravated. The consequences of, (1) the accumulation of a reserve equal to theoretical accrued depreciation on a straight-line-unit-of-property-life-expectancy basis, which will approach 35 to 45 per cent of the cost of the property, or from 54 to 82 per cent of the capital contributed by the investors, and (2) the threat of imputing an invalid economic meaning to such a reserve in order to justify its deduction from accounted for original cost, are justifiably extremely disturbing to the investor.[2]

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[1]Samuel Ferguson. The bearing of the interest factor on reinvestment of depreciation reserve funds. Edison Electric Institute Bulletin. 9 (no. 5):175. 1941.

[2]Herbert B. Dorau. Economic implications of public utility depreciation accounting. The New York Certified Public Accountant. 14 (No. 9):414. 1944. An excellent rebuttal to this article was writtenby John Bauer in the October 1944 issue of this magazine.

The evolution of the concept of a charge for the use of long-lived property in cost accounting, taxation, fire insurance, the law of dividends, public utility regulation, bankruptcy, and eminent domain has resulted in at least three distinct meanings of the word depreciation. The lack of a common concept of depreciation today is amply illustrated by the quotations from Ferguson and Dorau and from the following recent sources.

In The New York Certified Public Accountant Bauer used depreciation in the sense of cost.

> It is true that the consumers, through rates paid for service, make regular contributions to cover the accruing depreciation. But these contributions do not constitute a return of capital to the investors. Like corresponding provisions for labor and materials charged to operating expenses, they are reimbursements to the company for costs incurred through the depreciation which has taken place; they prevent impairment of capital, and preserve fully the private investments.[1]

In an instruction pamphlet a description of physical condition is referred to as depreciation. "Another indication of depreciation may be dark rings slightly brownish in color at one end or both."[2] Personal correspondence

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[1]John Bauer. The function of public utility depreciation accounting. The New York Certified Public Accountant. 14 (No. 14):604. 1944.

[2]Instructions - How to operate and maintain flourescent lights. Montgomery Ward and Company. (Received with purchase, February, 1949.)

from a financial executive to Robley Winfrey confused income and depreciation:

> I do not know of a single manufacturing enterprise that is using the sinking fund method. There have been a few cases in which we advocated the use of the method due to the fact that the income from the enterprise apparently followed that method, but this suggestion was not followed in any instance.[1]

In a public address by an eminent engineer depreciation is used as a synonym for physical wear:

> This year the total maintenance costs are estimated, for state, county, city and local roads at 1,103 millions of dollars. This amount represents 72 cents for each dollar expended for construction. Even such a comparison does not reveal the cost of keeping the present road system in operation, because a large percentage of the construction expenditure of 1,531 millions of dollars goes for reconstruction of roads depreciated beyond the possibility of maintenance.[2]

The study of the development of the concepts of depreciation indicates the following probable origins

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[1]Robley Winfrey, Ames, Iowa. Personal correspondence. 1949.

[2]T.H. MacDonald. Highways in public service. Address presented to the 46th Annual Meeting of the Road Builders Conference, February 7, 1949.

of these concepts.[1] The original cost basis probably developed from the inventory methods applied in early accounting practice; the replacement cost basis probably developed from the businessman's endeavor to maintain the same ownership pattern during periods of rising prices. The physical condition basis probably developed from the association of this charge with the "wear and tear" on property as it is commonly used in definitions of depreciation. Many of the controversies about the subject of depreciation could be more intelligible if the objectives assumed by the various writers were clearly stated. This lack of a clear statement of objectives by the parties involved in discussions is one of the major reasons why the subject of depreciation is still controversial.

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[1]The best bibliography of the literature on depreciation written during the last century is The Accountant's Index. New York, American Institute of Accountants. 1921 (with supplements to date.)

PART III

THE FUNDAMENTAL CONCEPT OF DEPRECIATION

CHAPTER VII

CURRENT CONCEPTS AND DEFINITIONS

The development of the concept of depreciation has resulted in an ambiguous meaning of the word depreciation which is associated with cost, value, replacement, and efficiency. The definitions which are in current use provide adequate evidence that such ambiguity is still one of the major obstacles in the rational discussion of the subject. Some of the most often quoted definitions of depreciation have their origin in public utility rate cases in which the value of the property was sought. Consequently the word depreciation was defined in terms of value. However, this definition was then applied to situations in which the evidence was cost. The first acceptance of depreciation by the United States Supreme Court in the Knoxville v. Knoxville Water Company case stated that: "A water plant, with all its additions begins to depreciate in value from the moment of its use."[1] A frequently quoted definition by the same

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[1]Knoxville v. Knoxville Water Co., 212 U.S. 13 (1909).

Court appears in the Lindenheimer v. Illinois Bell Telephone Company case:

> Broadly speaking, depreciation is the loss, not restored by current maintenance, which is due to all the factors causing the ultimate retirement of the property. These factors embrace wear and tear, decay, inadequacy, and obsolescence.[1]

The above definition did not specify the nature of "the loss." It has been variously interpreted as the loss in value[2] and loss in usefulness.[3]

The federal commissions have modeled their definitions after the opinions of the courts. The Federal Communications Commission uses the following definition of depreciation of telephone properties:

> Depreciation, as applied to depreciable telephone plant, means the loss in service value not restored by current maintenance, incurred in connection with the consumption or prospective retirement of telephone plant in the course of service from causes which are known to be in

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[1] Lindenheimer v. Illinois Bell Telephone Co., 292 U.S. 167 (1934).

[2] L.R. Howson. Depreciation fact or theory. Water Works and Sewerage. 91 (No. 3):164-5. 1944. In this article Mr. Howson incorrectly inserted the word value in the definition.

[3] Percival F. Brundage. Depreciation - an old subject with a new importance. Harvard Business Review. 13:334-43. 1935.

> current operation, against which the company is not protected by insurance, and the effect of which can be forecast with a reasonable approach of accuracy. Among the causes to be given consideration are wear and tear, decay, action of the elements, inadequacy, obsolescence, changes in the art, changes in demand and requirements of public authorities.[1]

A similar definition is used by the Federal Power Commission for the accounts of electric utilities.[2] The Interstate Commerce Commission,[3] in an opinion in 1931, used essentially the same definition as that quoted from the Federal Communications Commission report. In general, these definitions which were stated in terms of value have been applied in terms of cost.

In 1943 the NARUC committee on depreciation suggested the following definition:

> Depreciation is the expiration or consumption, in whole or in part,

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[1]Federal Communications Commission. Uniform system of accounts for telephone companies. Washington, D.C., Government Printing Office. 1935. p. 4.

[2]Federal Power Commission. Uniform system of accounts for electric utilities. Washington, D.C., Government Printing Office. 1936. p. 5.

[3]Interstate Commerce Commission, 177ICC, 351-500, Docket Nos 14700 and 15100 at page 422, July 28, 1931.

> of the service life, capacity, or utility of property resulting from the action of one or more of the forces operating to bring about the retirement of such property from service; the forces so operating include wear and tear, decay, action of the elements, inadequacy, obsolescence, and public requirements. Depreciation results in a cost of service.[1]

Much criticism was aroused by the substitution of "life, capacity, or utility" for value in the definition. The substitution was only a recognition in words of that which had been practiced for years.

In the same year the American Institute of Accountants defined depreciation accounting (instead of depreciation) as follows:

> Depreciation accounting is a system of accounting which aims to distribute the cost or other basic value of tangible capital assets over the estimated useful life of the unit (which may be a group of assets) in a systematic and rational manner. It is a process of allocation, not of valuation. Depreciation for the year is the portion of the total charge under such a system that is allocated to the year. Although the allocation may properly take into account occurrences during the year, it is not intended to be a measurement of the effect of all such occurrences.[2]

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[1]NARUC Report (1943), op. cit., p. 30.

[2]American Institute of Accountants. Bulletin 20. Journal of Accountancy. 76:484. 1943.

Unfortunately this definition is a description of the application of depreciation in accounting rather than a statement of the concept of depreciation in general. In the Cost Accountants' Handbook the following quotation is presented as an explanation of the concept of depreciation:

> Himmelblau (Third International Congress on Accounting) refers to depreciation as the process "of spreading the value of a fixed asset over the accounting periods comprising its service life." According to Montgomery (Auditing Theory and Practice) depreciation is "an allocation of the entire cost of depreciable assets to the operating expenses of a series of fiscal periods." J.B. Bailey (Journal of Accountancy, vol. 74) describes depreciation as "the accounting for the consumption or the wasting of invested capital." In all of these statements the essential conception is that of assigning the cost of property to the accounting periods included in useful life.[1]

Individual authors have expressed a variety of ideas about the concept of depreciation. Schultz, in an economic dissertation, presented the following idea under the heading "The Meaning of Depreciation":

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[1]Theodore Lang. Cost accountants' handbook. New York, Ronald Press Company. 1944. p. 1193.

There seems to be no disagreement as to that fact that all of Man's creations inevitably and irresistably tend, as individual items, toward ultimate decay or disuse. The element of change is a matter of fact inherent in every material thing. Whether the time elapsing in which the change is effective is infinitestimally small or infinitely large is immaterial, the fact remains that change does occur. This change from its original identity can be referred to as wastage.

If now a value be established for the original article and a value likewise established for the result of the change (in many cases that final value can be considered as zero), then the difference between the original and final values will be the complete measure of depreciation.[1]

We may, however, consider depreciation dynamically or statically, and it is there that interpretations diverge sharply. If we view it dynamically, we may consider the forces bringing about depreciation as being in constant operation. Corrective action, though it may delay, cannot eternally defer an inevitable wastage as being susceptible to constant checking and interruption and even to recovery, hence depreciation is non-existent until it appears completely and finally as a non-controvertible fact.[2]

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[1]Robert Schultz. Depreciation and American railroads. Philadelphia, Robert Schultz. (Dissertation published by author.) 1934. p. 9.

[2]Ibid., p. 10.

Bonbright has stressed the various meanings which have been associated with both value and depreciation. Concerning depreciation he wrote:

> The standard, lexicographer's definition of depreciation is "fall in value." Far more frequently, however, the word is used in special senses by accountants and appraisers. Substantially all of these technical meanings are variants of four basic concepts, which may be designated (a) impaired serviceableness, (b) fall in value, (c) difference in value, and (d) amortized cost.[1]

One of the most succinct discussions of depreciation appears in a recent textbook on auditing by Kohler. This discussion recognizes the way in which depreciation is applied better than any other statement which has come to the author's attention.

> Depreciation is <u>expired utility</u>. It refers to part or all of the services that a limited-life asset will no longer yield, regardless of whether such services have actually been yielded, or if yielded, whether they have benefited production. Depreciation is commonly regarded as a function of use, but because it is also a function of disuse, maintenance, changes in

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[1]Bonbright, op. cit., p. 183.

production, and progress of the arts--interrelated and inseparable causes that are magnified by the age of the asset--it generally finds expression, in accounting, as a function of time. Thus, a machine wears out because of use and it wears out faster if it is used sixteen hours a day rather than eight. A machine that stands continuously idle also becomes potentially less and less useful as time goes on; in fact, certain machines age more speedily from disuse than from use. Again, from lack of maintenance or from unskilled maintenance, a machine will deteriorate rapidly. Or if the productive process in which the machine is altered, the machine may not be adaptable to the change. And when new devices have been perfected and another machine is available that will perform the same operation more simply, more quickly, or more cheaply, a machine's future usefulness may be severely diminished. All of these factors are present to some extent in every manufacturing enterprise; but it should be recognized that they may be measured compositely more accurately than individually, not only because of their interrelated character, but also because the collective experience from which future estimates of usefulness are necessarily derived links depreciation with periods of time. By the same token, the measurement of depreciation in a large group of fixed assets tends to be more accurate than the measurement of depreciation in a single asset.[1]

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[1]E.L. Kohler. Auditing. New York, Prentice-Hall Inc. 1947. p. 137.

The above quotation might well serve as the basic statement of the concept of depreciation as it is used today.

The many opinions[1] about the nature of depreciation generally have two ideas in common. First, depreciation is related to service. Second, although the definitions of the word depreciation, when unmodified, may mean cost-depreciation, value-depreciation, or physical condition of the property, the application of the concept to monetary problems is almost always in the sense of cost-depreciation. Indeed, it is difficult to imagine a case wherein depreciation is calculated for a useful monetary purpose when it is not based on cost. Cost-depreciation may refer to either a periodic or an accrued charge.

Either the periodic or accrued charge generally corresponds to the usefulness or service capacity which is expended during the period under consideration if it is to be consistent with the charges made for the use of consumable supplies, e.g., coal, steel, lumber. The charges for long-lived properties and consumable supplies should be consistent since only an arbitrary time re-

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[1] A more complete summary of the definitions of depreciation may be found in Summary of Definitions Covering Depreciation and Related Terms, Edison Electric Institute, New York, 1939, 89pp.

striction provides the basis for the classification of assets as either consumable supplies or long-lived assets, i.e., a property is long-lived whenever it is not totally consumed during a span of time equal to the accounting period.[1]

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[1]Certain kinds of assets are not totally consumed during the accounting period but because of arbitrary rules they are not included in the fixed (long-lived) assets, e.g., prepaid insurance.

CHAPTER VIII

RECOMMENDED DEFINITIONS

The recognition of the common ideas expressed in the various definitions and discussions suggests the following definition of depreciation and the sub-definitions which apply to the application of the general definition. Since depreciation may be determined in units of service without recourse to dollars as a dimension it is convenient to define depreciation without reference to a monetary unit.

Depreciation is the decrease in the number of available units of service which a unit of property or group of property units can be expected to render.

Cost-depreciation is the decrease in the available units of service expressed as a function of the cost of the property. Annual cost-depreciation is the cost-depreciation for one year. Accrued cost-depreciation is the total cost-depreciation from the date of installation to any point in time.

Unallocated cost is the cost of the existing property minus the accured cost-depreciation. Cost-depreciation reserve for a single unit is equal to the accrued cost-depreciation; for a group of units it is the accrued cost-depreciation on only the existing units of property.

Value-depreciation is the change in the present worth of the anticipated returns from the services to be rendered by a property. Value-depreciation can be determined only after a valuation is completed and cannot be a factor in the calculation of the value of a property.

CHAPTER IX

DEPRECIATION AS A FUNCTION OF USE

Depreciation is the consequence of use. It is also the consequence of idleness. If a property has a finite life, i.e., the number of units of service which can be rendered by the property is finite, the rendering of a unit of service will decrease the total number of units of service which are available. A unit of service is available if it is reasonable to anticipate that the property in its present environment will render the service. Likewise, a property is partially idle when it is being utilized at a lower rate, either with respect to quantity or quality, than was anticipated at the time of its application to a particular project.[1] In many instances, the services which idle properties could have rendered become unavailable services. This is particularly true of properties in which the service is related

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[1]For example, a mechanical corn picker which was purchased by an Iowa farmer who anticipated using it during the fall harvest season is not "idle" during the remainder of the year. A steam turbine which is necessary for standby service is not "idle" in the above sense.

to the point of time at which they can be used. Real estate which stands vacant is a good example of this. The advent of the unavailability of services depends not only upon the idleness of property but upon external forces which determine how the property can be utilized. When time, the elements, and the economic forces have no effect upon the ability of the property to yield the optimum amount of service, then idleness has no effect on the availability of the services. However, when any of these forces affect the optimum output depreciation of the property results.

A parallel concept of depreciation may be obtained by considering the relation between the units of service rendered by the property and the products of that property. It was previously stated that many individuals consider depreciation as a function of use. Thus, it may be helpful to visualize a process of transformation whereby a unit of service contributed by the property is removed from the property and caused to become a part of the product of that property. Lerner, in a recent economics textbook, expressed this idea as follows:

> Equipment can be considered as "imprisoned" factor services. All existing equipment (except that provided by nature) has been made by factors of production applied

> in the past and (since the equipment is not yet worn out) devoted to consumption in the future. The existing equipment may be considered as incorporating these factor services applied in the past and holding them until the equipment is worn out in the course of producing the final consumption goods. At that point the past factor services will be released from the equipment where they have been imprisoned since their first application.[1]

The transformation of units of service into products which can be utilized is a desirable transformation. However, not all of the potential services of a property contribute to a product which can be utilized to advantage. Some of the services become unavailable because of physical and economic forces which reduce the number of available services by an undesirable transformation.

The cycle of events which occurs in any business enterprise which is continuous in its operation is comprised of the purchase of consumable supplies, labor, and long-lived property; the transformation of these materials and services into a product which can be sold; sale of the product; and the return of the money to working capital. The ideal of cost-depreciation should be

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[1]A.P. Lerner. The economics of control. New York, The MacMillan Company. 1944. p. 325.

the evaluation of the transformation of the services of the cost of the long-lived property into its component part of the salable product.

Examples of such a transformation have been utilized in other discussions of this process. For example, a lead pencil renders service and is consumed. This is not an apt illustration of depreciation in the usual sense because the pencil does not exist when it has rendered its total service.[1] Cost-depreciation is directly proportional to the per cent of the length of the pencil consumed. A better example is an internal combustion engine built fifty years ago which has been maintained in the best possible condition. This engine is no longer capable of yielding services which are of any use for a majority of power installations because the cost of the services is too high to permit their sale. Thus these services are no longer available. If the engine had been allowed to deteriorate physically the net result would have been that the services would become unavailable because the engine would no longer run. The choice between maintenance policies is one of considerable importance in

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[1]The lead pencil is an example of depletion which is not considered in this dissertation because the problems encountered are chiefly problems of valuation and not allocation.

the determination of the number of units of service which are available.[1] The cost-depreciation of the engine whether it is maintained or not should be based on the total available services at the time of purchase and the transformation thereof whether it be of a desirable or undesirable nature.

The transformation of the investment[2] in long-lived property may occur in either a desirable or undesirable manner. The desirable transformation results in a usable product. The undesirable transformation yields

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[1]Maintenance policy should be based on an engineering economy study of the costs involved. It is recognized that maintenance policies are influential in determining the life of the property and should be carefully studied, but it is outside the scope of this study to discuss the factors which determine the optimum maintenance program.

[2]L. Amoroso. The transformation of value in the productive process. Econometrica. 8:11. 1940.

"So we conclude that the transformation of value which occurs in the dynamics of the productive process can be likened to the transformation which is effected in a mechanical process and like the latter is governed by a principles analogous to that of the conservation of energy, with this fundamental difference: that the conservation of energy in the mechanical process represents a natural law which teaches us how certain facts occur, while, on the contrary, the transformation of value which is effected in the productive process represent a rule of conduct, which tells us how the facts occur, if the conduct of the individual is affected by a criterion of rationality."

nothing which is usable. The undesirable transformation of long-lived property may occur as a result of the passage of time in two ways. First, the physical materials of the property may deteriorate because of the action of time and the elements. The services which were available no longer exist but have disappeared, i.e., transformed into an unavailable form. Such deterioration is similar to that which occurs during storage of coal when it oxidizes, or of wood when it rots, or of steel when it rusts. Second, long-lived properties are more likely to be influenced by the introduction of competitive services which cost less because of technical advancements in either the properties or processes which provide the same service.

The transformation of the usefulness of a property into its component of a usable product represents the optimum conversion of the original investment. However, the investment in idle property experiences an economic transformation because of both physical deterioration with time and the increase in the cost of production relative to newer methods and properties which might be called "economy deterioration." This latter economic transformation is a conversion of the original investment into a form which cannot be recovered. The probability of this undesirable transformation occuring is reflected in the risk and uncertainty[1] associated with a business.

A complex situation arises when an investment in a machine which is producing a usable product is thereby undergoing a desirable transformation and may be simultaneously experiencing an undesirable transformation because of physical and "economy deterioration." This combination always occurs whenever the machine is only partially utilized, i.e., partially idle. This combination of transformations may also occur when a machine is producing at the anticipated output but is producing a product which is inferior to the products of improved machines.

The distinction between cost-depreciation and obsolescence in the current usage is that cost-depreciation includes the charge for the desirable transformation and the transformation due to physical deterioration and

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[1] Risk and uncertainty are applied in the sense used from Frank Knight in Risk, Uncertainty and Profit, and by David A. Kosh in "Uncertainty and the Provision for Depreciation in Public Utility Industries," Journal of Business of the University of Chicago, 16(no.4):209-218, 1943.

"We shall consider a 'risk' to exist when we anticipate not a single unique event but rather a probability distribution with known parameters. An 'uncertainty' will be held to exist when we anticipate a probability distribution for which the parameters themselves consist of probabilities." Kosh, op. cit., p. 211.

risk--not including uncertainty. Ordinary obsolescence is the charge for the transformation because of "economy deterioration." Ordinary obsolescence cannot logically include a charge for uncertainty because an "uncertain event" is by definition that event in business toward which no planned action can be taken. The current practice is to distinguish these "uncertain" events leading to retirement by the term "extraordinary obsolescence."

The undesirable transformation of the investment in long-lived property is closely related to the profit required to justify an investment. In competitive business the undesirable transformation affects the overall business policies related to departments in which the undesirable transformation is high but unrecognized, causing them to report higher net returns than other departments in which little undesirable transformation occurs. This may cause a maldistribution of productive effort and financial losses or smaller profits to the business. However, competition will tend to alleviate any faults which might creep into pricing policies from this source. In monopolies, particularly regulated monopolies, this check is not operative.

Public utilities are generally permitted to establish rates which are adequate to cover all costs.

Thus, all transformations are charged as a cost of the product. Kosh has suggested that the inclusion of those factors which have been shown to contribute to an undesirable transformation should be eliminated from causes of depreciation which are included in the definitions of depreciation. These factors are among those stated in a New York Public Service Commission definition of depreciation which includes the following:

> Among the causes to be given consideration are wear and tear, decay, action of the elements, inadequacy, obsolescence, changes in the art, changes in demand and requirements of public authorities.[1]

Kosh objects to the inclusion of obsolescence, changes in the art, and changes in demand because these are a part of the reason for the profit allowed a utility. Thus, a fair return is made up of two parts: "pure interest, or the wages of capital; and profit, the payment for bearing uncertainty."[2] To summarize he states that:

> The term "depreciation," because of the connotations it bears, has at present too wide a scope and embraces too many unlike factors. If depreciation is to be understood in its

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[1]Ibid., p. 209.

[2]Ibid., p. 210.

> everyday sense of lessening in service value, then we should clearly recognize that there are two groups of factors causing depreciation. One group contains factors which are predictable and which will become more so as the statistical data become more complete; the other group contains factors that are uncertainties. The first is paid for by consumers above the line as part of operating expenses; the second is also paid for by consumers, but below the line, as profit. Hence, a "depreciation reserve" affecting factors from the second group is a contradiction in terms and shows an imperfectly thought-out concept of depreciation. (Underlining added.)[1]

Although the elimination of these factors from the causes which are included in the definitions may be possible, it generally is not feasible to try to separate these causes from the causes of retirements upon which statistical predictions are based. It would seem better to modify the fair return to correspond with the lessened amount of uncertainty, if any, which is occasioned by the inclusion of changes in the arts, and demand in the estimate of the life of the property.

The undesirable transformation corresponds to the risk and uncertainty associated with long-lived property. Since it is the possibility of this undesirable

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[1] Ibid., p. 218.

transformation occurring which necessitates a fair return greater than pure interest, any guarantee of the return of the total cost of a property is in effect a decrease in the risk or uncertainty which faces a business and could be recognized by a reduction in the allowable return.

In an individual competitive business the charging of the undesirable transformation to the cost of a product is a burden to the product. The undesirable transformation is in general a function of management and society and is a charge against them, not against the product of a property. The firm which recognizes this overtly should be able to anticipate its costs and profit requirements in a more enlightened manner.

The cost-depreciation reserve is an account in which is recorded the total annual cost-depreciation allocations. As such it contains an allowance for whatever elements influence the prediction of the life of the property. It does not contain provision for any uncertainties. An uncertainty is unpredictable and the only adequate reserve in such a case is 100 per cent of the cost of the property. Thus, such things as radical changes in technology, demand, or action of the public authority are not properly considered as component parts of the allocations of cost-depreciation.

The concept of depreciation would be incomplete unless the fact that it is solely a "paper and pencil" idea were stressed. Within a firm, depreciation can neither increase nor decrease the financial gains or losses before taxes except as it is an aid in understanding these gains or losses. In relation to taxes, the depreciation allocation can influence the net income available after taxes for a single year and does not influence the total net income available after taxes for the life of the business only if taxes are not progressive.

In conclusion, an excerpt from an article by Hatfield concerning the common erroneous concept that "the primary object of the depreciation allowance is to preserve the dollar investment in the business."[1] In his opinion "the primary object of any accounting entry is to state what has occurred."[2] In reply to those who believe that "the long term drain on working capital due to failure to make adequate reservation for depreciation is almost certain to lead to insolvency", he says:

> The statement is triply misleading:
> (1) it is the disbursing of cash, not

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[1] H.R. Hatfield. Financial aspects of depreciation. The Journal of Accountancy. 69(no.1):48. 1940.

[2] Ibid., p. 48.

> the failure to write something in the ledger, that weakens the financial position, (2) there is no basis for assuming that a long term policy of recording depreciation means an accumulating fund of current assets. . ., (3) in many corporations the avoidance of exaggerated statement of profits is to a considerable extent secured without any reservation, or specific recognition of depreciation, by treating recurring replacements as expense.[1]

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[1]Ibid., p. 48.

CHAPTER X

INTEREST AND THE CONCEPT OF DEPRECIATION

The consideration of the relation of interest to depreciation[1] is necessary if the concept of depreciation is to be removed from a static system and placed in a dynamic system, a system wherein all transactions are dated. In general, the relation between interest and depreciation has been attained through a valuation of the anticipated future returns. This valuation approach is not generally applied in business because the depreciation considered is a cost element.

The concept of depreciation as the measure of the utilization of the services which a long-lived property renders implicitly includes a concept of the distribution of these services over a period of time. Since the investment of money in any asset which is not the equivalent of cash requires a payment for the lesser

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[1]A different aspect of the relation between interest and depreciation is discussed by P.T. Bauer and P.R. Marrack in "Depreciation and Interest", The Economic Journal, 39:237-43, London, 1939. In this article the authors discuss the effect of a change in the rate of interest versus a change in the rate of depreciation upon the incentive to invest.

liquidity of the asset plus any risk, an investment in services to be delivered in the future requires a return of interest in addition to the money invested in these services. Thus the purchase price of a property includes an implicit discount of the cost of future services. The overt statement of the rate of interest may never be made but the fact remains that no rational businessman would purchase a service to be delivered in the future without some compensation for the investment of his funds. If speculation and hedging are assumed to be negligible, the compensation will be in the form of interest.

A simplified example in which ten identical units of service are available at the beginning of each of ten years will be considered. The price established in the market today for the first unit of service is $p. What price should the purchaser pay for the contract to deliver the ten units of service? The first thing which is apparent is that the purchaser will have to anticipate what the market price of each of the units of service will be during each successive year. Then in order to express these prices in terms of money today he will have to discount these estimates. If he is meticulous he should examine the discount rate applicable to each year. The risk that the service may not be desirable when it is delivered increases as the date of delivery becomes farther removed. Thus, the discount should be greater, i.e., the interest required greater, for later years. After careful consideration a price could be established and from this an average rate of interest could be calculated. However, if the same machine would have delivered the ten units of service over a five-year period the price of the machine would have to be different even though the prices of the units of service and the same respective discounts would have been applied. The resultant average interest rate would be different. Thus, the concept of the interest rate as a unique quantity which can be applied to all property is a fictitious concept the use of which will result in no clarification of the cost of the services. The market is only an imperfect analyzer of the average anticipation including the discounts. Thus, although the original cost is the discounted anticipated prices at which these services can be purchased, the reduction of this cost to a specific average interest will generally imply an accuracy and uniformity of the rate of interest which probably does not exist.

In actual cases, since there is no reason to assume equal anticipated prices of the units of service or equal rates of discount, the utilization of a system based on discounted anticipated prices in cost-depreciation accounting is meaningless because the estimates of future prices discounted at various estimated rates of interest for estimated lives of the property results in an estimate of doubtful accuracy in which the assumptions on which the estimates are based depend upon the individual and cannot be checked. The obvious assumptions which have been necessary to standardize these estimates are that the prices of homogeneous units of service when delivered are the same, and that the interest rate is constant. If the anticipated price at which the unit of service could be purchased when it is to be delivered is a constant and the anticipated interest rate is a constant, the following relation between the cost of the property and the cost of the unit of service can be developed assuming the units of service are delivered at the end of each year beginning after the date of purchase.

C = Cost of property
p = anticipated price of a unit of service
i = rate of interest

$$C = \frac{p_1}{(1+i_1)} + \frac{p_2}{(1+i_2)^2} + \frac{p_3}{(1+i_3)^3} + \cdot \cdot + \frac{p_n}{(1+i_n)^n}$$

Since $p_1 = p_2 = p_3 \ldots = p_n$ by assumption and

$i_1 = i_2 = i_3 \ldots = i_n$ by assumption,

$$\frac{C}{p} = \frac{1}{(1+i)} + \frac{1}{(1+i)^2} + \frac{1}{(1+i)^3} + \cdots + \frac{1}{(1+i)^n}$$

If both sides of the above equation are multiplied by (1+i) and then the first equation subtracted from second equation the result is

$$\frac{C}{p} - \frac{C(1+i)}{p} = 1 - \frac{1}{(1+i)^n}$$

$$p = \frac{C(1+i)^n\,[1 - (1+i)]}{(1+i)^n - 1} = \frac{C(i)(1+i)^n}{(1+i)^n - 1}$$

If the price at which the homogeneous units of service can be purchased is assumed to be constant, the anticipated price, p, of each unit of service must be greater than the quotient of the original cost of the property divided by the total number of anticipated units of service. The assumption of equal cost of each unit of service at the time of delivery of the service is more consistent with the intent that the performance of identical services should evoke the same cost and that identical services which are to be delivered at different future dates should cost the same at the time of purchase. The recognition of the necessity of discounting future services assumed to be equally priced results in the conclusion that if the allocation per unit of service equals cost/ total units the units of service are unequally priced at the time of the purchase of any long-lived property. If the price of the unit of service, p, is charged as the cost of that unit when the service is rendered, the net income will <u>not</u> include the interest on the investment in the services. Also the price of a unit of service, p, is greater than the cost of the long-lived property divided by the total number of services.

The cost of a unit of service as indicated by the cost of the property is dependent upon both the estimate of the years of life of the property and the interest rate required to induce the investment. The calculation of the cost of a unit of service by dividing the original cost by the total estimated output assumes either that the price of the unit of service varies such that the discounted amounts are equal, or that the interest rate is zero. In either case the above equations reduce to

$$p = \frac{\text{original cost of the property}}{\text{number of units of service}} .$$

The assumption of complete divisibility of the services of the property is obviously unreal. The units of service of a property can be purchased only in groups according to the design of the property. Investors do not have the choice of purchasing one or two units of service. Even if they did the cost of installation and interruption of production in many instances would make such divisibility undesirable. The situation could arise in which it is anticipated that the services could be purchased in small groups, i.e., in more fragile machines, at a lower price next year than they can be purchased now, but management will choose to pay more for the future services now to prevent interruption of production in the future. The consideration of convenience and cost of installation may affect the cost of the property apart from the anticipated price of the units of service.

The further assumption that all units of service from a single property are homogeneous leads to serious errors. Many properties throughout their life yield a variety of services some of which could be obtained by a substitute means. For example, a locomotive originally used on main line hauls is finally relegated to switching duty which could be performed better by an engine specifically designed for such service. The price of the services rendered by the locomotive on long hauls is different from the price of the services necessary for switching. The allocation of the cost of such a property on the basis that all services are equal results in a psuedo obsolescence in later life.

Although the concept of depreciation as a quantity in a dynamic economic system requires the recognition of interest, the inclusion of interest in the ordinary calculations of cost-depreciation requires so many assumptions to make it applicable that the benefits of the application are apt to be an illusion. The use of a single interest rate which is applied to a series of anticipated prices which are assumed equal yields no pertinent information about specific properties. The advantage of assuming zero interest rate, if the assumption is acknowledged, is that additional consideration and application of judgment to each case, which merits it, is required. Only in theoretical studies[1] in which the assumptions are stated clearly and results qualified in accordance with the assumptions should interest be included. Since the compounding effect of the interest formulas generally causes large errors in the annual depreciation estimates in the later years of the property life even though actual estimates of life and salvage value are only slightly in error, it is usually better to omit interest in the estimation of cost-depreciation.

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[1]H.F. Fowler, in Depreciation of Capital, London, P.A. King Ltd., 1934, in an economic analysis arrived at the following conclusion:

"We can now see if we assume conditions of competitive stationary equilibrium, the Sinking Fund Method is the only one which is compatible with these conditions."

CHAPTER XI

DEPRECIATION AND REPLACEMENT

Replacement is the beginning and the end of the process of depreciation in a continuous property except for the original installation. The time at which the retirement of the old property and the consequent replacement by new property takes place is a point of discontinuity in the investment process. The exact time when this occurs is dependent upon the replacement policy of the firm. Replacement or retirement is the end of the useful life of the old property. Thus the replacement policy of a firm affects the depreciation policy by influencing the date of retirement, i.e., the useful life, of a property.

The relation between cost-depreciation practices and replacement policies results from the dependence of depreciation theory upon the theory of economic life[1]

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[1]G.A.D. Preinreich (The economic life of industrial equipment. Econometrica. 8 (no.1):37. 1940.) states that: "All rules of economic life are also rules of depreciation, since each suggests the apparently most logical way (out of innumerable other possibilities conforming to the terminal condition) in which costs ought to be distributed in the corresponding circumstances."

which is a function of replacement policy. Thus, replacement policies of a firm influence depreciation practice. The sequence of financial events related to the use of long-lived property, i.e., purchase, depreciation, retirement, replacement by another purchase, may have occasioned some misunderstanding as to the relation between depreciation, retirement, and replacement. Statements to the effect that depreciation is to provide for either retirement or replacement of the present property are evidence of a misunderstanding. In a recent article following a discussion of the 60 per cent price increase since 1939 this opinion was recorded: "Business men have been prone to introduce a new concept. Depreciation reserves, they say, should provide funds for the replacement of fixed assets. . . ."[1] Blough commented on a similar idea as follows: "It has also long been recognized that the purpose of depreciation accounting is to allocate cost of existing facilities, not to provide funds for replacement."[2] The article in Fortune continued:

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[1]The depreciation dilemma. Fortune. 39 (no.1): 66. 1949.

[2]Carmen G. Blough. Replacement and excess construction costs. The Journal of Accountancy. 84 (no.4): 335. 1947.

> Actually, depreciation and replacement are two separate and distinct considerations and the practice of lumping them together is responsible for much of the confusion and muddled thinking on the subject of depreciation.[1]

Another misunderstanding about the relation between depreciation and replacement is the belief that the dollars recorded in the depreciation reserve are available for purchase of replacements. In the mid-thirties a study made by Fabricant on the capital structure of the economy of the United States[2] was widely discussed. Based in part upon Fabricant's survey, the testimony of A. H. Hansen before the Temporary National Economic Committee maintained that reinvestment of depreciation allowances could be made only by expanding the productive capacity of the economy. In reply to this, May asked the following question: "Do substantial depreciation and depletion allowances become available for replacing units or for returning the capital represented thereby?"[3] After

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[1]The depreciation dilemma. Fortune. 39 (No.1): 66. 1949.

[2]Solomon Fabricant. Capital consumption and adjustments. New York, National Bureau of Economic Research. 1938. 271 pp.

[3]G.O. May. The relation of depreciation provisions to replacement. The Journal of Accountancy. 69(no.5):341. 1940.

examining the records of several companies for the years of the depression he concluded that depreciation allowances are not necessarily available for replacement. Meigs[1] in 1945 arrives at the same conclusion, i.e., only current appropriations are available.

Closely related to replacement studies is the efficiency of the property. In the current literature efficiency is generally used loosely but it is implied that efficiency is an index of the performance of the property relative either to its performance when new or to the performance of extant properties which provide the same service. The relation between efficiency and depreciation is that an inefficient property will have high costs of operation which may encourage replacement. However, it is possible for a property to operate as efficiently as it did when new and be near the end of its economic life because of technological improvements which make the cost of alternative means of providing the service less. Many engineers have yet to divorce depreciation from efficiency.

Replacement of a property in competitive businesses must generally be justified by showing that

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[1] R.J. Meigs. Are depreciation reserves available for improvements. Public Utilities Fortnightly. 35(no.1):46-49. 1945.

a money savings will result from the replacement. In regulated industries, the effect of the replacement upon the rate base must also be considered. Since a discussion of replacement analysis in a broad sense is beyond the scope of this dissertation, the reader is referred to a text such as that of Grant.[1] As an illustration of a correct replacement analysis and some of the vagaries which are encountered in such an analysis the following examples and quotations are presented.

The comparison of the anticipated annual costs of operation of two or more properties is one approach whereby the feasibility of replacement can be studied. An integral part of a proper replacement study is the concept of a "sunk cost." Grant emphasizes this point as follows:

> This difference between the "cost" of owning and operating a machine not yet purchased and the "cost" of continuing the same machine in service after it has been purchased exists to a much greater degree in economy studies relative to the services of machines or structures which have no active secondhand market, or which have substantial costs of installation and removal. The point of view that an investment once made in physical property

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[1] E.L. Grant. Engineering economy. New York, The Ronald Press. 1938. p. 182-222.

> may be partially or entirely a "sunk cost," in the sense that it is not recoverable through the sale of that property, is one that is essential in many economy studies, particularly in those dealing with proposed replacement.[1]

According to the above idea, the cost of continuing an old property in service for an additional year is based solely upon the anticipated change in the resale value or salvage value of the old property during that period, not upon any arbitrary allocation of the original cost, and not upon the amount recorded in the depreciation reserve. The comparison must be set up in such a way that the two or more proposals are acceptable alternatives. An example of a comparison of annual costs follows.

An industrial firm operates its own power plant which has a maximum demand of 3500 kw. At present the demand is met by a combination of a new high pressure and temperature steam power plant and a 1000-kw low pressure and temperature turbo-generator supplied by an old steam generator serving as a supplementary power source. The management is considering whether to discard the 1000-kw low pressure turbine and its steam generator and purchase a 1000-kw Diesel powered unit. The following data were assembled:

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[1] Ibid., p. 20.

	1000-kw steam turbine	1000-kw Diesel
Cost new	$72,000 (1929)	$125,000 (1949)
Fuel cost	1.5 mills/kw hr	0.88 mills/kw hr
Labor & Superintendence	1.5 "	1.5 "
Repairs & Supplies	0.6 "	0.3 "
Taxes	0.25 "	0.25 "
Insurance	0.2 "	0.2 "
Probable life	25 years	20 years
Depreciation Reserve	$46,000	
Average hours per year of operation per year for the past 4 years	1800 hours	
Estimated kw output per year	1,400,000	1,400,000
Present bid for turbine	$7000	
Estimated salvage "value"	$3000 (5 yrs. hence)	$5000

It is company policy that all investment in replacements must pay for themselves in ten years and earn at least 5 1/2% interest.

Assume straight-line depreciation.

Comparison of Estimated Annual Costs

Diesel Power

Capital Recovery[1] (Depreciation (based on company policy of repayment in 10 years)

$$\frac{120000}{10} = 12000$$

(Average interest

$$120000\left(\frac{0.055}{2}\right)\left(\frac{11}{10}\right) + 5000(0.055) = 3900$$

Total = 12000 + 3900 = 15,900

Fuel	0.0088 (1,400,000) =	12,300
Labor & Superintendence	Omit in comparison because it is the same for both alternatives	
Repairs	0.003 (1,400,000) =	4,200
Insurance	omit, see above labor	
Taxes	omit, see above labor	
Total estimated annual cost		$32,400

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[1] Capital recovery is composed of two parts: (1) the allotment based on the dollars which must be expended in the future to purchase the property or which can be realized from the sale of the property today, and (2) the interest on these dollars. The above calculation is based on an approximation in which straight line cost-depreciation and an approximation of the average interest is used. (Grant, op, cit., p. 85.) If the capital recovery factor or its equivalent the sinking fund factor is used, the total of the allotment and interest would be $16,175 instead of the $15,900, i.e., (120,000)(0.13267) + (5000)(0.055) = 16,175, Grant, op. cit., p. 413. The

Steam Plant

Capital Recovery (Depreciation (based on bid for turbine)

$$\frac{7000-3000}{5} = 800$$

(Average interest

$$(7000-3000)\left(\frac{0.055}{2}\right)\left(\frac{6}{5}\right) + 3000(0.055) = 297$$

	Total = 800 + 297	= 1,097
Fuel	0.015(1,400,000)	= 21,000
Repairs	0.006(1,400,000)	= 8,400
	Total estimated annual cost	≃$30,500

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[1](continued from page 106)
error in the approximation becomes greater as the time interval is extended, e.g., Grant (p. 87) shows that for 8 per cent interest the error is 3 per cent for 10 years and 10 per cent for 20 years. Thus the average interest method should be used for short time intervals only.

The principles which are illustrated in the foregoing replacement study and those which should be considered in conjunction with such a study follow:

1. The period for the recovery of the investment is dependent upon management's judgment, not upon the estimated life of the equipment.

2. The investment must earn adequate interest during the recovery period to justify itself.

3. Items for which the cost is the same in each alternative may be omitted.

4. The original cost or "sunk cost" of the old equipment has no bearing upon the replacement study.

5. The amount of money allocated for depreciation to the account for the old equipment has no bearing upon the replacement study.

6. The amount of depreciation chargeable to the old equipment is determined by the decrease in "secondhand" or salvage value. If the salvage value is zero, there is no depreciation charge for the old equipment.

7. If the estimate of the life of new equipment is decreased because of foreseeable obsolescence, the life of the old equipment should not be longer than that of the new equipment.

8. The decision to replace is based upon intangibles which cannot be evaluated in terms of money, e.g., the available funds for replacement, judgment as to the trend of business over the short term, other possibilities of investing the same money.

It should also be noted that an analysis favoring the Diesel would have resulted if the capital recovery cost of the old property had been determined by allocating the original cost less salvage over the probable life. A total capital recovery charge of approximately $3000 by the average interest method or approximately $5500 by the compound interest capital recovery method would have been obtained. In either case the annual cost of operating the steam plant over the next five years would have been equal to or greater than that for the Diesel, i.e., steam plant $32,400, Diesel $32,400 using the average interest method or steam plant $34,900, Diesel plant $32,400 using the capital recovery factor.

The use of the unallocated cost of the old property as a part of the cost in a comparison is made to appear more plausible by arguing that the new machine should be charged for the unrecovered cost of the machine which it replaces. Otherwise money will be lost on the machine which is retired without any way of recovering it. The rebuttal to this argument is inherent in the idea of "sunk cost." Thus, whenever a new machine can be anticipated to perform the same services at a lower cost than an old machine (when the cost of paying for the new machine plus interest on the investment is included as part of these lower costs) the differential between the higher costs of the old machine and the lower cost of the new machine is a return which will be foregone to the business if the replacement is not made regardless of the amount of the original investment in the old property which has been allocated. Thus, the fact that the cost of continuing an old machine is greater than that of a new machine, can be camoflouged by charging the new machine with the unrecovered cost of the old machine when the cost of the old machine has not been completely allocated. Another example will illustrate this latter point.

An air compressor is 15 years old and it is estimated that the annual cost of the power consumed is $500. The average repair costs for the past four years have been $210 per year. The original cost of the air compressor was $3200. The present amount in the depreciation reserve is $2000. The company can sell the compressor today for $400. The net salvage value at the end of five years will be zero.

A centrifugal air compressor which will perform the same service will cost $2000. Its estimated life is 18 years. The company requires all replacements to pay for themselves in 6 years and earn 7 per cent on the money invested. The annual cost of operation is estimated at $280. The cost of the repairs for the first 9 years will be about $50 per year. Only the above items of cost will be affected by a replacement of the compressor.

Comparison of Annual Costs

Old Compressor

Capital Recovery (Depreciation:

$$\frac{400}{5} = \$80$$

(Average interest:

$$\frac{400(0.07)}{2}\frac{(6)}{(5)} = \$16.80$$

Total = 96.80

	$ 97
Cost of operation	500
Repairs (assuming past average will continue for 5 years)	210
Total annual cost	$807

New Centrifugal Compressor

Capital Recovery (Depreciation:

$$\frac{2000}{6} = \$333$$

(Average interest:

$$\frac{2000(0.07)}{2}\frac{(7)}{(6)} = \$82$$

Total =	$415
Cost of operation	280
Repairs	50
Total annual cost	$745

The replacement of the compressor is financially advisable since it will pay for itself in 6 years while earning 7 per cent on the investment and it can be operated at $62 a year less than the old compressor. This savings is equivalent to a return of about 3 per cent above the 7 per cent required. However, if the $800 which was unallocated (assuming the old compressor was sold for $400) had been considered as an additional burden upon the new compressor the additional charge would have been $800/6 or $133 per year. This additional cost would have revealed the old compressor to have a lower annual cost. When the result of a comparison including this additional burden is considered, the fallacy is apparent.[1] Assume the old compressor is retained. The annual cost is $807 and at the end of 5 years the old compressor is retired. At the end of 5 years the company has had an expense of $310 more on capital and operation costs than it would have had had it purchased the new compressor and in addition the cost of the new compressor would have been

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[1]"Although authorities on equipment policy are by no means unanimous on the point, the prevailing view--with which we agree--is that replacement decisions should not be influenced by the book value, or unrecovered cost, of the asset considered for retirement. Not infrequently there is marked unwillingness to 'take a loss' on the disposal of assets with substantial remaining book value, and their replacement is handicapped accordingly." George Terborgh. Dynamic equipment policy. New York, McGraw-Hill. 1949. p. 4.

five-sixths allocated to expense. Thus, at the end of 5 years, the company must invest approximately $2000 most of which would have been returned by now had the new compressor been purchased and has $310 less funds available with which to purchase the new compressor. The discussion of the two previous examples illustrate how replacement analyses may alter the time at which a unit is retired.

Factors in a replacement study which may influence management to retire a property are: (1) the period of repayment ("pay off" period) required by the company or the economic life of property, (2) the relative amounts and cost of fuel, power, repairs, and supervision, (3) the interest rate required to justify an investment, (4) the intensity of use, (5) the "second-hand" market, (6) maintenance policies. Undoubtedly one of the most significant factors is the "pay off" period for an investment. Most companies require that an investment pay off in 5 years or less. A recent survey found that 32 per cent of the manufacturers require a "pay off" period of 3 years or less and 76 per cent require 5 years or less.[1] If the economic life is less than the "pay off"

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[1]Business' needs for new plants and equipment, 1949-53. New York, McGraw-Hill. 1949. p. 11. See also MAPI survey of replacement policies. Washington, D.C., Machinery and Allied Products Institute Bulletin No. 2119. 1948. p. 4.

period, the economic life will determine the date of retirement. When replacement studies are made on the basis of a "pay off" period, the results should not be interpreted as a comparison of the cost of production between the old and new properties. The relative amount and cost of fuel or repairs become more influential with an increase in the intensity of use. In the first example an increase in the number of kilowatt hours by 20 per cent would have made the annual cost of the Diesel less than that of the steam power plant. A decrease in interest rates required generally favors the new property and thus shortens the life of installed equipment. The proximity of similar industries may influence the "secondhand" bids on old properties. Industries located in rural areas should expect longer property lives because the depreciation based on resale approaches zero rapidly after the property is constructed or purchased and installed. Maintenance policies affect the quantity of labor and supplies and in addition the efficiency of operation of the property. Thus meager maintenance may increase fuel costs for power installations or heating installations but apparently reduce direct expenditures on labor and supplies. Such meager maintenance which increases fuel costs may shorten the economic life even more than it shortens the physical life of the property.

Recent publications by reputable sources have based parts of their depreciation analysis upon replacement policies which consider either the original cost or the unallocated cost as a factor in the comparison of two alternatives or in the determination of the cost of operating the new property. Several examples of these faulty analyses follow:

> Obsolescence becomes effective only when production can be carried on more cheaply by replacing a given unit, <u>the undepreciated or unrecovered cost of which unit is considered as a part of the cost of replacement</u>.[1]

> Another way of putting the matter is to say that all costs of wasting assets must be recovered through depreciation rates based upon the natural physical life of such assets; and that whenever the cost of any asset is not so returned during the period of its usefulness because of the shortening of life from obsolescence then such unrecovered cost should be recovered during the natural physical life of the asset which replaces it.[2]

> If displacement of capital goods is being contemplated, it must be decided whether the remaining investment of installed equipment may be amortized out of the anticipated reduction in costs or increase in

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[1]Saliers, op. cit., p. 54.

[2]Ibid., p. 57.

> profits from utilization of the improvement.[1]

> Considering only the financial or profit aspect, when does it pay to scrap the old and substitute the new? In general, it pays to scrap a particular machine or process when the additional profit that can be obtained by the use of the new machine or process will be sufficient to provide for interest on the unexpired value of the old machine or technique, together with the repayment of that value over the expected period of enjoyment of such excess profit.[2]

> Professor Saliers and others have argued that the undepreciated balance should be added to the cost of the asset acquired. . . . It seems obvious that future periods should benefit from the use of the more efficient asset, and it seems to follow that these future periods should bear the obsolescence on the inefficient one.[3]

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[1]C.E. Troxel. Measurement of obsolescence of capital goods. Journal of Business of the University of Chicago. 12:147. 1939.

[2]Lewis H. Kimmel. Depreciation policy and postwar expansion. Washington, D.C., Brookings Institution. 1946. p. 35.

[3]Carl T. Devine. Deferred maintenance and improper depreciation procedures. The Accounting Review. 22(no.1):39. 1947.

These examples emphasize the need for a competent analysis of replacement. The life of a property is justly dependent upon management's judgment but in addition it may be influenced by improper application of the judgment.[1] Replacement policy affects cost-depreciation policy by influencing the economic life of the property on the basis of anticipated costs, not on the basis of the cost-depreciation allocations of the original cost of the property.

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[1]Victor H. Stempf. Trends in accounting procedures. The Journal of Accountancy. 69(no.6):452. 1940. Stempf stated: "Inherently, industry is loath, if not in fact unable, to discard the old and install the new equipment before the investment has been recouped and unless competitive extremity forces the issue."

PART IV

ELEMENTS OF COST-DEPRECIATION

CHAPTER XII

COST

The evaluation of the cost-depreciation incurred during any time interval less than the life of the property depends upon the following items: (1) the cost of the property, (2) the useful or service life of the property, (3) the salvage value, (4) the basis of allocation of the cost less salvage value (depreciable cost). The proper determination of each of these items has provoked many controversies. Of the four items, only "the basis of allocation" is not subject to a confirmation by a reasonable estimate after the property is retired.

Since the word cost does not have a unique meaning, the definition which was stated in the introduction[1] should be recognized as pertaining only to the problems of allocating the expenses incurred when a property is acquired. The meaning of the word cost is dependent upon the situation. Cost in the sense in which it is applied here means the outlay of money, goods or services by the present owner. The general application of

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[1] Supra, p. 7.

this meaning of cost assumes a constant value of the dollar, and neither collusion nor questionable financial manipulations during acquisition of the property. The above viewpoint eliminates the problem of whether cost implies the sum of the expenses incurred in the manufacture, the price to the wholesaler, the list price, or the price arrived at after haggling. Cost in nearly every case[1] depends upon what was the outlay by the present owner when he purchased the property.

Of the two assumptions which qualify the definition of cost, the assumption that the value of the dollar is constant needs the greatest emphasis. It is the variation in the value of the dollar which is provoking the most controversy among those who use cost-depreciation methods today, i.e., original cost vs. reproduction cost as the depreciation base. The validity of the argument for reproduction cost depends first, upon whether it is important to preserve the real savings of previous generations, and second, whether reproduction cost is a good index of the change of the dollar value.

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[1]Under public utility regulation by the federal government the utilities are required to interpret cost as the cost not to themselves but to the first firm using the property in public service.

The dollars invested by any individual represents goods and services foregone, i.e., values foregone. The return of these dollars should be equivalent to the values foregone plus a compensation for foregoing them. J. B. Clark summarized society's obligation to protect property values as follows:

> Society, then makes it one of its primary ends to protect for owners the values that represent and reward their personal sacrifices. . . . The rights that center in the forms of property are trivial, those that center in the value of the property vital.[1]

If these dollars do not have the same value,[2] then higher rates of interest should be necessary to provide an incentive for savings. The experience in recent years has shown that these high rates of interest and profits are an invitation for government, labor and even the stockholders to demand more from business and the investor. They demand more because they do not appreciate the effect of the change in the dollar value on the apparent profits. Evidently, one better way of assuring the

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[1] J.B. Clark. Capital and its earnings. Publication of the American Economic Association. 3(no.1): 61-62. 1888.

[2] Walter Rautenstrauch. The economics of business enterprise. New York, John Wiley and Sons. 1939. p. 153.

investors protection[1] of their personal sacrifices is to devise a flexible cost-depreciation base which will fluctuate in direct proportion to the dollar value. If it is desirable to protect the personal sacrifices of the investors, the use of reproduction cost as a means of compensating for the fluctuation of the dollar merits consideration.[2]

Reproduction cost may mean either the cost of purchasing an identical unit of property or the cost of purchasing a unit of property which will produce the identical services in the most economical manner. Each concept will show a change in the cost of the services rendered by a unit of property. Neither concept will necessarily be proportionate to the change in the value of the dollar.

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[1]Protection is not intended to imply a guarantee of the return of the investment. Instead it is a protection of the investor against being compelled to accept a devaluated dollar as compensation for personal sacrifice in the past which would today be equivalent to a greater number of dollars. If the investment cannot earn this increased number of dollars it is a poor investment and should be recognized as such.

[2]A method of accounting using a stabilized dollar to compensate for this fluctuation has been proposed by H. E. Sweeney, op. cit.

The cost of purchasing an identical unit of property is a function of the present prices of the factors of production and the present production function for the manufacture of the property unit. Thus, the change of the cost of an identical unit depends upon changes in prices of labor, materials, and management's services modified by the changes in the proportionate combination of these factors. Since technological advances may have eliminated the manufacture of similar property units, the reproduction of an identical unit can well yield a purely fictitious cost.

The cost of replacing the services by the most economical method may imply the use of the price of fundamentally different equipment. In this case the cost of reproduction has little relation to the original cost of the outmoded equipment. For example, the cost of replacement of ten 5000-kw turbogenerators operating on low pressure and low temperature steam by a 50,000-kw turbogenerator operating on high pressure and high temperature steam is dependent upon the cost of a <u>different</u> steam design, <u>different</u> materials, <u>different</u> turbogenerator design, and <u>different</u> maintenance and service costs, i.e. a different production function for the services. Since each of these factors is different than that of the old power plant, the composite cost can have little relation to the change in the value of the dollar. Apparently neither concept of reproduction cost provides an adequate method for adjusting the original cost to correspond with the change in the value of the dollar.[1]

The value of the dollar is a function of the changing prices of all elements in the economy. The change in the "price level" is an indication of the change in the value of the dollar. The quantitative determination of a factor denoting the change in price level (or the value of the dollar) is different because the problems discussed in connection with reproduction cost also influence the construction of index numbers. For example, identical units of property do not exist over long periods of time as a basis whereby prices may be weighted. Thus, some arbitrary index number[2] which closely corresponds

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[1]George Terborgh, in "Depreciation Policy and the Postwar Price Level," (Machinery and Allied Products Institute, Chicago, 1947, 22 pages) arrives at the same conclusion:

"If this view is correct, it follows that specific replacement or reproduction cost is irrelevant to the adjustment of depreciation policy, and that we must rely on some measure of generalized purchasing power." (p.11.)

[2]A similar suggestion was made by C. Frank Smith, Depreciation techniques and changing price levels, Iowa Business Digest. 20(no.4):1-3. 1949.

to the variation in the value of the dollar should be used, e.g., an index similar to the construction cost index of the Engineering News-Record or the cost of living index of the Bureau of Labor Statistics.

Carmen G. Blough, research director of the AIA, suggested a similar procedure in a recent article:

> It is possible, however, and indeed highly probable, that the solution to this problem is not in changing accounting procedures. Maybe accepted business concepts of profits are at fault. . . . Perhaps we should begin a system of measuring business activity in terms of index numbers. Maybe existing accounting procedures would be most effective for reporting basic data if a plan for measuring profits in terms of constant units of value were developed and supplementary statements in terms of such a constant unit were adopted.[1]

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[1] Carmen G. Blough, op. cit., p. 335-6.

CHAPTER XIII

SERVICE LIFE

Useful life and service life, or probable useful life and probable service life generally connote the time interval during which the property has been or is expected to be used as a productive agent. The significance of each of these property lives is dependent upon the method and data used in its determination.[1] Property lives whether in terms of years or service units are generally determined by (1) the use of the property accounting records, (2) the use of actual installation and retirement dates, (3) arbitrary estimates, and (4) the analysis of the optimum economic life.

The useful life based on accounting records reveals the time interval during which the property unit is recorded in the property records. This is the most frequent basis of an analysis. The property life so de-

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[1]An extensive study of the various methods of estimating service life was made by the American Gas Association and the Edison Electric Institute under the title "An Appraisal of Methods for Estimating Service Lives of Utility Properties." It was prepared under the direction of cooperating committees on depreciation in 1942.

termined is dependent upon the accountant's methods of retiring properties. In some instances, property is retired from the accounts when the original cost has been written off regardless of the retirement of the property from production. Conversely, property which has been removed from service may be retained on the records until its cost is wholly allocated to expense. In other cases the records correspond exactly with physical life.

The useful life based on work orders to install and remove property reveals the time interval during which the property has been installed. This analysis fails to reveal whether the property has been used throughout the entire period. Nevertheless, it is probably a better indication of the life during which a property is used than the life based on accounting records.

The useful life based on arbitrary estimates whether pure guesswork or based on tabulated estimates in published form, e.g., Bulletin "F", have little relation to actual property life. Although arbitrary estimates are likely to be regarded as of little value when it is realized that the estimates do not correspond to actual life, many individuals rely on arbitrary estimates of general probable life when they are tabulated in various sources. This reliance on published estimates is probably worse than the use of a rough estimate based on past experience.

While the use of probable life based on Bulletin "F" listings is not appropriate, it is compulsory[1] on most businesses for income tax purposes. It is unfortunate that a large percentage[2] of these businesses use these same values for their own records and policies. As previously noted, many of the estimates of the probable lives in Bulletin "F" were originally arbitrary estimates collected from various sources and revised by the BIR. Since that time the BIR has made some use of mortality statistics but only in a limited number of cases.[3] Even though the

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[1]Since the issuance of T.D. 4422 in 1934 it has been necessary for the individual to prove those probable lives which do not closely correspond to Bulletin "F" estimates. Most businesses either lack the data or personnel to make adequate studies to prove their claims. Thus, use of Bulletin "F" estimates is mandatory. In an article, "Trends in Accounting Procedure," by Victor H. Stempf (op. cit., p. 451-460), he also expresses the belief that the Treasury may foster low depreciation rates by recommending long lives.

[2]A MAPI survey revealed that 84% of 182 firms surveyed used the same depreciation rates "for book and for income tax purposes." MAPI Survey of Depreciation and Replacement policies, op. cit., p. 7.

[3]Philip Donham, in "Some Observations on Depreciation Allowances," The Accounting Review, 21(no.4):415-418, 1946, expresses the idea that because management is reluctant to replace equipment which has not been fully depreciated the insistence of the BIR upon longer lives than business uses to justify the purchase of equipment has given rise to statistical evidence to support longer lives.

probable life of an item of property as stated in Bulletin "F" were representative of the average property life throughout the United States, each firm is subjected to production and climatic conditions which differ sufficiently from the average to warrant a separate estimate. For example, the estimate of the composite probable life for freight train cars in Bulletin "F"[1] is 28 years. Yet, recent studies of freight train cars have shown a dispersion ranging from 14 years to 30 years according to the types of cars, vintage of cars, and location of car's usage, and from 19 to 26 years on composite accounts of all freight train cars of a single railroad.[2] Consequently, the cost of making these estimates of probable life might reimburse a company within one or two years by tax savings alone. Thus, all of the additional advantages to management would be extra returns from such a study.

Optimum economic life[3] of a property unit is generally considered as that period of time beginning with

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[1]Bulletin "F", op. cit., p. 65.

[2]Robley Winfrey, Ames, Iowa. Personal correspondence concerning the analysis of statistics from three Class I railroads. 1949.

[3]Optimum economic life may also be defined as a period during which the profits of the entire business are maximized or a period during which the welfare of society is maximized. (The possibility of maximizing the welfare of society was suggested by an unpublished article by J.A. Nordin.)

the purchase and ending whenever its anticipated cost of producing the service for an ensuing time period exceeds the cost of producing the service by a feasible alternative or the cost of terminating the service. Thus, the end point of the optimum life is based upon replacement policy. Since cost of operation includes maintenance cost and maintenance has considerable influence on the probable life, maintenance policy is pertinent to the optimum economic life. Although replacement policy and maintenance policy are factors determining the end point of not only the optimum but of the actual physical life, cost-depreciation is not a provision for either retirement or replacement of any or all of the property of a firm.

A systematic determination of the probable life of property based on past experience may be pursued by using the methods of statistical analysis. A method which may be easily and quickly applied to give results which are as accurate as most data will warrant is described in the bulletin, Statistical Analysis of Industrial Property Retirement, by Winfrey.[1] Whatever the source of data a proper statistical analysis of the data modified by studies of the past and forecasts of the future will yield the

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[1] Winfrey, Bulletin 125, op. cit., p. 82.

best possible estimate of the useful life. Such an analysis will yield results superior to intuitive estimates because it will require that the factors which affect the life of the property be recorded in a systematic manner. These factors may be treated by mathematical methods which can be relied upon to minimize preconceived ideas about the life of the property. Modification of the mathematical results by factors of judgment will indicate more clearly what additional factors should be considered. Jeming has proposed a means of determining the standard deviation of these estimates, thus providing a criterion by which the estimates of service lives may be judged.[1]

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[1] Joseph Jeming. Estimates of average service life and life expectancies and the standard deviation of such estimates. Econometrica. 11:141-150. 1943.

CHAPTER XIV

SALVAGE VALUE

The salvage "value"[1] of a property is that portion of the original cost which is not expended within the useful life of the property. The determination of the salvage "value" depends upon the disposition of the property when it is retired.[2] Properties are generally disposed of in one of the following ways: (1) by sale outside the firm, (2) by reuse within the firm, and (3) by demolition or discard as refuse. Since it is necessary to ascertain the salvage "value" before the part of the original cost which is to be allocated is determined, salvage "value" is a forecast.

The salvage "value" of properties which are to be sold upon retirement is dependent upon a forecast of

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[1]"Value" as used here means the price which will be established in a market at a future date, not the present worth of future services.

[2]The importance of an accurate estimate of the salvage value is discussed by Joseph Jeming in "Depreciation and its Relation to Plant Accounting and Property Records," Proceedings of the National Conference of Electric and Gas Utility Accountants, Edison Electric Institute, American Gas Association, Detroit, Michigan, April 11-13, 1949, p. 257-263.

the price to be received. If the property is to be sold as a unit, the problem is strictly one of forecasting the price of the unit at the time when the useful life terminates. If the property is to be dismantled before selling, the quantity of material resulting from the dismantling is estimated. In the latter case experience will be a good guide as to the quantity of material, but the unit prices should be determined by forecast, not necessarily by averages of past sales.

The salvage "value" of properties which are to be reused within the firm presents another forecasting problem. It is different from the case of a sale in that the final disposal of the property from its present function will not result in a payment of money to the firm. Thus, the possibility of checking the estimate is eliminated. The importance of this estimate is dependent upon its influence on the replacement of the machine. Salvage "value", replacement or retirement policies, and useful life are so closely related that the determination of salvage "value" can materially influence the other two items. For this reason it is preferable to establish the salvage "value" at the cost of a feasible substitute rather than at the value (present worth) of the future services. If this policy is followed the decisions based upon such an estimate of salvage "value" would have been reasonable whether that property were reused or not.

Comparisons of salvage "values" or useful lives of similar properties should always include cognizance of both quantities. For example, freight train cars which are to be rebuilt have shorter lives and higher salvage than similar cars which are used until they are sold for scrap. This variation of property life with salvage and reuse policies is another reason why tables of probable lives are not universally applicable.

Retired properties which are of no further use to a company or to anyone else obviously represent a case where the original cost has been entirely expended. In most instances these same properties require an outlay of money to remove them. The question then arises whether salvage "value" can be negative.

Salvage "value" in the sense that it was originally defined as the remainder of the original cost can not be negative. Neither can it be negative when it is used in the computation of cost-depreciation when cost-depreciation is considered as an allocation of a prepaid expense. However, the cost of removal of this useless property is an expense attributable to the services rendered by the property and this cost should be allocated to the products. It can be allocated by creating a special item or account. The use of a special item or account differentiates between prepaid expense and costs which have not been incurred. For the purpose of allocating costs to the products of a property the result will be the same. On the other hand for the purposes of the balance sheet the former, negative salvage, would imply an expenditure of funds which has not been made. Paton's opinion is:

> Where, however, removal or demolition cost is expected to exceed gross recoverable value by a substantial amount it is technically preferable to accrue the estimated net outlay at retirement through a separate reserve or to label the allowance for depreciation in such a way as to disclose its composite character.[1]

The subtraction of forecasted salvage "values" from the original cost presents the same anomaly of dimensions as was previously discussed in reference to cost, i.e., original cost, \$ (1949) - salvage "value" \$ (1959) = depreciable cost, \$ (?). The rectification of this anomaly can be attained in a similar manner to the one in cost except that the index numbers would have

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[1] W. A. Paton. Advanced accounting. New York, The Macmillan Company. 1941. p. 261.

to be forecasted. The use of current prices will not help since the change in market conditions for property to be retired will differ by the time of the retirement of the present property. Thus, the estimate of salvage "value" is one which is at best subject to considerable error.

CHAPTER XV

ALLOCATION OF DEPRECIABLE COST

The allocation of the depreciable cost of a long-lived property is generally an arbitrary assignment of a portion of the total cost of the property to the cost of production either on the basis of the services rendered by the property or the time elapsed during the accounting period. Because the evaluation of the cost-depreciation is always an estimate and it is not susceptible to the same degree of accuracy of measurement which characterizes the cost of labor and consumable supplies, it is frequently said that the assumption of a method of cost-depreciation allocation is equivalent to the assumption of the profit.[1] Thus the limit of arbitrariness of allocations is controlled only on any author's assumptions about profit. A survey, Table I, made in 1938, indicated that 122 out of 126 companies

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[1]Preinreich stated this as follows: "No matter how far analysis and conjecture are carried, it is necessary to assume the form of the profit function either deliberately or by doing--perhaps unwittingly--something equivalent. Any depreciation method ever devised amounts merely to such an assumption." G.A.D. Preinreich. Annual survey: the theory of depreciation. Econometrica. 6:237. 1938.

Table I

Tabulation of Opinions Regarding the Relation of Depreciation to Volume of Production and Profits

Classification	Should Depreciation Charges be Related to Volume of Production?			Should Depreciation Charges be Related to Profits?		
	Yes	No	Total	Yes	No	Total
Light machines & metal work	16	12	28	2	28	30
Heavy machines & metal work	8	8	16	0	14	14
Food products	4	9	13	0	14	14
Autos, accessories, etc.	4	3	7	1	8	9
Extractive industries	7	3	10	0	9	9
Heavy chemicals	4	4	8	1	8	9
Textiles	1	7	8	0	8	8
Printing, etc.	3	1	4	0	4	4
Light chemicals, drugs	3	1	4	0	3	3
Steels & metals	4	3	7	0	5	5
Paper, paper products, etc.	3	1	4	0	4	4
Sugar	0	1	1	0	1	1
Shoes & clothing	1	0	1	0	1	1
Tobacco	0	1	1	0	1	1
Glass	0	2	2	0	2	2
Miscellaneous	8	5	13	0	12	12
	66	61	127	4	122	126

Table reproduced from Wyman P. Fiske, The Controller, January 1938; reprinted in Rautenstrauch, op. cit., p. 164.

answered "no" to the question "Should depreciation charges be related to profits?" It is difficult to believe that a peremptory division of time makes a cost determinate or indeterminate and that the allocation of cost-depreciation in preference to other costs should be awarded the responsibility of determining profit. Paton summarized his position as follows:

> In this connection the unreasonableness of focusing attention peculiarly upon depreciation in interpreting an unfavorable operating result should be noted. If revenues are less than expenses this does not mean that some charges are earned in full and others are earned in part or not at all; each dollar recovered should be viewed as representing proportionate recoupment of all applicable charges.[1]

It is conceivable that the means of determining the proper cost-depreciation is unknown but being unknown does not necessarily mean that it is multi-valued. Another comment by Paton concerning a similar accounting problem was:

> It is a common error of human thinking to assume that essential principles are inoperative whenever conditions are sufficiently involved to obscure their operation.[2]

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[1]W.A. Paton, op. cit., p. 275.

[2]W.A. Paton, op. cit., p. 306.

Cost-depreciation is generally considered to be an allocation of investments which have already been made. In this respect it has been said that the effects of any depreciation policy is solely an effect on the book entries. However, these book entries are a part of the information upon which management bases its policies and investors form their opinions. If the problems of depreciation were only of historical significance, there would be less reason to discuss them. The policies and opinions which are based on depreciation allocations affect consumers, investors, and taxpayers directly and forcibly.

Classification of Allocations

The methods of allocation of the cost of properties may be classified according to the property which they encompass, i.e., a single property unit, group properties, or a composite group. The earlier discussions of depreciation generally considered the single unit of property. More recently the group and composite group methods of analysis have become equally important. In a recent survey[1] 49 per cent of the companies surveyed

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[1]MAPI Survey of Replacement and Depreciation Policies, op. cit., p. 6.

had most of their equipment in unit depreciation accounts and 51 per cent used group or composite group accounts.

Group accounts and composite accounts are alike in that in each the account contains many single units. They are unlike in that group property accounts contain similar units of property whereas composite accounts contain heterogeneous units of property, perhaps all of the properties owned by a firm. The group account is capable of yielding more accurate results than either single or composite group methods because the prediction of probable life is less likely to be in error for a group than for a single unit and the composite method introduces an additional problem of the statistical weighting of the various types of property in the composite group.

The methods of allocation also may be classified according to the process of distributing the cost over the service life, i.e., the straight-line method, the interest methods, the declining balance methods, and the unit of production method. These methods of distribution may be applied to any of the classifications which were made on the basis of the property encompassed. The use of the various methods of distributing the cost is shown in Table II. The survey was concerned with unregulated business and does not mention interest methods

Table II

Classification of Methods of Apportioning Depreciation Drawn from Cases Studied[1]

Classification	1	2	3	4	5	6	7	8	9[2]	Total
Light machinery & metal work	33	-	3	-	1	2	2	-	1	42
Heavy machinery & metal work	18	2	-	2	1	1	-	-	-	24
Food products	19	-	-	-	-	-	-	-	-	19
Autos, accessories, etc.	16	-	-	-	1	-	1	-	-	18
Extractive industries	12	-	-	6	-	-	-	-	-	18
Heavy chemicals	9	-	-	-	2	-	-	-	-	12
Textiles	9	-	-	1	-	-	1	1	-	11
Printing, etc.	10	-	-	-	-	-	-	-	-	10
Light cehmicals & drugs	9	-	-	-	-	-	-	-	-	9
Steels & metals	6	-	1	-	2	-	-	-	-	9
Paper, paper products,etc.	7	2	-	-	-	-	-	-	-	9
Sugar	5	-	-	-	-	-	-	-	-	5
Shoes & clothing	2	-	-	-	-	-	-	-	-	2
Tobacco	2	-	-	-	-	-	-	-	-	2
Glass	2	-	-	-	-	-	-	-	-	2
Miscellaneous	19	1	-	-	-	1	2	-	-	23
Total	178	5	4	9	7	4	6	1	1	215

[1]Rautenstrauch, op. cit., p. 164.

[2]Titles of column headings, 1 to 9.

1. "Straight-line Time." In this classification were included all companies apportioning the net cost of the assets in terms of time, with equal charges in every equal time period, regardless of conditions.

(Footnote 2 continued)

2. "Diminishing Balance." The companies in this group took as their annual depreciation charge a constant percentage of the net depreciated value of fixed assets. The method assumed some salvage value, as it could never completely amortize the cost of any asset. It also resulted in higher depreciation in the earlier years of use.

3. "Straight-Line Time with Arbitrary Rate Changes." This classification was basically straight-line time, but with some arbitrary variations, such as: (a) reduction of rate in depression years; (b) arbitrarily higher rates for the first 3 or 4 years.

4. "Unit of Production." Under this method a unit depreciation charge was set up for each unit of production--as ton of iron, barrel of oil, case of canned goods, machine hour, and the like. The annual depreciation charge was computed by multiplying the unit charge by the number of units produced during the year.

5. "Per Cent of Normal Factor." The straight-line basis was followed to determine a charge for a year of "normal production," which was set in terms of production units of capacity. In any year the actual depreciation charge was that percentage of the "normal" charge which actual production bears to "normal" production.

6. "Flat Charge." The officers set up an entirely arbitrary charge, frequently based on what earnings could stand.

7. "Remaining Useful Life Based on Periodic Appraisals." Companies in this classification made periodic appraisals of their assets and redetermined depreciation charges on the basis of such appraisals. This was the method suggested in T.D. 4422.

8. "Constant Wear and Tear with Fluctuating Obsolescence." Wear and tear was covered on a straight-line basis. Reservations were made for obsolescence on a fluctuating, arbitrary basis.

9. "Obsolescence Constant, Wear and Tear a Per Cent of Normal." Depreciation was first computed on a straight-line basis. The annual charge was then divided to cover obsolescence and wear and tear. The obsolescence portion was taken regardless of conditions. The wear and tear part was allowed to fluctuate as under (5) "Per Cent of Normal Factor."

because their stronghold is in the public utility field. Since the application of these distributive processes to the single unit provides the simplest illustrations it will be examined first. Before an adequate comprehension of the results of these methods can be obtained, the effect of any errors of estimated life and salvage "value" and the consequent adjustments should be considered.

It should be remembered that nearly all allocations are based on predictions. Thus, considerable error in the probable life at age zero can be expected when single unit accounts are used. The physical property studies of Winfrey[1] indicate the minimum and maximum actual life of units in a large majority of the 18 types of properties classified according to their mortality characteristics are at least plus or minus 50 per cent of the average life of similar properties. Thus, actual data indicate that the life of a single unit of property may be either much longer or shorter than the average life of similar properties. The best forecast of the probable life of a single unit is the average life expectancy of similar units of the same age modified by any changes which are foreseen. Therefore, for any single unit the forecast

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[1]Robley Winfrey, Bulletin 125, op. cit., p. 142-149.

of probable life may be in considerable error unless revisions of the original forecast are made at reasonable intervals. These revisions necessitate adjustments of the cost-depreciation allocation. Common practice a decade ago (Table II) was to disregard revisions.

Adjustment of Allocations

Adjustments of cost-depreciation allocation may be made in one of the following three ways.[1] First, the periodic allotment is changed to correspond to that which would have been made and the surplus (deficit) is adjusted to compensate for the cumulative error. Second, the same adjustment of the periodic allotment is made as in the first case but the cumulative error is adjusted by a compensating change in the single periodic allotment at the time the prediction is changed. Third, the periodic allotment is adjusted so that the remaining undepreciated cost is spread over the remaining years of life (the expectancy)of the property. No adjustment of the other accounts is necessary in the second and third methods.

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[1] Adjustment of accounts necessitated by retirement of property before it is fully depreciated generally affects only the accounts of the year of retirement. Further discussion of such adjustments may be found in Fundamentals of Accounting by Perry Mason. Chicago, Foundation Press. 1942.

Each of these methods of adjustment has been suggested by recognized authorities. The first method (hereinafter called the surplus method) is suggested by Mason and Paton[1] as technically correct. The second method (hereinafter called the single period method) is suggested by Marston and Agg.[2] The third method (hereinafter called the spreading method) is suggested by the Bureau of Internal Revenue.[3]

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[1] W.A. Paton, op. cit., p. 342, and Perry Mason, Fundamentals of accounting, op. cit., p. 287.

[2] Marston and Agg. Engineering valuation. New York, McGraw-Hill Co. 1936. p. 83.

[3] Bulletin "F" (1942), op. cit., p. 9.

CHAPTER XVI

METHODS OF ALLOCATION - SINGLE PROPERTY UNIT

Straight-line Method

The straight-line method when applied to a single property unit allocates equal amounts of the depreciable cost to equal periods of time throughout its service life only in the most restricted case, i.e., when the life of the property and salvage "value" are predicted accurately at age zero. This is evident from the formulas for the periodic allotment and for the unallocated cost. When D_y represents the periodic allotment, C, the cost of the property, S, the salvage "value" and n, the probable life, the equation of the annual allotment is

$$D_y = \frac{C - S}{n} .$$

When U represents the unallocated cost and x, the age of the property, the equation of the unallocated cost at age x is

$$U = C - x\left(\frac{C - S}{n}\right) .$$

These equations will represent a straight line from the time of purchase to the retirement of the property only when S and n are constant, figure 1.

In the series of charts, figures 1 to 16, the annual cost-depreciation allotments are presented in a column chart in order to emphasize the periodicity of the bookkeeping entries. The unallocated cost is presented as a line chart in preference to a column chart in order to portray the results more in harmony with the concept of cost-depreciation as a continuous consumption of services. When the forecast of the probable life is revised from time to time the result is a series of straight lines of different slopes.

In order to illustrate the effect of the aforementioned adjustments on each of the distributive processes, two assumed modifications of the forecasts are applied to these processes. The first modification assumes that the probable life is forecasted to be 12 years when the property is new, $n_o = 12$, 10 years when the property is three years old, $n_3 = 10$, and 9 years when the property is seven years old, $n_7 = 9$. The second modification assumes the probable life is forecasted to be as follows: $n_o = 9$, $n_3 = 10$, $n_7 = 12$. The first modification illustrates the cases in which the successive forecasts of

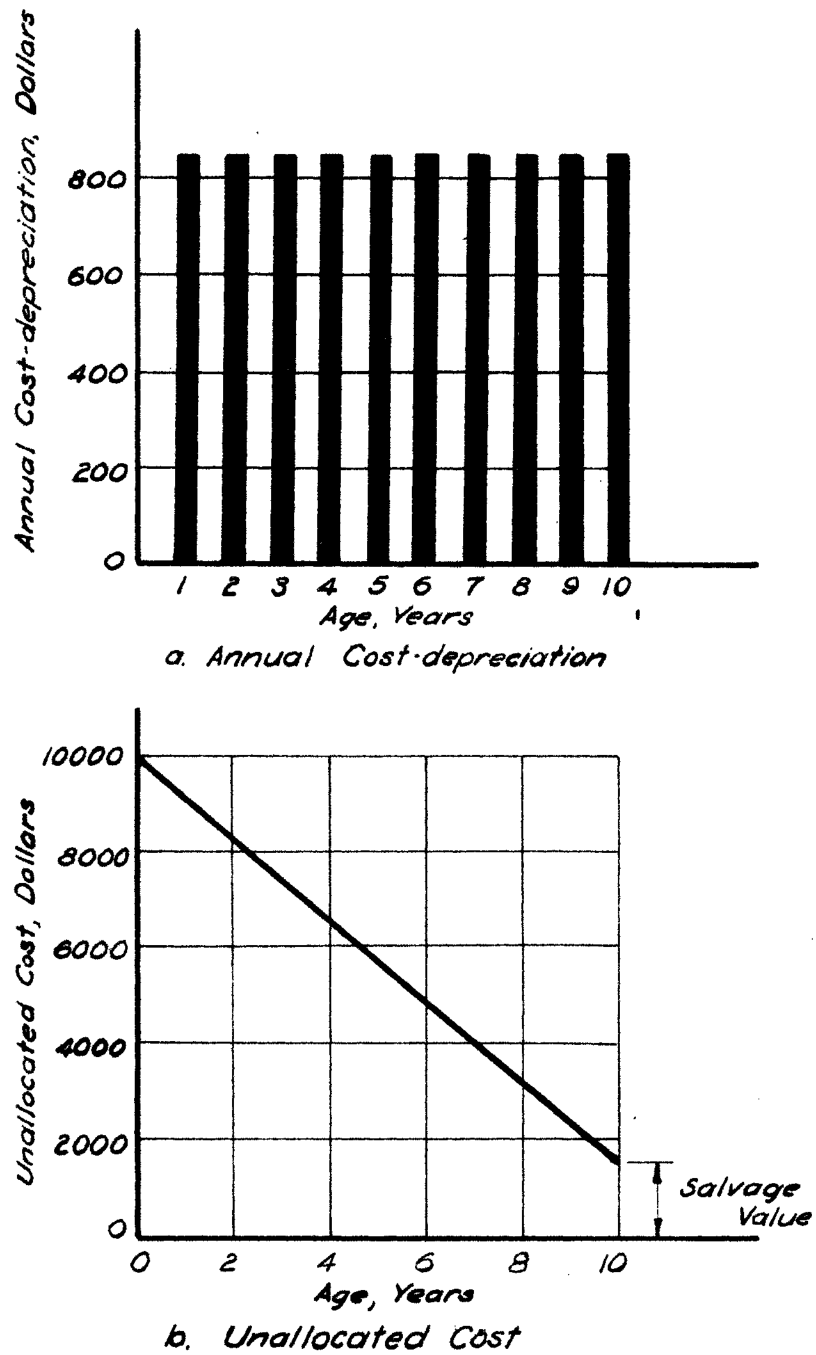

Fig. 1. Annual cost-depreciation and unallocated cost, straight line method, probable life constant. Case A: cost, $10,000; salvage value, $1500; n_o, 10 yr.

probable life indicate a decreased probable life. The second modification illustrates the cases wherein the successive forecasts of the probable life indicate an increased probable life. The cost of the property is assumed to be $10,000 and the salvage "value" $1500. Although the forecasted salvage "value" will vary in the actual application, it is assumed constant and the effect of the assumption discussed.

<u>Adjustment to surplus</u>

When the straight-line method is adjusted by debiting or crediting surplus and accrued cost-depreciation, the following equations may be developed for the annual allotment, unallocated cost, and the adjustment.

Symbols

x = the age of the property

$\bar{x}_k$ = the age of the property at the time the kth forecast is applied

n_k = the forecasted probable life during the period in which the kth forecast is applicable

e_k = the expectancy during the kth period, $n_k = x + e_k$

$D_{y,k}$ = annual cost-depreciation during the kth period

U_k = unrecovered cost during the kth period

Z_k = adjustment at the time of the kth period

The equation for the annual allotment during the kth period is

$$D_{y,k} = \frac{C - S}{n_k}$$

The equation for the undepreciated cost during the kth period is

$$U_k = C - \frac{x(C - S)}{n_k}$$

The equation of the adjustment of the surplus and accrued cost-depreciation at the time of the kth forecast is

$$Z_k = \bar{x}_k \frac{(C - S_k)}{n_k} - \bar{x}_k \frac{(C - S_{k-1})}{n_{k-1}}$$

and since the salvage "value" is constant

$$Z_k = \bar{x}_k (C - S) \left[\frac{1}{n_k} - \frac{1}{n_{k-1}}\right]$$

The adjustment will be a credit to the surplus account, when Z is positive. Table III and figures 2 and 3 illustrate the application of the above equations to the assumed conditions.

When the first revision of the probable life forecast is made, the book entries for the adjustment of the accrued cost-depreciation in Case A-1 are:

	Dr.	Cr.
Surplus	425.00	
Accrued Cost-depreciation. (Reserve Account)		425.00

To correct accrued
cost-depreciation to
correspond with the
revised estimate of
probable life,
Jan. 15, 1940.

The corresponding entries for Case A-II are:

Surplus		283.33
Accrued Cost-depreciation. (Reserve Account)	283.33	

To correct accrued
cost-depreciation to
correspond with the
revised estimate of
probable life,
Jan. 15, 1940.

Adjustment by varying single periodic allotment

When the adjustment of the cost-depreciation is achieved by varying the allotment to a single period, a large deviation from the adjacent allotments is generally the result. The impact of such an adjustment may be sufficient to cause a negative depreciation book entry for that period. In order to avoid this negative depreciation entry Marston and Agg have suggested that zero depreciation be entered until the cumulation of allotments will offset the adjustment.

The "single period" method of adjustment accomplishes the same results as the "surplus" method of adjustment except that the periods when the adjustment is made by the "single period" method will experience an excessive fluctuation of reported costs and net income.[1] The adjusted annual allotment in this "single period" method is equal to the "surplus" method annual allotment for the year following the application of the revised forecast plus or minus the surplus adjustment. Thus the equations for the two methods are the same with the above modification. The similarity of these methods can easily be seen by comparing the two illustrative examples as shown in Table III and IV and figures 2 to 5. Since these two methods are similar, the subsequent illustrations applied to the single unit of property will not consider the "single period" adjustment.

Adjustment by spreading undepreciated cost

The adjustment of the cost-depreciation by spreading over the remaining service life that portion of the depreciable cost which has not been charged bases future calculations on the unrecovered cost which includes

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[1] If this method of adjustment is used, adequate supplementary notes concerning the calculation of the cost-depreciation for the periods affected should be included so that anyone using theme figures can properly interpret them.

Table III

Annual Cost-Depreciation and Unallocated Cost, Forecasts of Probable Life Revised at Ages 3 and 7, "Surplus Adjustment"

	Case B-I $n_o = 12$, $n_3 = 10$, $n_7 = 9$		Case B-II $n_o = 9$, $n_3 = 10$, $n_7 = 12$	
Age	Annual cost-depreciation, $	Unallocated Cost, $	Annual cost-depreciation, $	Unallocated Cost, $
0		10000.00		10000.00
	708.33		944.44	
1		9291.67		9055.56
	708.33		944.45	
2		8583.34		8111.11
	708.34		944.44	
3		7875.00		7166.67
	850.00	#Z_2	850.00	#Z_2
4		6600.00		6600.00
	850.00		850.00	
5		5750.00		5750.00
	850.00		850.00	
6		4900.00		4900.00
	850.00		850.00	
7		4050.00		4050.00
	944.44	#Z_3	708.33	#Z_3
8		2444.45		4333.33
	944.45		708.33	
9		1500.00		3625.00
			708.34	
10	#adjustment			2916.66
	$Z_2 = 425.00$		708.33	
11	$Z_3 = 661.11$			2208.33
			708.33	
12				1500.00
Total	7413.89	Total	9874.99	

#adjustment (Case B-II):
$Z_2 = -233.33$
$Z_3 = -991.66$

Sample application of formulas Case BI, Age 1

$$D_{y,1} = \frac{10000-1500}{12} = 708.33$$

$$Z_2 = 3\left(\frac{8500}{10}\right) - 3\left(\frac{8500}{12}\right) = 425.00$$

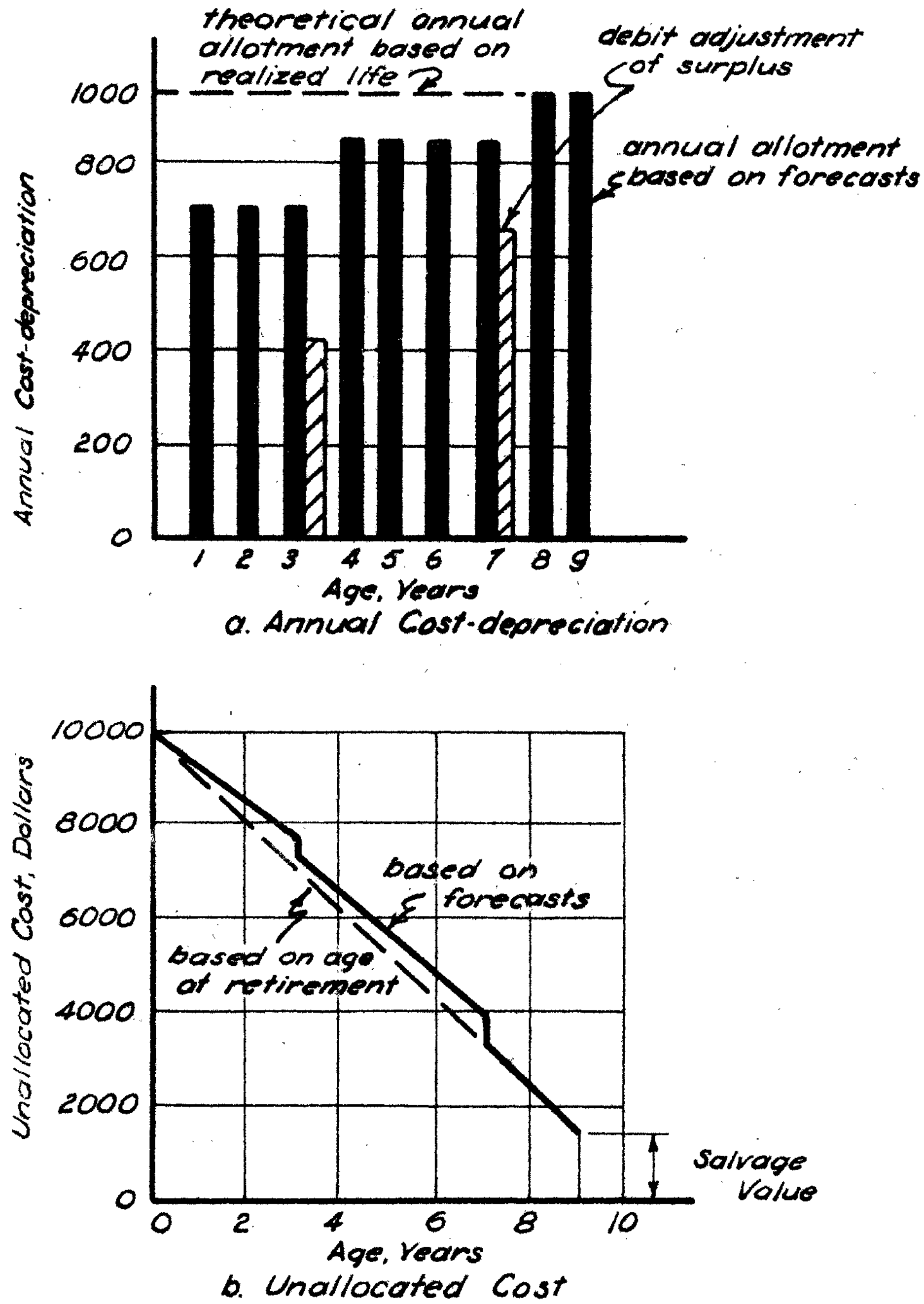


Fig. 2. Annual cost-depreciation and unallocated cost, straight line method, downward revision of probable life adjusted to surplus. Case B-I: Cost, \$10,000; salvage value, \$1500; n_0=12yr, n_3=10yr, n_7=9yr.

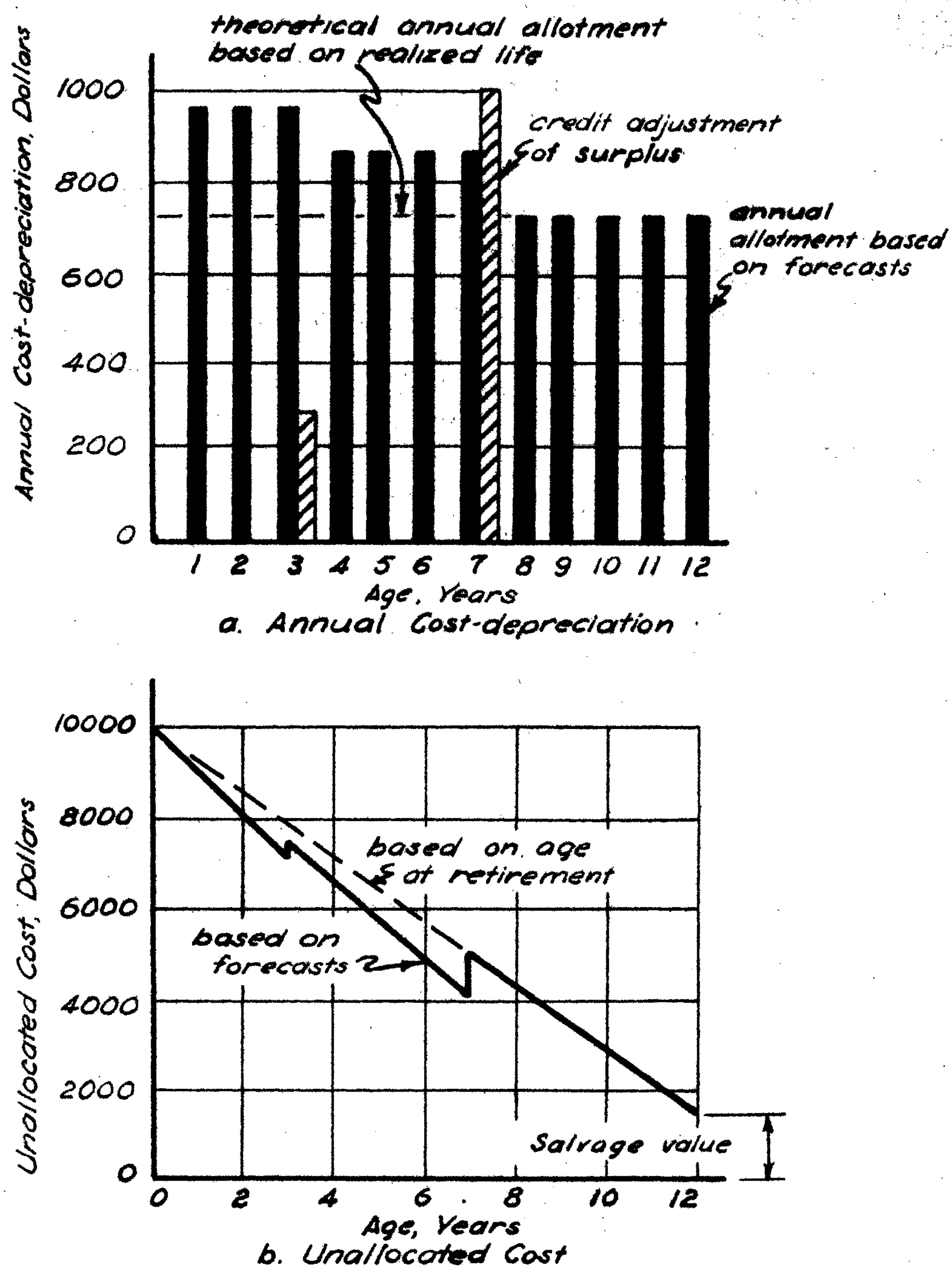


Fig. 3. Annual cost-depreciation and unallocated cost, straight line method, upward revision of probable life adjusted to surplus. Case B-II: Cost, \$10,000; salvage value, \$1,500; n_0, 9; n_3, 10; n_7, 12 yr.

Table IV

Annual Cost-Depreciation and Unallocated Cost, Straight-Line Method, Probable Life Revised at Ages 3 and 7, Adjustment Made by Change in Single Period Allotment

	Case C-I $n_o = 12$, $n_3 = 10$, $n_7 = 9$		Case C-II $n_o = 9$, $n_3 = 10$, $n_7 = 12$	
Age	Annual cost-depreciation, $	Unallocated Cost, $	Annual cost-depreciation, $	Unallocated Cost, $
0		10000.00		10000.00
	708.33		944.44	
1		9291.67		9055.56
	708.33		944.45	
2		8583.34		8111.11
	708.34		944.44	
3		7875.00		7166.67
	1275.00		566.67	
4		6600.00		6600.00
	850.00		850.00	
5		5750.00		5750.00
	850.00		850.00	
6		4900.00		4900.00
	850.00		850.00	
7		4050.00		4050.00
	1605.55		(-183.33)#	
8		2444.45		4333.33
	944.45		708.33#	
9		1500.00		3625.00
			708.33	
10				2916.66
			708.33	
11				2208.33
			708.33	
12				1500.00

Sample calculation:
Case C-I, age 4

$$D_{y,1} = 8500 \left[\frac{4}{10} - \frac{3}{12}\right] = 1275.$$

#If this is entered as zero the ninth year allotment would be $525.00.

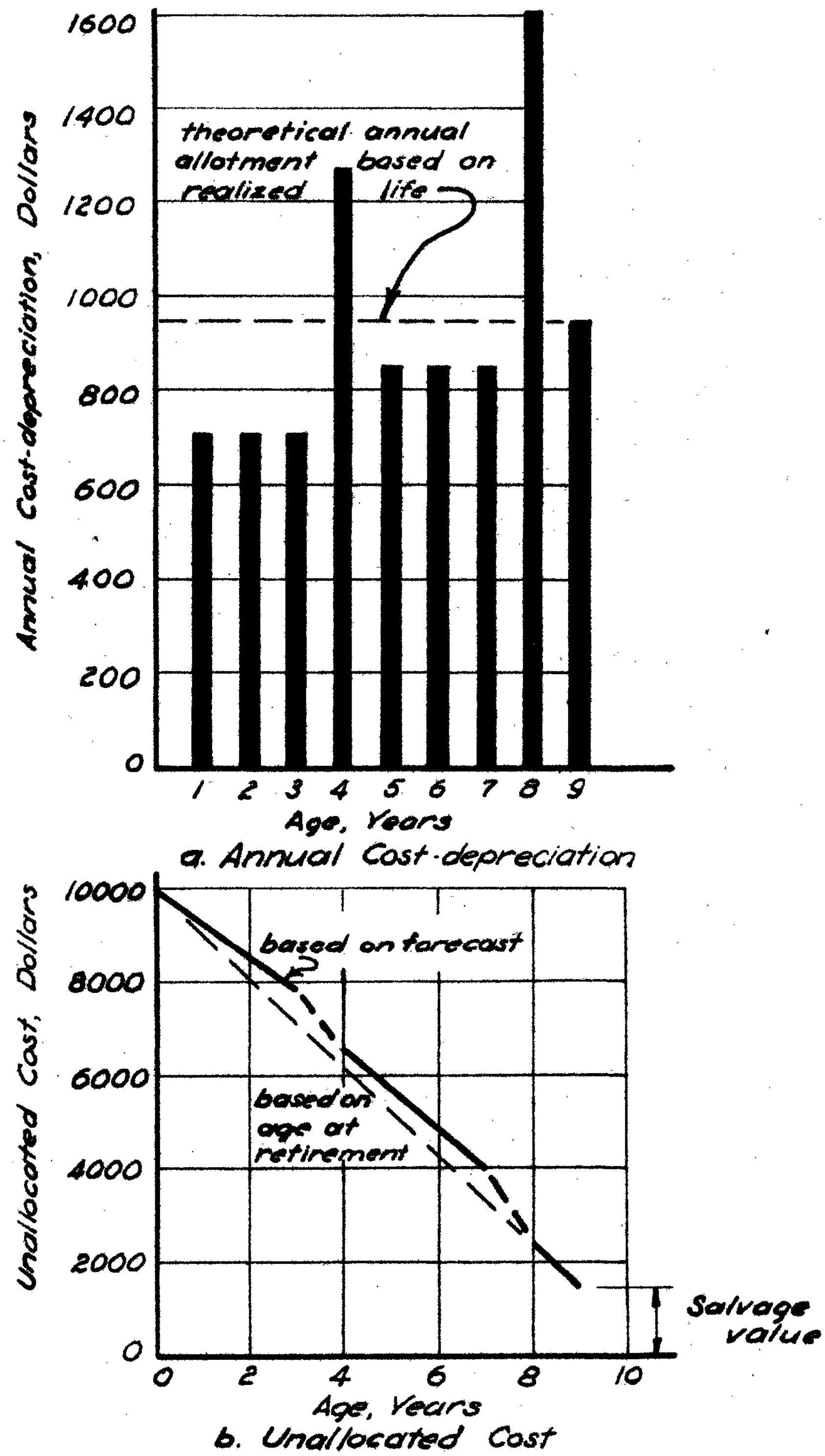


Fig. 4. Annual cost-depreciation and unallocated cost, straight line method, downward revision of probable life adjusted in single period. Case C-I: cost, $10000; salvage value, $1500; $n_o = 12$, $n_s = 10$, $n_r = 9$ yr.

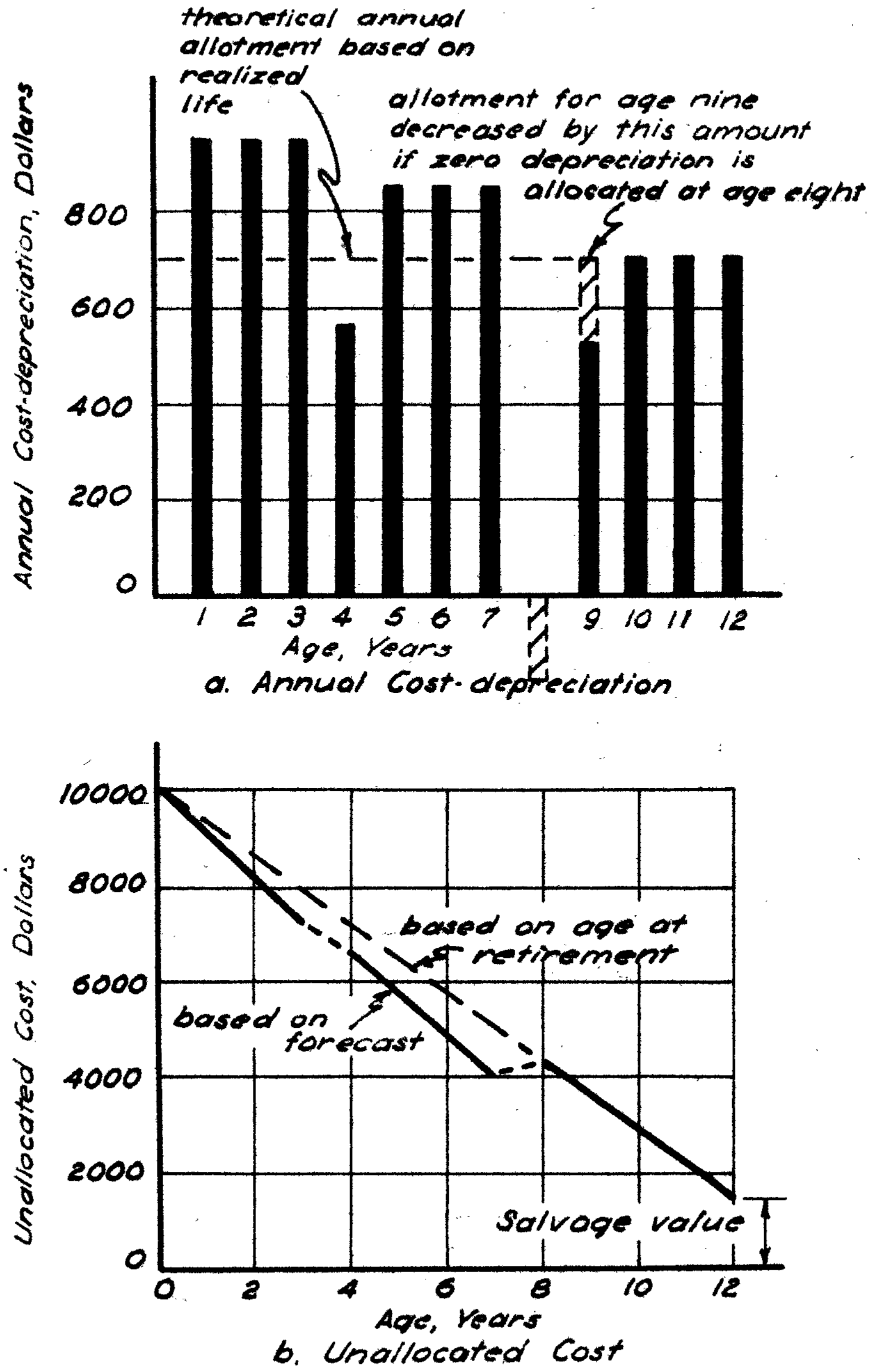


Fig. 5. Annual cost-depreciation and unallocated cost, straight line method, upward revision of probable life adjusted in single period. Case C-II: cost, $10,000; salvage value, $1500; n_o=9, n_3=10, n_r=12 yr.

the cumulative errors of the past forecasts. The equations representing this adjustment are more complex than those of the previous methods. For the period when the second revision of forecasts applies and if the estimates of salvage "value" are constant, the equations for the annual cost-depreciation and unallocated cost are:

$$D_{y,2} = \left[\frac{C - S}{e_2}\right]\left[1 - \frac{\bar{x}_1}{e_o} - \frac{(\bar{x}_2 - \bar{x}_1)(e_o - \bar{x}_1)}{e_o e_1}\right],$$

and

$$U_2 = C - (C - S)\left\{\frac{\bar{x}_1}{e_o} - \frac{(\bar{x}_2 - x_1)(e_o - \bar{x}_1)}{e_o e_1} - \left[\frac{x - \bar{x}_2}{e_2}\right]\left[\frac{e_o - \bar{x}_1}{e_o} - \frac{(\bar{x}_2 - \bar{x}_1)(e_o - \bar{x}_1)}{e_o e_1}\right]\right\}.$$

Note:
$n = x+e$
$n_o = e_o$

If the depreciation rate for the kth period is R_k, i.e., $R_2 = \frac{1}{e_2}\left[\frac{e_o - \bar{x}_1}{e_o} - \frac{(\bar{x}_2 - \bar{x}_1)(e_o - \bar{x}_1)}{e_o e_1}\right]$, the equation for the annual allotment and the unallocated cost during the kth period when the estimate of salvage has been constand can be reduced to

$$D_{y,k} = \frac{C - S}{e_k}\left[1 - \bar{x}_1 R_o - (\bar{x}_2 - \bar{x}_1)R_1 - (\bar{x}_3 - \bar{x}_2)R_2 - \dots - (\bar{x}_k - \bar{x}_{k-1})R_{k-1}\right], \text{ and}$$

$$U_k = C - [C - S]\left[\bar{x}_1 R_o - (\bar{x}_2 - \bar{x}_1)R_1 - (\bar{x}_3 - \bar{x}_2)R_2 - \dots - (x - \bar{x}_k)R_k\right].$$

The equations indicate that in this method all previous forecasts and ages at which the forecasts were made must be known before either the annual allotment or unallocated cost can be calculated. Actually the calculation requires only the last entry in the books and the salvage "value" to be known since the term in square brackets in the equation for $D_{y,k}$ is the summation of all previous annual deductions as recorded in the books. The equations emphasize the dependence of the future allotment and the unallocated cost on the past forecasts. Table V and figures 11 to 14 illustrate the application of this adjustment.

Summary, straight-line method

A comparison of the three methods of adjusting the straight-line distribution of the depreciable cost of a single item shows that the method of adjustment materially affects the pattern of distribution. If the adoption of the straight-line method is based on the desire to distribute the depreciable cost in equal periodic allotments over the service life of the property, the first method utilizing the surplus account will always provide the best approximation to this distribution. In addition, the "surplus" method of adjustment bases

Table V

Annual Cost-Depreciation and Unallocated Cost, Straight-Line Method, Probable Life Revised at Ages 3 and 7, Adjustment Made by Spreading Undepreciated Cost Over Remaining Life

	Case D-I $n_o = 12$, $n_3 = 10$, $n_7 = 9$		Case D-II $n_o = 9$, $n_3 = 10$, $n_7 = 12$	
Age	Annual cost-depreciation, $	Unallocated Cost, $	Annual cost-depreciation, $	Unallocated Cost, $
0		10000.00		10000.00
	708.33		944.44	
1		9291.67		9055.56
	708.33		944.45	
2		8583.34		8111.11
	708.34		944.44	
3		7875.00		7166.67
	910.71		809.52	
4		6964.29		6357.15
	910.71		809.53	
5		6053.58		5547.62
	910.72		809.52	
6		5142.86		4738.10
	910.71		809.53	
7		4232.15		3928.57
	1366.07		485.71	
8		2866.08		3442.86
	1366.08		485.72	
9		1500.00		2957.14
			485.71	
10				2471.43
			485.72	
11				1985.71
			485.71	
12				1500.00

Example of the application of the formula for the calculation of the annual depreciation in Case C-I at age 8:

$$D_{y,2} = \frac{(10000-1500)}{2}\left[1 - \frac{(3)}{12} - \frac{(7-3)(12-3)}{(12)(7)}\right] = 1366.07$$

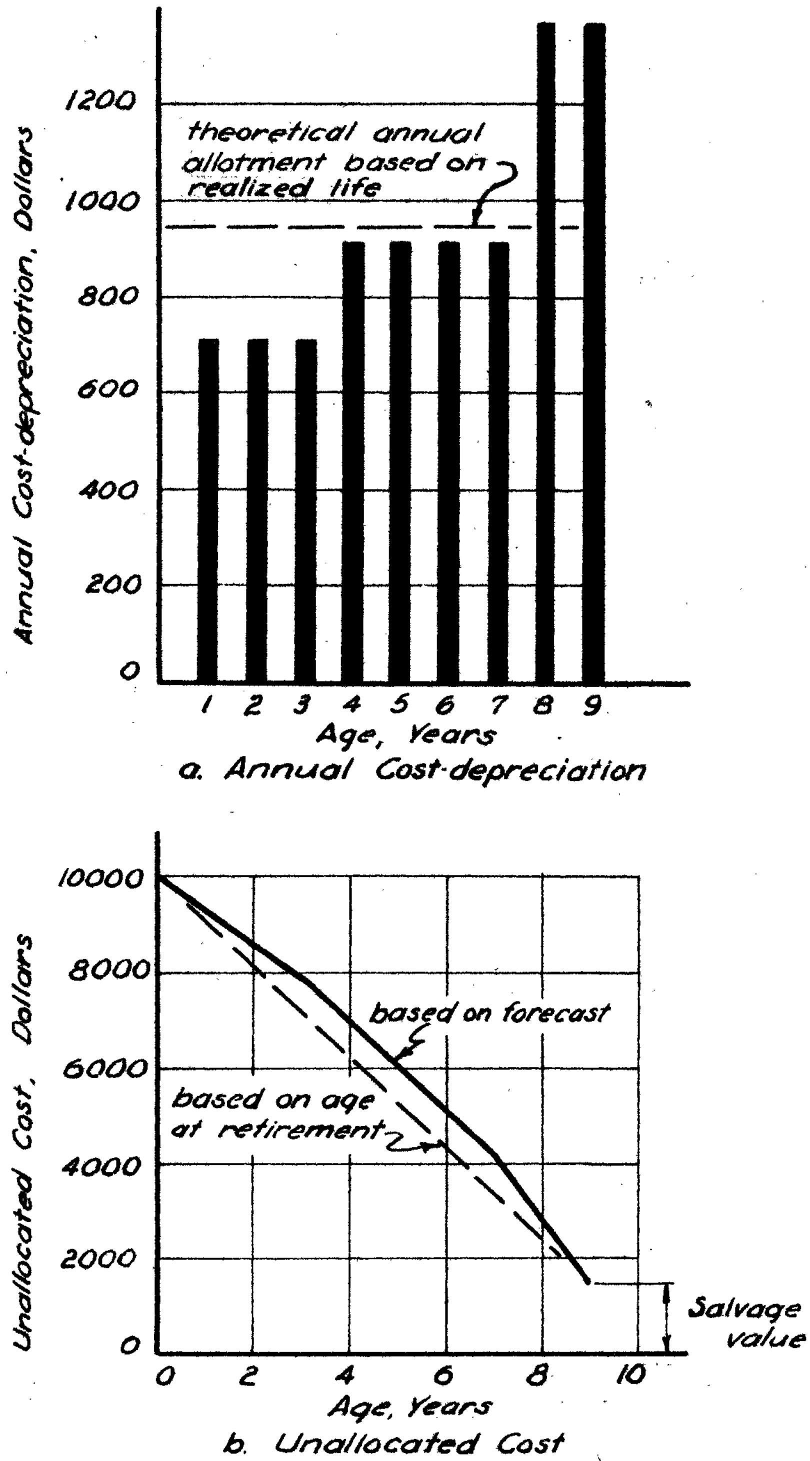
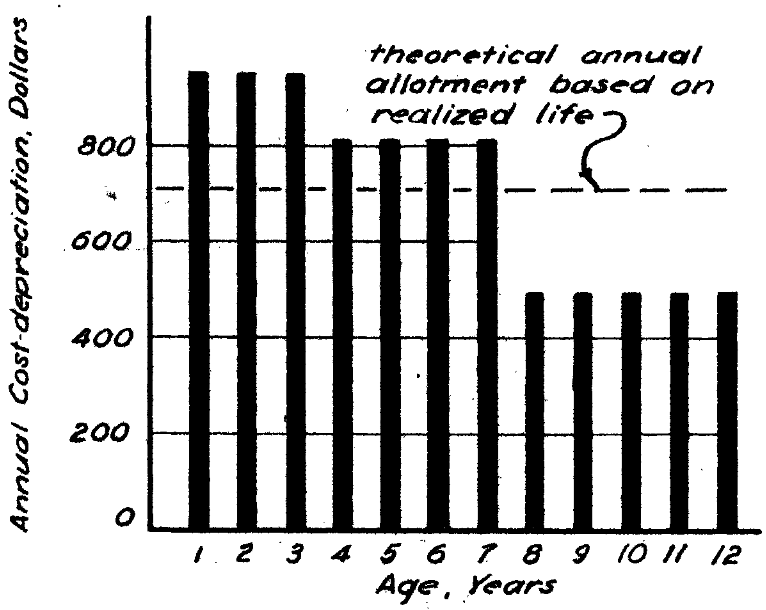
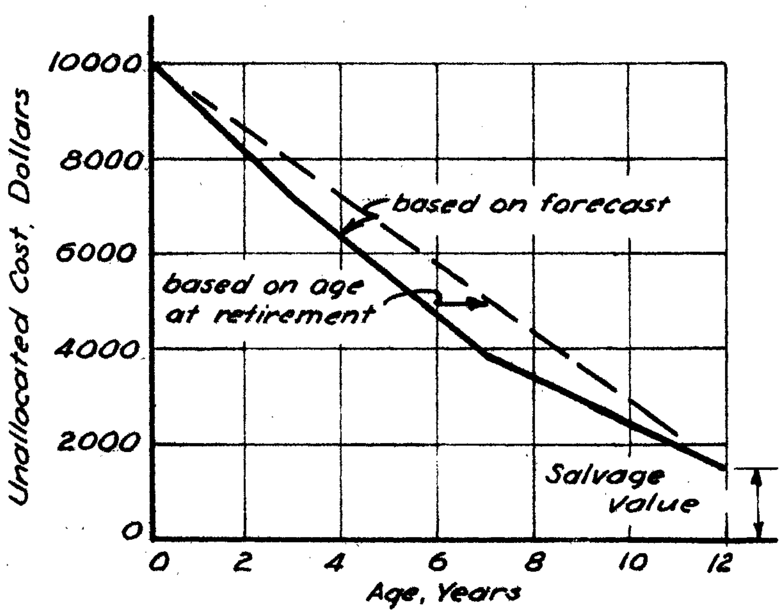


Fig. 6. Annual cost-depreciation and unallocated cost, straight line method, downward revision of probable life adjusted by spreading. Case D-I: cost, \$10,000; salvage value, \$1500; $n_0 = 12$, $n_3 = 10$, $n_1 = 9$ yr.



a. Annual Cost-depreciation



b. Unallocated Cost

Fig. 7. Annual cost-depreciation and unallocated cost, straight line method, upward revision of probable life adjusted by spreading. Case D-II: cost, $10,000; salvage value, $1500; $n_1 = 9$ yr., $n_3 = 10$ yr., $n_7 = 12$ yr.

cost-depreciation allocations on forecasts of the future not on prior forecasts which have been discarded as the "spreading" method of adjustment does.

The spreading method has two advantages -- first, it is simpler than either of the other methods, in spite of the equations. Second, the total of the annual allotments at retirement will equal the cost except when extraordinary circumstances cause sudden retirement. The second advantage is shared by the "single-period" method but not by the "surplus" method. However, the differences between the objective of equal periodic allotments of the straight-line method and results occasioned by the "spreading" adjustment are great enough to warrant recommending the "surplus" adjustment. The adoption of the "surplus" method by the Bureau of Internal Revenue would necessitate the acceptance of an amortization of the "surplus" adjustment over a reasonable time in order to counteract the effect of the large fluctuations in reported net income on the income tax of the periods in which the revisions are made.

The comparison in Table VI of the numerical examples reveals how these adjustments affect the straight-line distribution in two specific cases. Table VI presents the percentage deviations of the book entries from

Table VI

A Comparison of the Deviation of the Allotments Based on the Straight-Line Method Using Assumed Forecasted Probable Lives and the Allotment Which Would Have Been Made Had the Age of Retirement Been Known at Age Zero

Case	Average of the difference between forecasted allotment and straight-line allotment based on age at retirement, %[1]	Minimum and maximum difference between forecasted allotment and the straight-line allotment based on age at retirement, %[1]
B-I, "surplus"	13	0 & 25
C-I, "single period"	15	0 & 35
D-I, "spreading"	20	3.6 & 45
B-II, "surplus"	16	0 & 33
C-II, "single period"	25	0 & 100[2]
D-II, "spreading"	26	4.7 & 33

[1] Each of the percentage values for the three adjustments can be calculated from Tables II, IV, and V.

[2] Based on zero depreciation instead of negative depreciation.

the straight-line distribution which would have been made had the realized age of retirement been known at age zero. The percentages in Table VI are not intended to indicate the magnitude of the discrepancies which can be expected from these adjustments. The magnitude of the discrepancies also is dependent upon the length of life of the property and the time interval between revisions. Nevertheless, the trend in the discrepancies will be the same.

In general when the forecasts of probable lives are too long and the forecasts are revised downward, the annual cost-depreciation will be too low initially and will increase as the retirement age approaches. This tendency for the annual allotment to increase will be augmented by the use of the third method. If the forecast of probable life is too short the converse will follow.

The revision of the estimate of the salvage "value" will affect each method similar to the revision of the probable life. The intensity of the effect of a revision will depend upon what proportion the salvage "value" is of the cost. In the equations which were developed assuming the salvage "value" constant, the quantity (C-S) could not be factored out if the salvage "value" varied, but would appear with the respective terms in the equations.

For example, the equations for calculating the annual cost-depreciation for the kth year using the "spreading" adjustment and revising the estimate of salvage "value" would be

$$D_{y,k} = \frac{1}{e_k}\Big[(C - S_k) - (C - S_0)\bar{x}_1 R_0 - (C - S)(\bar{x}_2 - \bar{x}_1)R_1 - \dots - (C - S_{k-1})(\bar{x}_k - \bar{x}_{k-1})R_{k-1}\Big]$$

where S_k is the forecast of the salvage "value" at the time of the kth forecast of probable life. Since the net salvage "value" for many properties is approximately zero, it has been suggested that the allocation be based on zero salvage "value" and the return from salvage when it is received be treated as income. For those cases in which the salvage "value" is an appreciable percentage of the cost of the property this suggestion will increase the apparent cost of using the property and might result in high cost estimates. Otherwise, in those cases where the salvage "value" is only a few per cent of the cost, this suggestion will eliminate one of the unknowns in the allocation process and merits consideration.

Interest Methods

The development of the interest methods of allocating depreciation has relied on the accepted investment and valuation mathematical principles. Three processes using interest whereby depreciable cost of a single unit of property is allocated are: (1) the sinking fund, (2) the present worth, and (3) the annuity. The sinking fund method is based upon the accumulation of an equal annual deposit which when compounded at a given interest rate over the service life of the property will equal the original cost of the property. The present worth method (sometimes called the compound interest method) is based upon the discounting of forecasted future operation returns. The annuity method is based upon the premise that an investment of a given sum of money may return an equal annual payment including interest on the remaining investment throughout its life. While each of these methods accomplishes a reasonable purpose by accepted mathematical procedures, none has as its purpose the allocation of cost. Thus the use of any of these methods in the allocation of cost is questionable. However, since the use of the sinking fund method is considered frequently, it will be examined in detail.

The mathematical formula which result from either the sinking fund theory or the present worth theory are identical. In the present worth formula the assumption of equal annual operation returns is adjusted by the use of the PFORR[1] factor. Thus if the PFORR is assumed to be unity and the same rate of interest used, the results will be the same. In the usual application of these two methods the sinking fund method generally utilizes a rate of interest comparable to that which is earned by conservative investments, two to four per cent, whereas the present worth method utilizes the rate of return which the business earns, generally somewhat higher than four per cent. In the following examples six per cent will be used.

The sinking fund method is based on the following equation where A represents the equal annual deposit and i the rate of interest.[2]

$$(C - S) = A \left[\frac{(1+i)^n - 1}{i} \right]$$

The annual allotment which is equal to the annual deposit <u>plus the interest accrued during the period on all past deposits</u> may be expressed as[3]

$$D_y = (C - S) \left[\frac{(1+i)^x - (1+i)^{x-1}}{(1+i)^n - 1} \right] .$$

---

[1]Probable-future-operation-return ratio. Marston and Agg, op. cit., p. 161-2.

[2]The development of this formula may be found in many textbooks on the mathematics of investment or in Bulletin 155 by Robley Winfrey, op. cit., p. 23.

[3]Ibid., p. 23.

The unallocated cost, U, may be represented by the equation

$$U = C - A\left[\frac{(1+i)^x - 1}{i}\right] .$$

When these formulas are applied to the property used in the straight-line illustrations with a service life of ten years, Table VII and figures 15 and 16 will result. If the two modifications of the forecasts of probable life which were used in the illustrations of the straight-line method are applied to the sinking fund method, the same adjustments can be made. However, only the "surplus" and "spreading" method will be examined. The salvage "value" is assumed constant unless specifically stated otherwise.

Adjustment to surplus

The "surplus" adjustment of the sinking fund method permits the present and future cost-depreciation charges to be based solely on current forecasts. The equations for the annual cost-depreciation and unallocated cost during the kth forecast period and the adjustment at the time of the kth forecast are:

$$D_{y,k} = (C - S)\left[\frac{(1+i)^x - (1+i)^{x-1}}{(1+i)^{n_k} - 1}\right] ,$$

Table VII

Unallocated Cost and Annual Cost-Depreciation Using the Sinking Fund Method with 6% Interest and 9-, 10-, and 12-Year Life
(C = \$10000, S = \$1500)

Case E

Age	Nine-year life		Ten-year life		Twelve-year life	
	Unallocated cost, \$	Annual cost-depreciation, \$	Unallocated cost, \$	Annual cost-depreciation, \$	Unallocated cost, \$	Annual cost-depreciation, \$
0	10000		10000		10000	
		739		645		504
1	9261		9355		9496	
		784		685		534
2	8477		8670		8962	
		832		725		568
3	7645		7945		8394	
		880		765		599
4	6765		7180		7795	
		930		815		635
5	5835		6365		7160	
		995		865		675
6	4840		5500		6485	
		1045		910		715
7	3795		4590		5770	
		1108		980		755
8	2687		3610		5015	
		1187		1030		805
9	1500		2500		4210	
				1080		850
10			1500		3360	
						900
11					2460	
						960
12	annual deposit = \$739		annual deposit = \$645		1500 annual deposit = \$504	

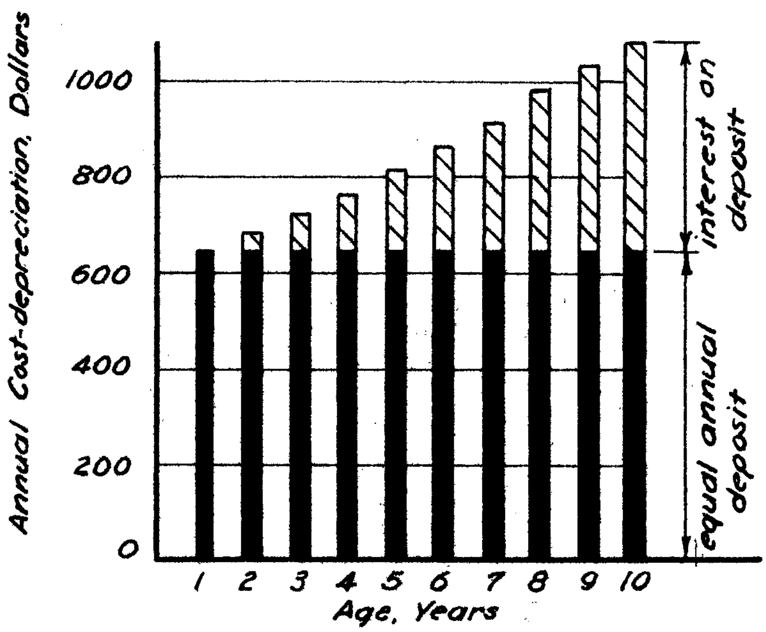
Sample calculations:

For nine-year life, age 1

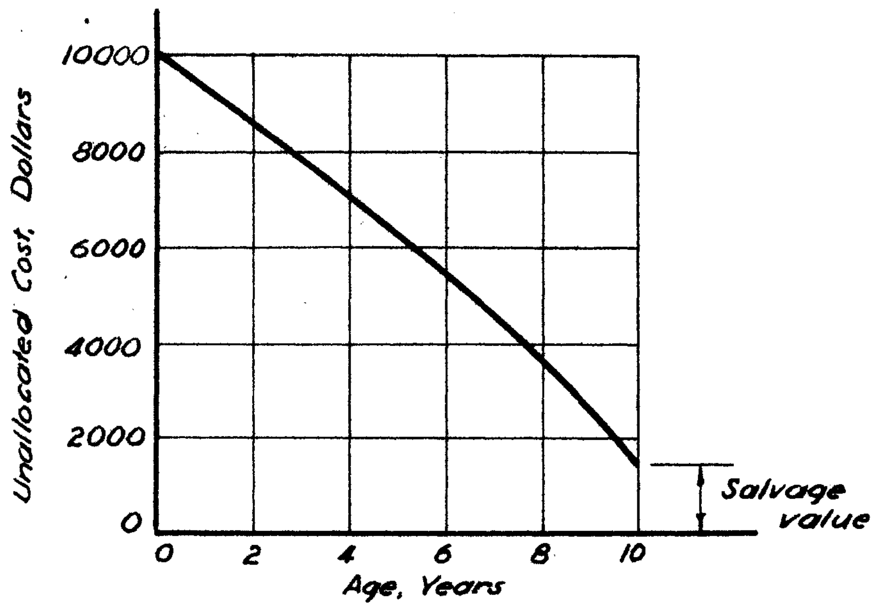
$$A = (10000 - 1500)\left[\frac{0.06}{(1.06)^9 - 1}\right] = 739$$

For twelve-year life, age 8

$$D_y = (10000 - 1500)\left[\frac{(1.06)^8 - (1.06)^7}{(1.06)^{12} - 1}\right] = 755$$



a. Annual Cost-depreciation



b. Unallocated Cost

Fig. 8. Annual cost-depreciation and unallocated cost, sinking fund method, probable life constant. Case E: $n_o = 10$ yr.; cost, \$10,000; salvage value, \$1500; interest rate, 6%.

$$U_k = C - (C - S)\left[\frac{(1+i)^x - 1}{(1+i)^{n_k} - 1}\right], \text{ and}$$

$$Z_k = (C - S)\left[(1+i)^x - 1\right]\left[\frac{1}{(1+i)^{n_k}} - \frac{1}{(1+i)^{n_{k-1}}}\right].$$

The book entries to record the adjustment will be of the same form as those shown in the straight-line method, page 151. Table VIII and figures 9 and 10 illustrate the application of these formulas.

Adjustment by spreading

The "spreading" adjustment of the sinking fund method may accentuate the increase of charges as the property ages or it may cause the charges to fluctuate severely. The equations for the annual cost-depreciation and the unallocated cost for period after the second revision of the forecast are:

$$D_{y,2} = (C - S)\left[1 - M - (1-M)(N)\right]\left[\frac{(1+i)^{x-\bar{x}_2} - (1+i)^{x-\bar{x}_2-1}}{(1+i)^{e_2} - 1}\right]$$

where $M = \dfrac{(1+i)^{\bar{x}_1} - 1}{(1+i)^{n_o} - 1}$ and

$$N = \frac{(1+i)^{\bar{x}_2-\bar{x}_1} - 1}{(1+i)^{e_1} - 1}$$

$$U_2 = C - (C - S)\Big\{\left[M + (1-M)(N)\right] + \left[1 - M - (1-M)(N)\right]\left[\frac{(1+i)^{x-\bar{x}_2} - 1}{(1+i)^{e_2} - 1}\right]\Big\}.$$

Table VIII

Annual Cost-Depreciation and Unallocated Cost, Sinking Fund Method, Probable Life Revised at Ages 3 and 7, Adjustment Made to Surplus
(C = \$10000, S = \$1500)

	Case F-I $n_0 = 12,\ n_3 = 10,\ n_7 = 9$		Case F-II $n_0 = 9,\ n_3 = 10,\ n_7 = 12$	
Age	Annual cost-depreciation, \$	Unallocated Cost, \$	Annual cost-depreciation, \$	Unallocated Cost, \$
0		10000		10000
	504		739	
1		9496		9261
	534		784	
2		8962		8477
	568		832	
3	#	8394	#	7645
	765		765	
4		7180		7180
	815		815	
5		6365		6365
	865		865	
6		5500		5500
	910		910	
7	##	4590	##	4590
	1108		755	
8		2687		5015
	1187		805	
9		1500		4210
			850	
10				3360
			900	
11				2460
			960	
12				1500

Case F-I: #debit surplus \$449; ##debit surplus \$795

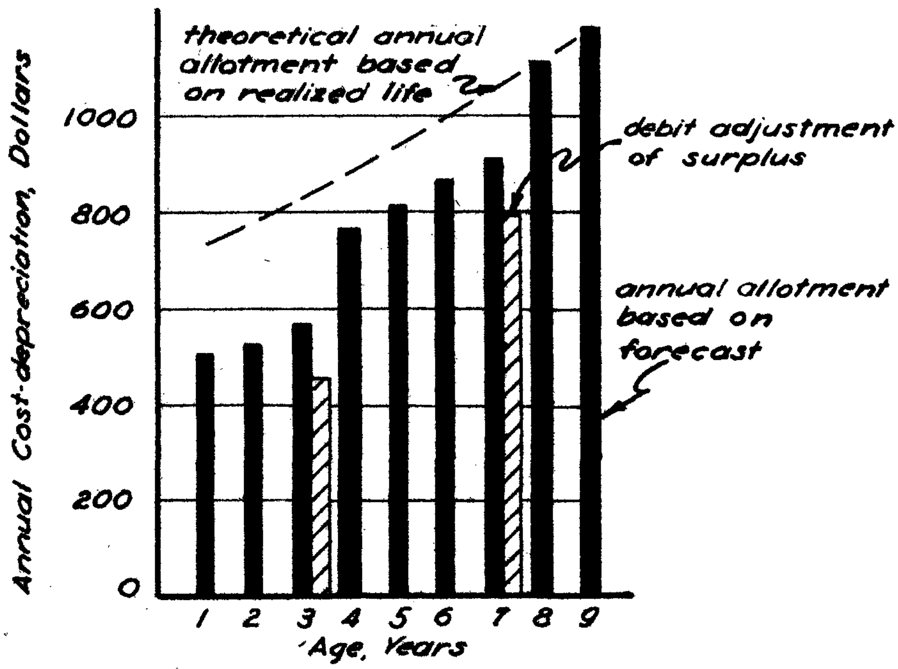
Case F-II: #credit surplus \$300; ##credit surplus \$1180

Sample calculation of annual cost-depreciation between ages 3 and 4:

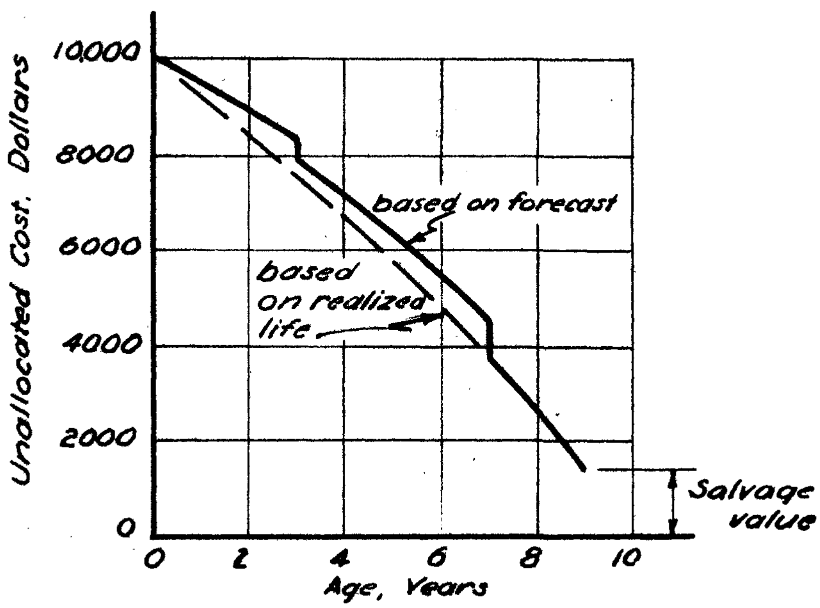
$$D_{y,2} = 10000 \left[\frac{(1.06)^7 - (1.06)^6}{(1.06)^{10} - 1}\right] = 910$$

Sample calculation of adjustment at age 7 in case F-II:

$$Z_2 = (10000-1500) \left[(1.06)^7 - 1\right]\left[\frac{1}{(1.06)^{12}-1} - \frac{1}{(1.06)^{10}-1}\right] = -1180$$



a. Annual Cost-depreciation



b. Unallocated Cost

Fig. 9. Annual cost-depreciation and unallocated cost, sinking fund method, downward revision of probable life adjusted to surplus. Case F-I: cost, \$10,000; salvage value, \$1500; interest rate 6 %; $n_0 = 12$, $n_3 = 10$, $n_7 = 9$ yr.

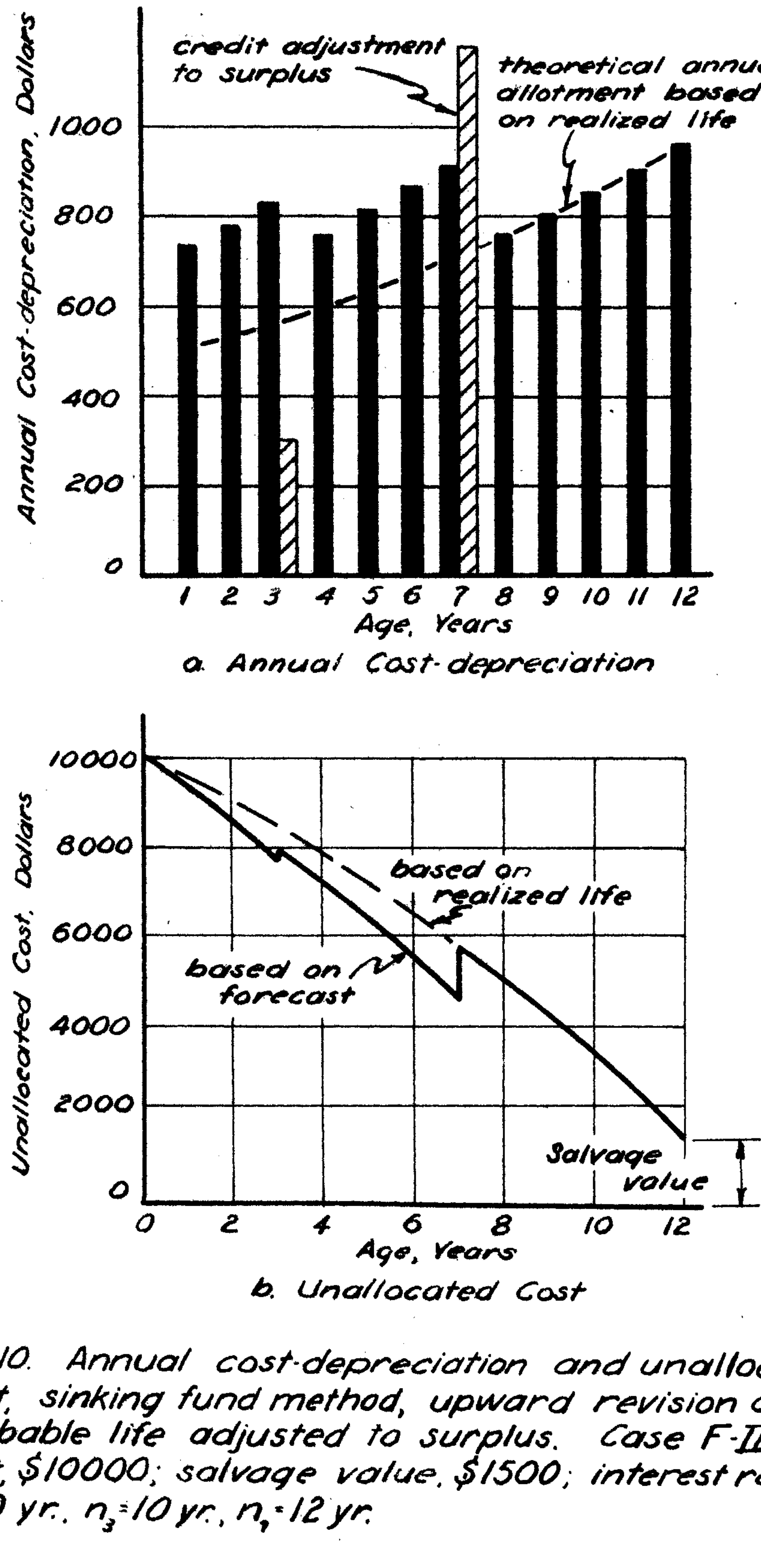


Fig. 10. Annual cost-depreciation and unallocated cost, sinking fund method, upward revision of probable life adjusted to surplus. Case F-II: cost, \$10000; salvage value, \$1500; interest rate 6%; $n_0 = 9$ yr., $n_3 = 10$ yr., $n_7 = 12$ yr.

The equations for the kth period are:

$$D_{y,k} = (\overline{U}_k - S)\left[\frac{(1+i)^{x} - (1+i)^{x-1}}{(1+i)^{e_k} - 1}\right] \quad \text{and}$$

$$U_k = \overline{U}_k - (\overline{U}_k - S)\left[\frac{(1+i)^{x-\overline{x}_k} - 1}{(1+i)^{e_{k-1}} - 1}\right] ,$$

where $\overline{U}_k$ is the undepreciated cost at the time of the kth forecast.

An examination of the latter two equations discloses that each equation is dependent upon all previous forecasts. As in the same adjustment of the straight-line method, the calculation of the kth entries are no more complicated than the initial calculation if continuing property records are kept. However, since the estimates of probable life enter these equations as exponents the effect on the annual charge of small errors in forecasting probable lives during the early life of the property is large, whereas a large error of estimate in the last few years has only a small effect on the annual charge. Thus the need for accuracy of forecasting is the greatest when forecasting is the least reliable. Table IX and figures 11 and 12 illustrate the application of this method of adjustment to the sinking fund distribution.

Table IX

Annual Cost-Depreciation and Unallocated Cost, Sinking Fund Method, Probable Life Revised at Age 3 and 7, Adjustment by Spreading Over Remaining Life

	Case G-I $n_0 = 12$, $n_3 = 10$, $n_7 = 9$		Case G-II $n_0 = 9$, $n_3 = 10$, $n_7 = 12$	
Age	Annual cost-depreciation, $	Unallocated Cost, $	Annual cost-depreciation, $	Unallocated Cost, $
0		10000		10000
	504		739	
1		9496		9261
	534		784	
2		8962		8477
	568		832	
3		8394		7645
	822		732	
4		7572		6913
	863		776	
5		6709		6137
	935		822	
6		5774		5315
	995		870	
7		4779		4445
	1592		522	
8		3187		3923
	1687		556	
9		1500		3367
			586	
10				2781
			621	
11				2160
			660	
12				1500

Sample calculation, Case G-II, age 11:

$$D_{y,2} = (10000-1500)\,[1 - 0.277 - (1 - 0.277)(0.521)]\left[\frac{1.2624 - 1.1910}{1.3382 - 1}\right] = 621$$

where $M = \dfrac{(1.06)^3 - 1}{(1.06)^9 - 1} = 0.277$, and

$$N = \frac{(1.06)^4 - 1}{(1.06)^7 - 1} = 0.521$$

$$U_2 = 10000 - (8500)\left\{[0.277 + (1-0.277)(0.521)]\,[1-0.277 - (1-0.277)(0.521)]\left[\frac{(1.06)^4 - 1}{(1.06)^5 - 1}\right]\right\} = 2160$$

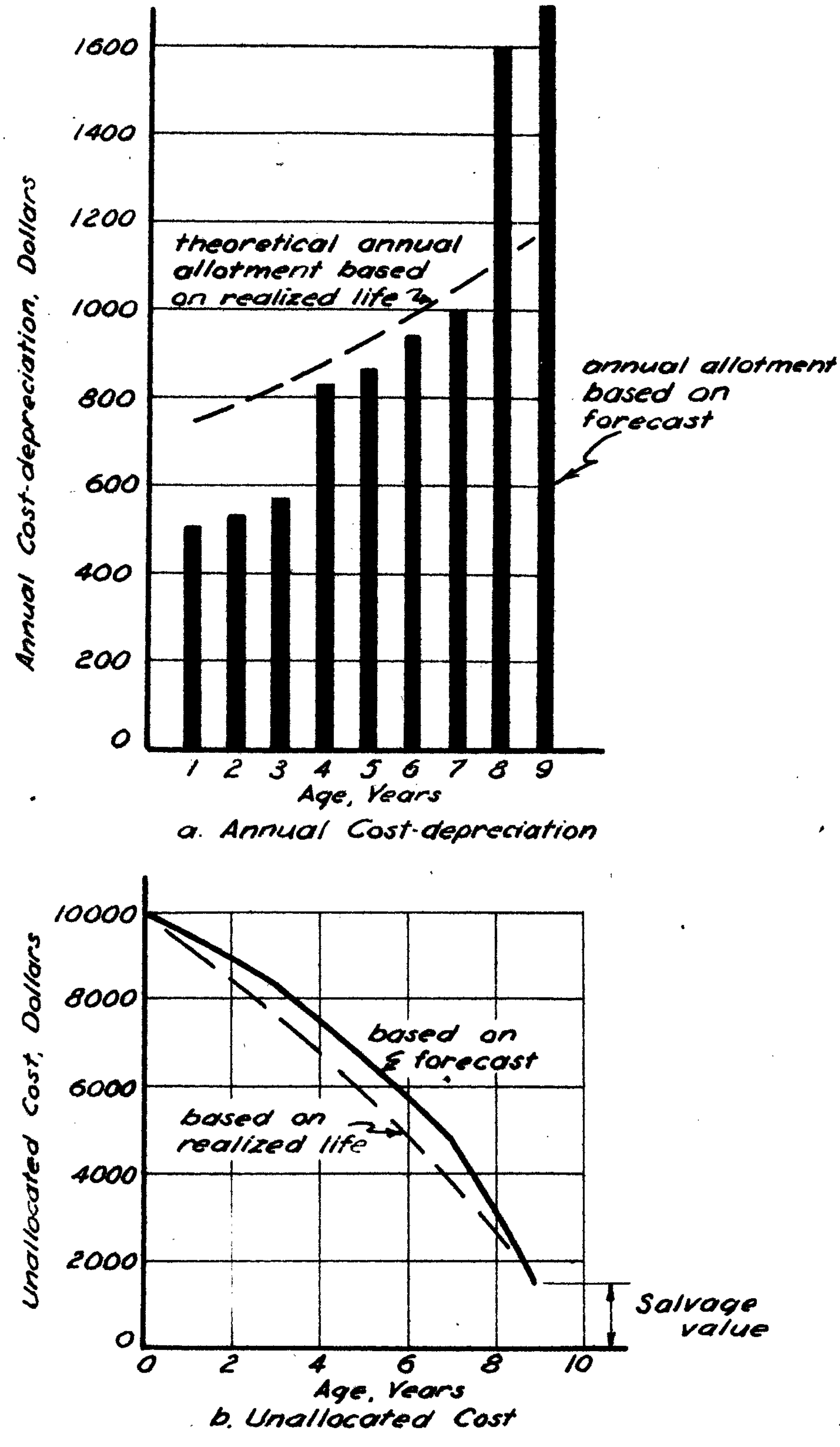


Fig. 11. Annual cost-depreciation and unallocated cost, sinking fund method, downward revision of probable life adjusted by spreading. Case G-I: cost, \$10000; salvage value, \$1500; interest rate, 6%; $n_o = 12$, $n_s = 10$, $n_r = 9$ yr.

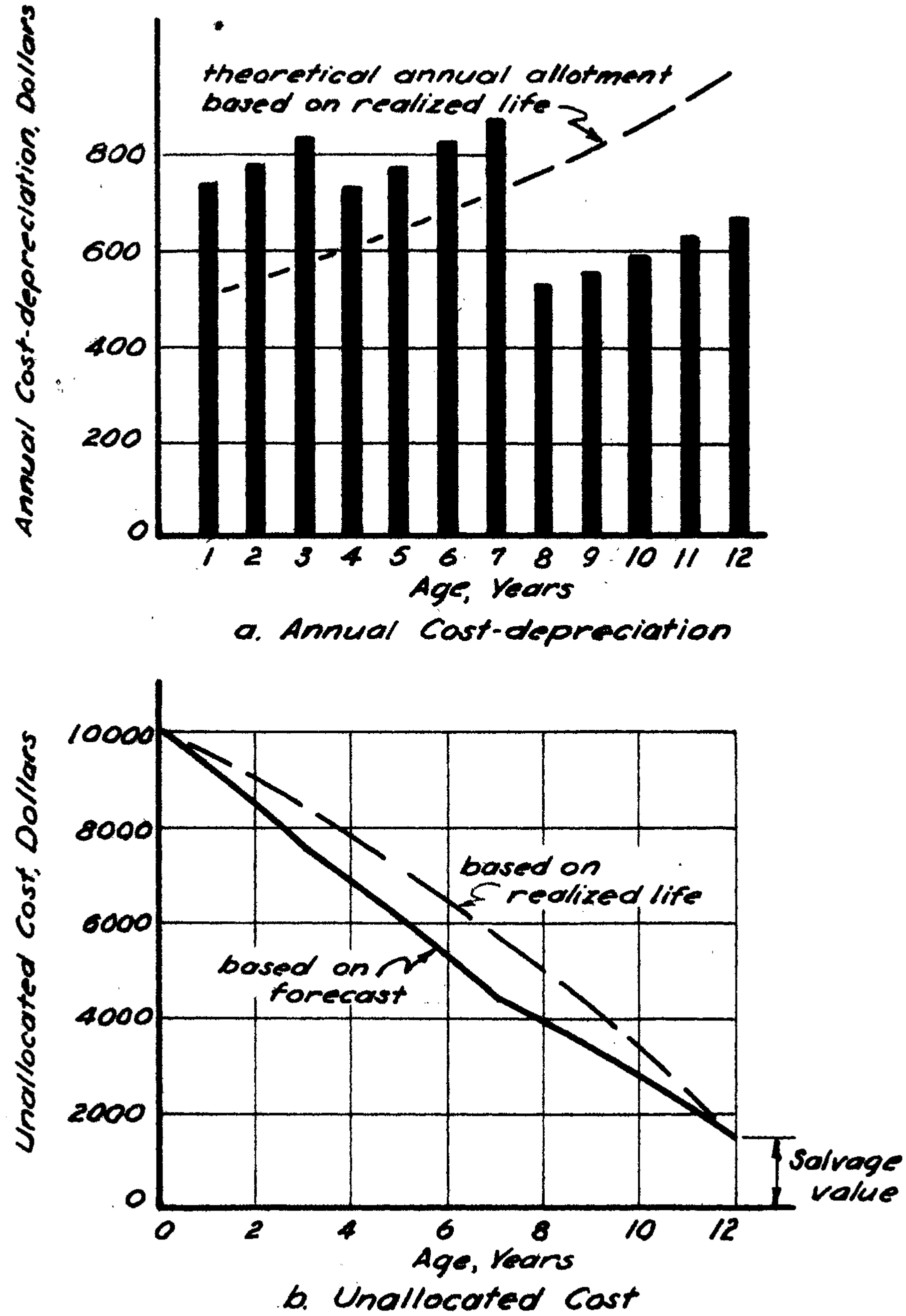


Fig. 12. Annual cost-depreciation and unallocated cost, sinking fund method, upward revision of probable life adjusted by spreading. Case G-II: cost \$10,000; salvage value, \$1500; interest rate, 6 %; $n_o = 9$ yr., $n_3 = 10$ yr., $n_7 = 12$ yr.

Summary, sinking fund method

If the sinking fund method is to be considered as a method of allocating cost-depreciation and if cost-depreciation is related to the consumption of services, the use of the method implicitly assumes one of the following things: (1) the services are equally priced and the consumption of services increases according to a compound interest curve as the property ages, (2) the services are consumed at a constant rate and the price of successive services increases according to a compound interest curve as the property ages, or (3) the composite change in both the consumption of services and the price of those services corresponding to a compound interest curve occurs as the property ages. If the distribution of cost-depreciation should follow the sinking fund curve, the "surplus" method of adjustment introduces the least error into the allocation when it is compared with the allocation which would have been made if the actual service life had been known initially.

The comparison in Table X of the previous numerical examples reveals how these adjustments affect the sinking fund distribution in the two illustrative cases. Table X presents the maximum, minimum, and average per cent deviations of the book entries from the sinking fund distribution which would have been made at age zero had the age of retirement been known for certain. These percentages may be calculated from Tables VII, VIII, and IX.

Table X

A Comparison of the Deviation of the Sinking Fund Allotments Using Forecasted Probable Lives and the Allotments Which Would Have Been Made if the Age of Retirement Had Been Known at Age Zero

Case	Average of the per cent deviation of the forecasted allotments from the sinking fund allotments based on age of retirement, %	Minimum and maximum difference between forecasted allotment and the allotment based on age at retirement, %
F-I, "surplus"	16	0 & 32
G-I, "spreading"	23	5 & 43
F-II, "surplus"	21	0 & 47
G-II, "spreading"	32	22 & 47

Again as in the straight-line comparisons these numbers have only qualitative significance. The magnitude of the deviations depend upon the rate of interest as well as the length of life of the property and the interval between revisions.

Forecasts of the probable life which are too long or too short followed by compensating revisions have different effects upon the allocations made by the sinking fund method. When the forecast of the probable life is too short and is revised upward, the equations show that the allotment for the following year must always be less than the previous allotment. This decrease produces a fluctuation in the annual allotments when the forecasts are successively revised upward. When the forecast of the probable life is too long and is revised downward the following annual allotment is increased. This increase augments the increasing characteristic which the sinking fund inherently possesses. The revision of forecasts will be best adjusted by the use of the "surplus" method because it will more closely correspond to the allocation which would be made by the sinking fund method if foresight were perfect.

The effect of revising the estimate of the salvage "value" depends upon the method of adjustment of the allocations and its magnitude upon the interest curve (rate of interest) which is assumed. If the "surplus" method is used the effect of a revision of the forecast of salvage "value" at any given age will be proportional to the change in the depreciable cost, but even if all other estimates remain the same, a given error in the forecast salvage "value" will cause a greater credit or debit to surplus and corresponding error in unallocated cost as the property gets older. Again the need for the greatest accuracy of forecasts arises in the early life of the property when the forecasts are least accurate.

Since in the "spreading" adjustment all future calculations depend upon all prior calculations, the errors introduced by the prior estimates of the salvage "value" will be increased by a compound interest factor and included in present allotments and unallocated cost. Thus errors in the early forecast of salvage "value" will have a more noticeable effect on the annual allotment, the longer the life of the property. A premium is placed upon accurate forecasts of salvage "value" during the early life when such forecasts are difficult to make.

Declining Allocation Methods

The declining allocation methods when they are used as a means of allocating the depreciable cost of a single unit of property allot a larger amount of the depreciable cost to the early periods of life of the property than to the later periods of life. Several methods whereby declining annual cost depreciation can be obtained have been suggested. These methods include the fixed percentage of the remaining balance, sum of the digits, and other methods such as the method suggested by Ashbaugh[1] designed to meet particular specifications.

The most common of these methods is the fixed percentage of the remaining balance. It is used by the Inland Revenue[2] (Great Britain), and a few companies in the United States. The formulas for the rate, r, unallocated cost, U, and annual cost-depreciation, $D_{y,k}$, when the method is applied to a single unit of property with a known life and salvage "value" are:

$$r = 1 - \left[\frac{S}{C}\right]^{\frac{1}{n}}$$

$$U = C\left[\frac{S}{C}\right]^{\frac{x}{n}}$$

$$D_y = Cr\left[\frac{S}{C}\right]^{\frac{x-1}{n}}$$

$$= C\left\{\left[\frac{S}{C}\right]^{\frac{x-1}{n}} - \left[\frac{S}{C}\right]^{\frac{x}{n}}\right\}$$

---

[1] W.L. Ashbaugh. Declining balance depreciation can work under T.D. 4422 plus I.T. 3818. The Journal of Accountancy. 83 (no.5):399-401. 1947.

[2] Depreciation allowances. The Economist (London). 144 (no. 5184):17-18. 1943.

The application of these formulas is illustrated in Table XI and figure 13. The salvage must be a positive number in this method since a zero salvage "value" will yield a zero unallocated cost at any age greater than zero and a negative salvage "value" will yield an imaginary number.

The revision of the estimates of probable life will necessitate the adjustment of the cost-depreciation allocations. These adjustments may be made in the same way that was explained in the discussion of the straight-line method. As in the other methods, the salvage "value" is assumed constant.

<u>"Surplus" adjustment</u>

The equations based on the "surplus" adjustment which represent the unallocated cost and the annual cost-depreciation during the period after the kth revision are:

$$U_k = C\left[\frac{S}{C}\right]^{\frac{x}{n_k}}$$

$$D_{y,k} = C\left\{\left[\frac{S}{C}\right]^{\frac{x-1}{n_k}} - \left[\frac{S}{C}\right]^{\frac{x}{n_k}}\right\}$$

$$z = C\left\{\left[\frac{S}{C}\right]^{\frac{\bar{x}_k}{n_{k-1}}} - \left[\frac{S}{C}\right]^{\frac{\bar{x}_k}{n_k}}\right\}$$

Table XI

Unallocated Cost and Annual Cost-Depreciation Using Declining Balance Method for 9, 10, and 12 Year Service Life (C = \$10000, S = \$1500)

Case H

Age	9 Year Life		10 Year Life		12 Year Life	
	Unallocated cost, \$	Annual cost-depreciation, \$	Unallocated cost, \$	Annual cost-depreciation, \$	Unallocated cost, \$	Annual cost-depreciation, \$
0	10000		10000		10000	
		1900		1730		1460
1	8100		8270		8540	
		1540		1440		1250
2	6560		6830		7290	
		1250		1180		1070
3	5310		5650		6220	
		1010		980		910
4	4300		4670		5310	
		820		810		780
5	3480		3860		4530	
		660		660		660
6	2820		3200		3870	
		540		550		570
7	2280		2650		3300	
		430		470		480
8	1850		2180		2820	
		350		370		410
9	1500		1810		2410	
				310		350
10			1500		2060	
						300
11					1760	
						260
12					1500	

Sample calculation:

$$1 - \frac{(1500)}{(10000)}^{\frac{1}{10}} = 0.173$$

$$D_{y,4} = 10000(0.173)(1-0.173)^6 = 977, \text{ i.e., \$980 approx.}$$

$$U_{k,4} = 10000(1-0.173)^4 = 4670$$

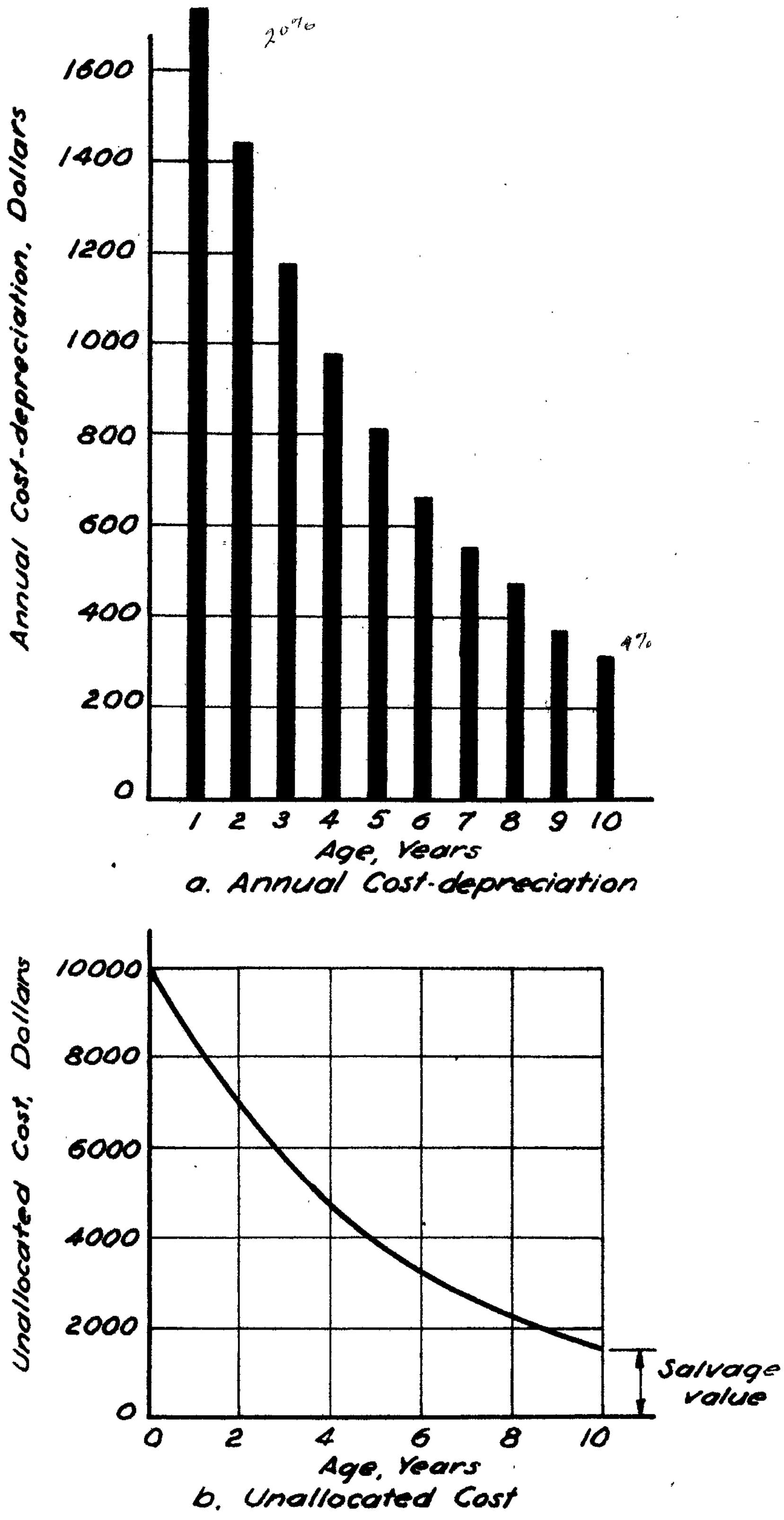


Fig. 13. Annual cost-depreciation and unallocated cost, declining balance method, probable life constant. Case H: cost, \$10000; salvage value, \$1500.

The application of these equations to the specific examples is illustrated in Table XII and figures 14 and 15.

Spreading adjustment

The equations based on the "spreading" adjustment representing the unallocated cost and the annual cost-depreciation in the period after the kth revision are:

$$U_k = C\left[\frac{S}{C}\right]^{\left[m \quad (1-m)\frac{(x-\bar{x}_k)}{e_k}\right]}$$

where m is the exponent which was applied during the (k-1)th period, when the age is $\bar{x}_k$ and

$$D_{y,k} = (U_k)_{x-1} - (U_k)_x$$

where $(U_k)_x$ represents the unallocated cost at age x during the period after the kth revision of the forecast. The application of these formulas to the specific cases is illustrated in Table XIII and figures 16 and 17.

Summary, declining balance method

The declining balance method which is most frequently used for a single unit of property is the fixed percentage of the remaining balance method. In this method annual allotments for the early years are much greater than those for the last years of a property's life. For example, in Table XI for a 10-year probable life over

Table XII

Unallocated Cost and Annual Cost-Depreciation, Declining Balance Method, Probable Life Revised at Ages 3 and 7, "Surplus" Adjustment. (C = \$10000, S = \$1500)

	Case J-I $n_0 = 12$, $n_3 = 10$, $n_7 = 9$		Case J-II $n_0 = 9$, $n_3 = 10$, $n_7 = 12$	
Age	Annual cost-depreciation, \$	Unallocated Cost, \$	Annual cost-depreciation, \$	Unallocated Cost, \$
0		10000		10000
	1460		1900	
1		8540		8100
	1250		1540	
2		7290		6560
	1070		1250	
3		6220		5310
	980		980	
4		4670#		4670#
	810		810	
5		3860		3860
	660		660	
6		3200		3200
	550		540	
7		2650		2650
	430		480	
8		1850#		2820#
	350		410	
9		1500		2410
			350	
10				2060
			300	
11				1760
			260	
12				1500

Case J-I: #"Surplus" adjustment: $Z_1 = 570$, $Z_2 = 370$

Case J-II: #"Surplus" adjustment: $Z_1 = 340$, $Z_2 = 650$

Sample calculation at age 7:

$$U_1 = 10000 \left(\frac{1500}{10000}\right)^{\frac{7}{10}} = 2650$$

$$D_{y,1} = 10000 \left[(0.15)^{\frac{6}{10}} - (0.15)^{\frac{7}{10}}\right] = 550$$

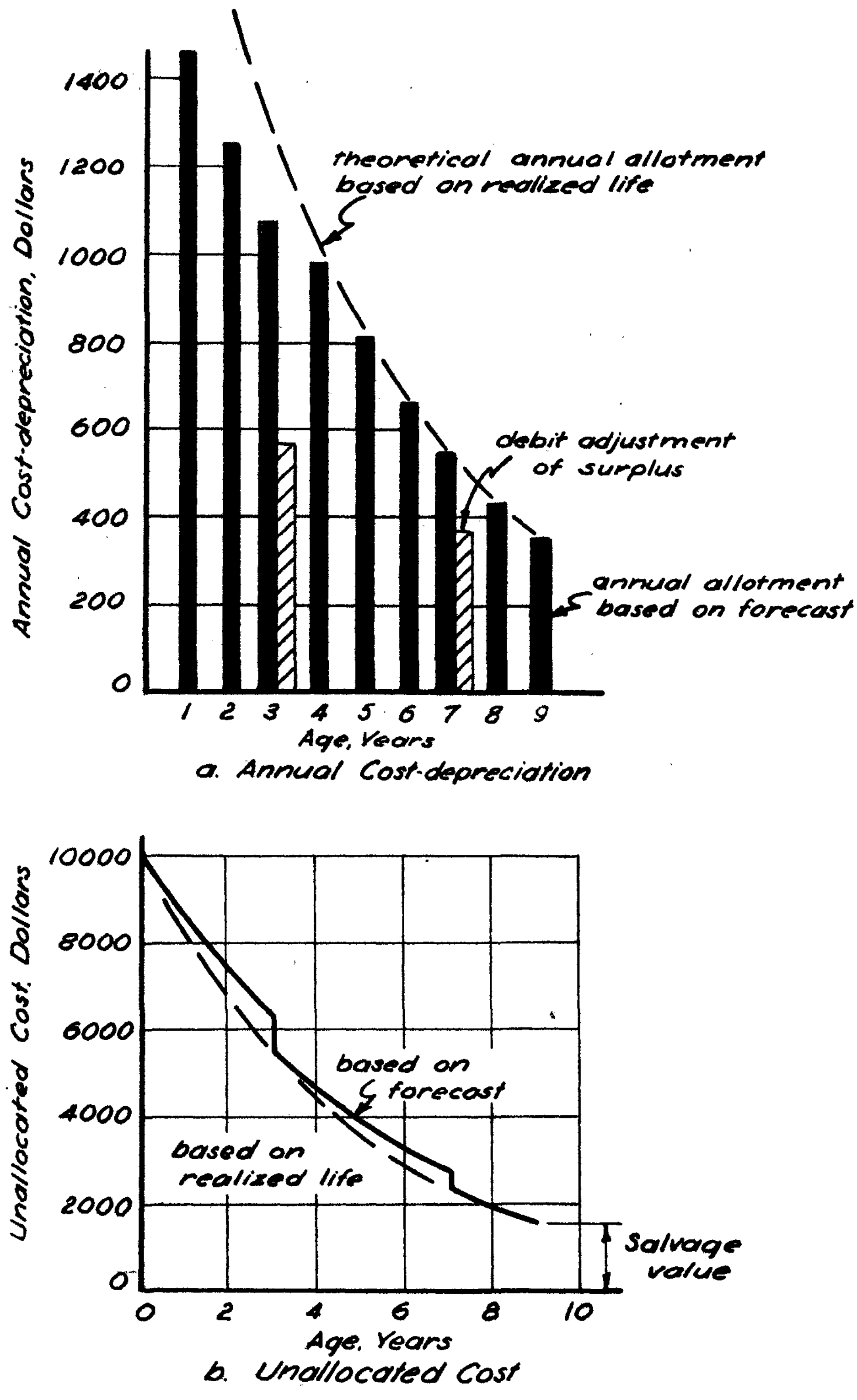


Fig. 14. Annual cost-depreciation and unallocated cost, declining balance method, downward revision of probable life adjusted to surplus, Case J-I: cost, \$10000; salvage value, \$1500; n_0 = 12 yr., n_3 = 10 yr., n_7 = 9 yr.

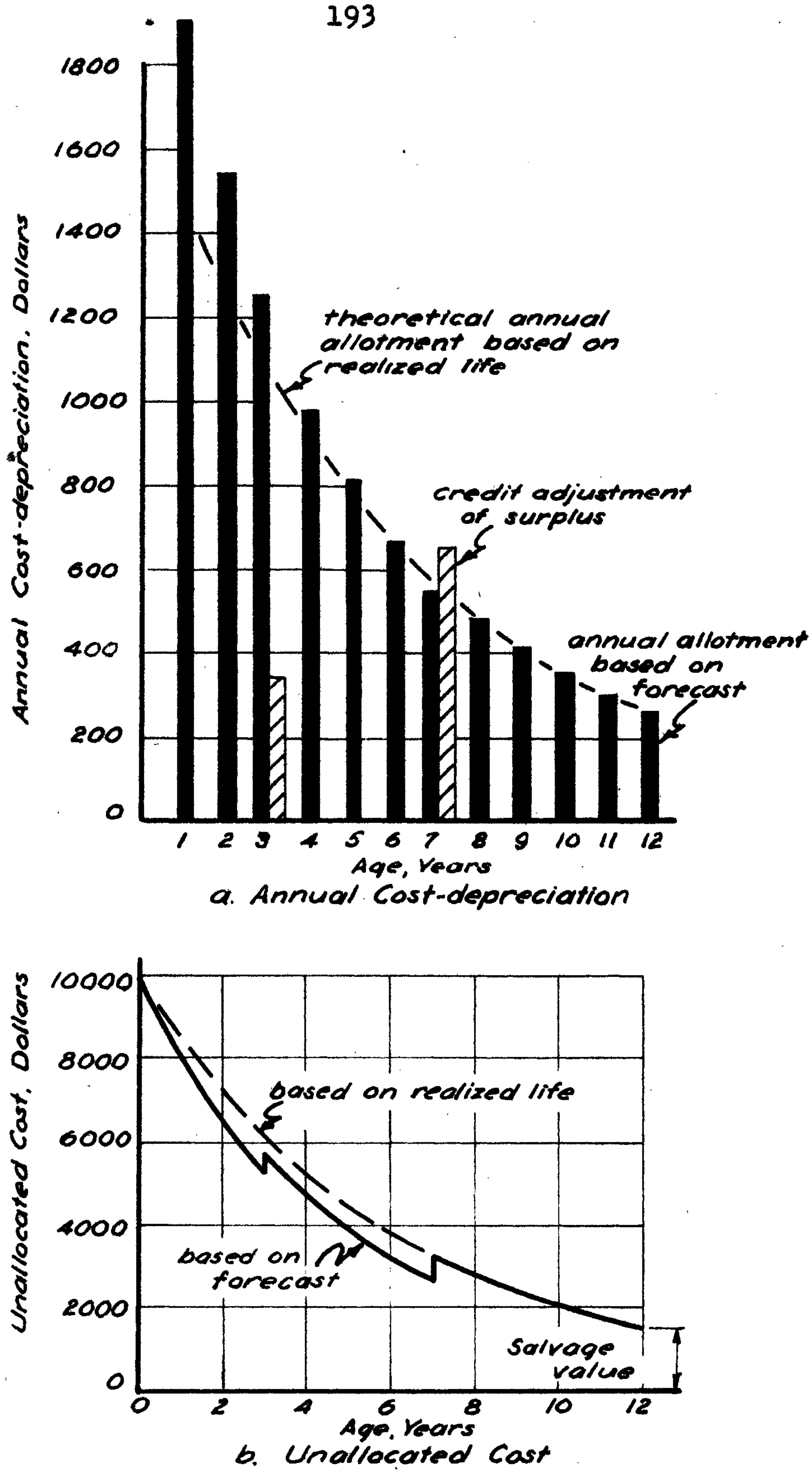


Fig. 15. Annual cost-depreciation and unallocated cost, declining balance method, upward revision of probable life adjusted to surplus. Case-J-II: cost, \$10000; salvage value, \$1500; n_o = 9yr., n_s = 10 yr., n_r = 12yr.

Table XIII

Unrecovered Cost and Annual Cost-Depreciation, Declining Balance Method, Probable Life Revised at Ages 3 and 7, "Spreading" Adjustment, (C = \$10000, S = \$1500)

	Case K-I $n_0 = 12$, $n_3 = 10$, $n_7 = 9$		Case - II $n_0 = 9$, $n_3 = 10$, $n_7 = 12$	
Age	Annual cost-depreciation, \$	Unallocated Cost, \$	Annual cost-depreciation, \$	Unallocated Cost, \$
0		10000		10000
	1460		1900	
1		8540		8100
	1250		1540	
2		7290		6560
	1070		1250	
3		6220		5310
	1170		879	
4		5050		4431
	955		732	
5		4095		3699
	775		611	
6		3320		3088
	628		510	
7		2692		2578
	682		265	
8		2010		2313
	510		237	
9		1500		2076
			213	
10				1863
			197	
11				1672
			172	
12				1500

Sample calculation at age 8, Case J-II:

Exponent during period at age 3 = $\frac{3}{9}$ = 0.333

After 1st revision $\frac{1}{3} + (1-\frac{1}{3})(\frac{4}{7}) = \frac{1}{3}\ \frac{2}{3}(\frac{4}{7}) = .714$

After 2nd revision = $\frac{1}{3} + \frac{2}{3}\left(\frac{4}{7}\right) + \left[1 - \frac{1}{3} - \frac{2}{3}\ \frac{4}{7}\right]\left[\frac{(x-7)}{5}\right] =$

$0.714 + (0.285)\ (\frac{1}{5}) = 0.771$

$U_2 = 10000(0.15)^{0.771} = 2310$

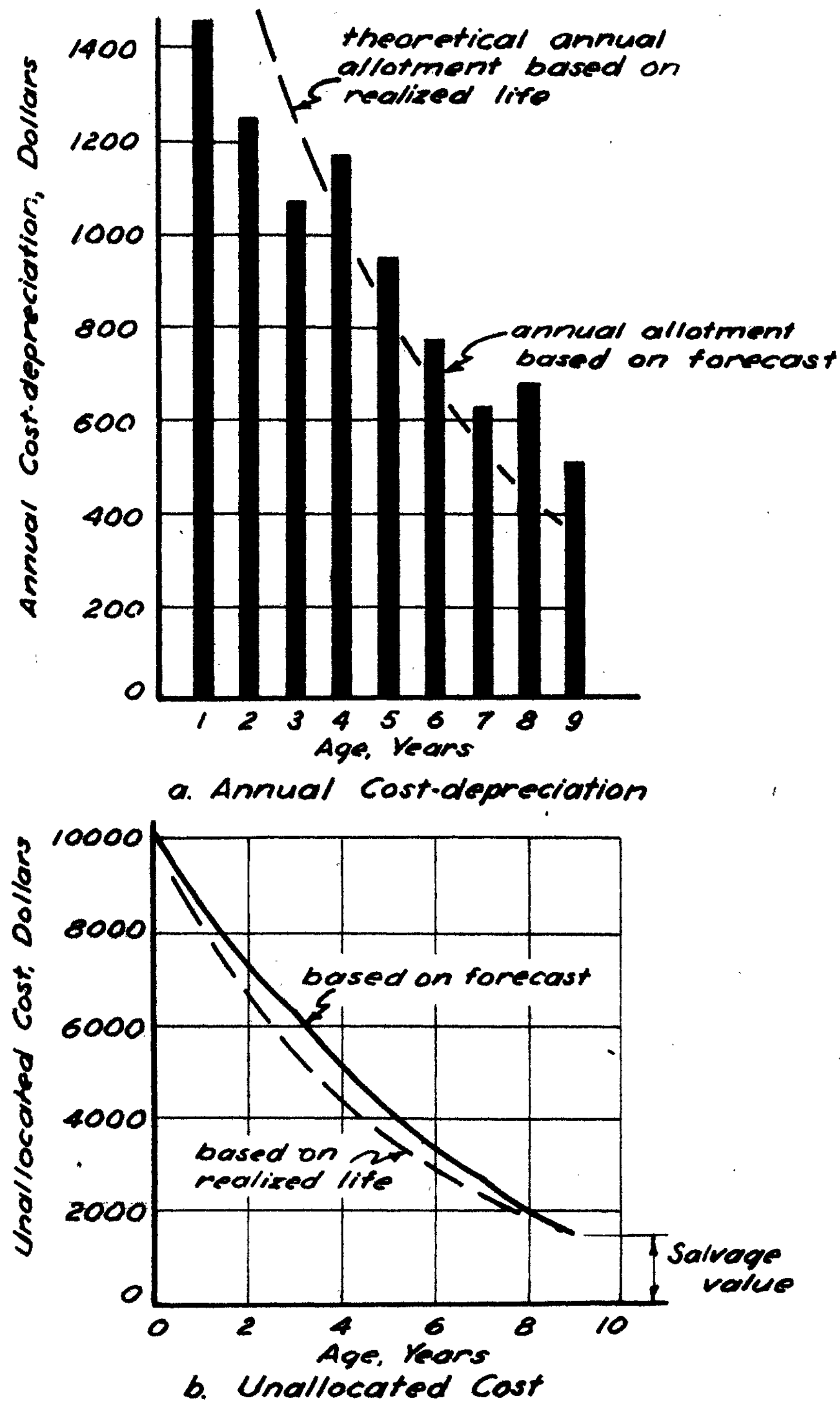


Fig. 16. Annual cost-depreciation and unallocated cost, declining balance method, downward revision of probable life adjusted by spreading. Case K-I: cost, $10000; salvage value, $1500; $n_0 = 12$, $n_3 = 10$, $n_7 = 9$ yr.

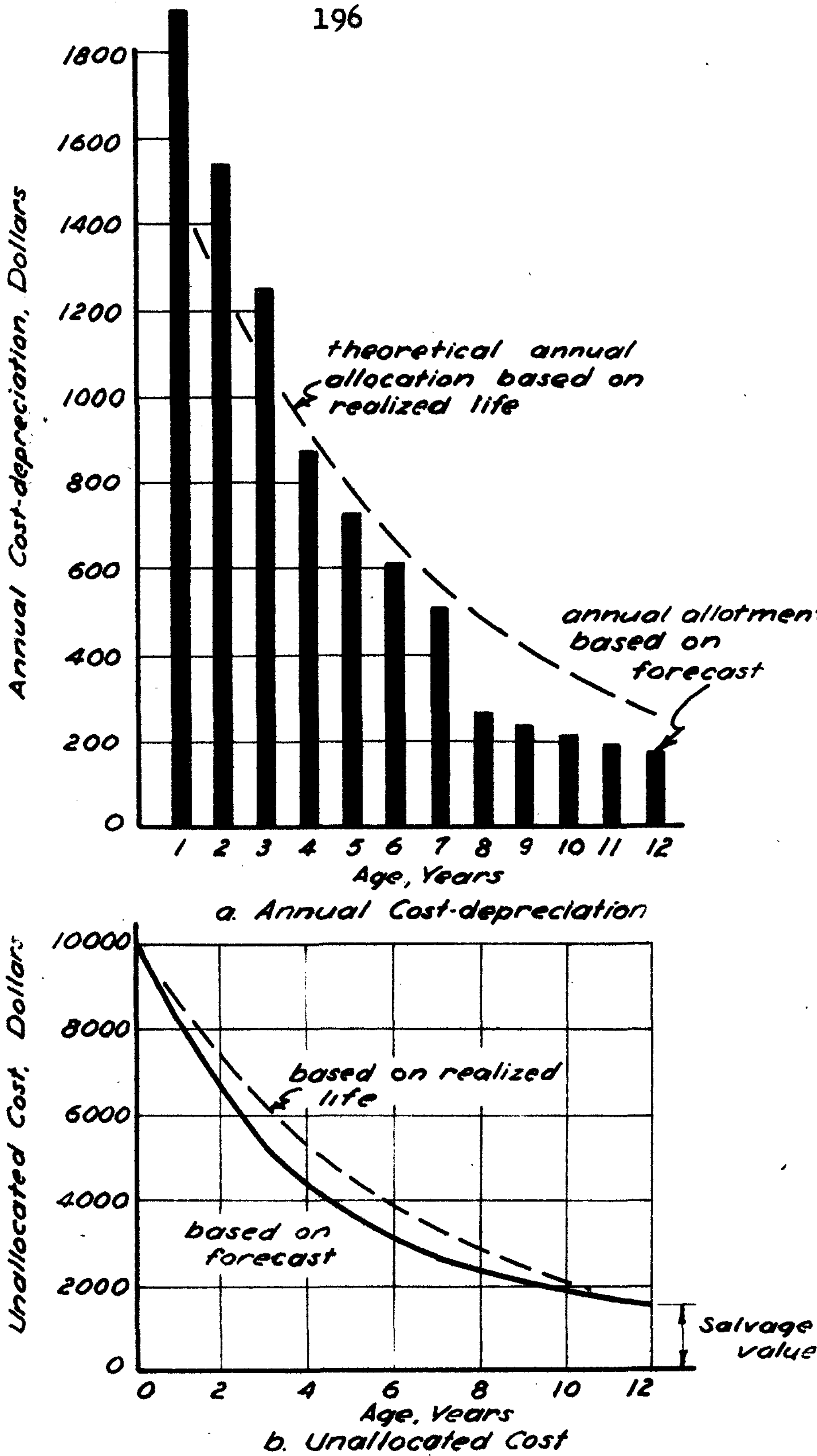


Fig 17. Annual cost-depreciation and unallocated cost, declining balance method, upward revision of probable life adjusted by spreading. Case K-II: cost, \$10000; salvage value, \$1500; n_0=9, n_3=10, n_7=12.

twenty per cent of the cost is allocated to the first year and less than four per cent to the last year of the ten-year life. The first annual allotment is five times the last annual allotment. If the life of the property were 25 years, the first allotment would be about six times the last allotment. However, if the life were 25 years and the salvage "value" were only $100 instead of $1500, the first allotment would be over eighty times the size of the last allotment.

If the allocation is related to the consumption of the service of the property, the declining balance method implicitly assumes a rigid pattern for the consumption or pricing of services, i.e., either that the quantity of service consumed declines with the age or that the price of the services consumed declines with age. Whereas many properties are used more during their early life than in later years or the quality of their products is greater in early than later life, the extreme differences which are imposed upon the annual allocations by this method seem highly unreal, particularly when the salvage "value" is only a nominal amount.

The illustrative examples of the applications of the fixed percentage method indicate that for these cases the "surplus" adjustment is the better means of correcting errors in prior forecasts. Table XIV summarizes for the numerical examples the variations between the allocations based on the forecasts and the allocation which would have been made had the age of retirement been known at age zero.

The estimate of the salvage "value" is influential in establishing the percentage depreciation rate which is multiplied by the remaining balance to determine the annual allotment. For example, the percentage used for a ten-year life property when the cost is $10,000 and the salvage is $1500, $1000, $500, and $100 is 17.3%, 20.1%, 26.0%, and 37% respectively. The forecasts of the salvage "value" and revision of these forecasts are important particularly during the early years of the property's life. As the property approaches retirement the variation in dollar allotments caused by a revision of salvage "value" forecasts is small because only a small portion of the cost is unallocated by the time the property reaches approximately 65 per cent of its age at retirement. Thus, relatively large variations in the percentage depreciation rate when applied to the small remaining balance affect the annual allotment only a little. In this method an even greater need for accurate forecasts of salvage "value" and probable life in the early life of the property

Table XIV

A Comparison of the Deviations of the "Spreading" and "Surplus" Adjustment of the Declining Balance Allotments from the Allotments Which Would Have Been Made if the Age of Retirement Had Been Known at Age Zero

Case	Average of the % deviations of the forecasted allotments from the allotments which would have been made if the age at retirement were used	Minimum and maximum % difference between forecasted allotments and allotments based on the age at retirement
H-I, "Surplus"	7	0 to 23
J-I, "Spreading"	25	16 to 53
H-II, "Surplus"	7	0 to 30
J-II, "Spreading"	24	3 to 42

than is necessary in either of the previous methods of allocation.

Unit of Production Method

In the unit of production method (use method, unit of service method) of distributing the cost of a single item of property over its life, the allocation of the cost is based on the services rendered by the property. In general the application of this method tacitly assumes the following: (1) all service units are similar and are equally priced, (2) cost-depreciation is only a function of these service units, and (3) the intensity of the use has little influence on the cost-depreciation allocations. With these assumptions, the following formulas may then be developed. The cost of a unit of service, D_u, when the forecasted total service units is N will be[1]

$$D_u = \frac{C - S}{N} .$$

The formula for the unallocated cost after X units of the total services have been used is[1]

$$U = C - \frac{X}{N}(C - S) .$$

[1]The algebraic form of these formulas is identical to the algebraic form of the straight-line formula. In either case, the unit of life is allocated equal increments of cost throughout the life of the property.

The principal difference between the unit of production method and the previous methods is the dimensions in which the life of the property is recorded. In the unit of production method, the life of the property is measured in terms of the dimensions which have an influence upon the retirement of the property whereas in the previous methods the life is measured by a lapse of time. The unit of production method should utilize the most apt measurement of life which may include time, number of products, physical properties or a combination of these.

The measurement of the quantity of the apparent product of a property unit may not be relevant in determining the cost allocation. The proper measurement may be entirely unrelated to the total production or total sales. For example, the life of a telephone pole is a function of the years of exposure to the elements, not the number of telephone calls. The life of a ball or roller bearing is more directly related to the load-hours than time interval alone. The use of dimensions such as psi-hours or hp-hours still fails to recognize the effect of intensity of use upon the quantity and quality of the services of the machine because it does not give proper weight to the periods when a machine is overloaded and thereby excessive wear occasioned.

The conversion of the cost allocation based on the unit of production method to a time allocation may result in a wide variety of the time distribution of cost including the straight-line, sinking fund, and declining allocation distributions. If N is equal to Qn where Q is a dimensional constant, the unit of production method will yield a straight-line time distribution. If

$$N = Q\left[\frac{(1+i)^{n} - 1}{(1+i)^{x} - (1+i)^{x-1}}\right],$$

the unit of production method will yield a sinking fund time distribution. Likewise, if

$$N = Q\left[\frac{C-S}{C}\right]\left[\frac{1}{\left(\frac{S}{C}\right)^{\frac{x-1}{n}} - \left(\frac{S}{C}\right)^{\frac{x}{n}}}\right],$$

the unit of production method would yield a fixed percentage of the remaining balance time distribution.

The allocations based on the revision of the forecasts of a property's life can be adjusted by either the "surplus" or the "spreading" method regardless of the dimensions in which the life is forecast. The illustrative examples of the three time distributions of cost also provide specific illustrations of the unit of production method when the above relations between N, i, S, and C are valid. As in the previous instances the "surplus" method will always provide the best means of correcting past errors of allocation when forecasts are revised.

If the assumptions regarding the homogeneity of service units, the relation between output and cost-depreciation, and the effect of the intensity of use are removed, the equation for that portion of the cost of a service unit d_o which varies with output is

$$d_o = f(C,S,N,\gamma,\beta)$$

where γ is a factor dependent upon the quality of the service and β is a factor dependent upon the intensity of the use based upon either a normal or rated output of the machine. The remainder, d_e, of the cost-depreciation is dependent upon conditions which are a function of variables other than the use of the property, e.g., the rusting, decay, or aging of materials to the detriment of their physical properties, and the development of alternative means of obtaining the same service. The total cost of a unit of service may be expressed as the vector sum of the costs attributed to the economic forces caused by age and invention. The cost of a unit of service is then

$$D_u = \bar{d}_e + \bar{d}_o$$

when $\bar{d}_e$ and $\bar{d}_o$ are the vector notations for the values d_e and d_o.

The advantage of the unit of production method is that it places the emphasis on the factors which should be considered before a forecast of life is made. Since this method requires a determination of the number of service units consumed during any period of time, either an overt assumption of the consumption of services or a determination of the consumption of service based on plant records is necessary. In contrast, the time distribution methods, i.e., straight-line, sinking fund, tacitly assume the rate at which services are consumed.

Opinions as to the desirability of using the unit of production method vary. Saliers believes that the production method introduces additional uncertainties into the allocations.

> At the outset it must be recognized that there are certain difficulties, theoretical as well as practical, in the application of this plan. The depreciation charge aims to return the cost of the asset less salvage, and this can be accomplished more easily when the return is secured by means of some mathematically determined method than when it is made to depend upon the fluctuations of production. In any event the future length of life of the asset in question is more or less uncertain, and when the production method is employed an additional element of uncertainty is introduced.[1]

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[1]Saliers, op. cit., p. 367.

Canning indicates that under certain conditions the unit of production ("service") formula provides a better method of allocation than the other methods. All of Canning's arguments are based upon the postulates that the cost of all service units from a unit of property is equal and that the depreciable cost allotment is in direct proportion to the output.

> Whether or not this method presents anything novel for consideration--the others being before us--is of little consequence. What is of vast consequence is the introduction of a system of service measures in lieu of a single arbitrary measure. There is no more reason why we should struggle along with one common service measure, the year of use, than that we should try to get along with one unit of physical measure for objects.[1]

> Aside from the one great merit noted, substitution of a better service measure, this rule has another great merit. It disregards *n* probable life altogether except to the extent that the rate of exploitation *must* be constant or that mere exposure rather than exploitation fixes the amount of service to be had. These exceptional cases are not the ones in which *n* is difficult to estimate. On the contrary, it is for the exposure-limited and the constant-service types that *n* can be most nearly estimated.

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[1]J.B. Canning. The economics of accountancy. New York, The Ronald Press. 1929. p. 281.

> Where wear, which is always a function of exploitation rate, is the effective or predominant cause of operating outlay, n is very difficult to estimate. Errors in the estimate of n are one of the most serious kinds.[1]

> n cannot be intelligently determined for any formula without regard for the amounts of O [operation outlays] and of S [units of service] that may be anticipated. . . . It is not legitimate to argue that O and S cannot be accurately forecast or forecast at all; for the straight-line method and every other involving n as an effective symbol implies willy-nilly that some particular trend is expected. Within the limits of our ability to forecast at all, this method has much more to recommend it than any other simple method yet proposed.[2]

The unit of production method of cost-depreciation is the most flexible of all the methods. With proper application it will undoubtedly provide the best approach to the analysis of cost allocation problems. This method may consider not only the time distribution of the consumption of services but the variation in the quality of the services consumed. Of considerable importance is the emphasis placed upon the use of the dimensions which are appropriate to the measurement of the life of the property.

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[1] Ibid., p. 282.

[2] Ibid., p. 283.

An often neglected factor in the life of property is the intensity of use. A machine which operates at or above the design stress is generally more likely to fail than one which is not loaded to that point. Similarly, materials, e.g., concrete pavements, which are subjected to repeated stresses and fatigue will carry less total load hours if the frequency of repetition is increased. Cost-depreciation may be even more a function of the intensity of use than of the total quantity of usage. The determination of the effect of the intensity upon the life of a property should be relegated to a specialist.

Although every property cannot be subjected to the scrutiny which the unit of production method requires, the use of this method should provide a solid foundation for a study of the cost allocations of major property units. If the complexity of the applications is too great for convenient use, approximations can be developed which conform more closely to the general characteristics of the allocations based on use methods.

Summary of Single Unit Methods

The allocation of the cost of a single unit of property over its useful life by the methods just presented result in a wide variety of annual allotments. The choice of a method depends upon the objectives. If a firm desires to distribute the cost of a property over time in some pattern either the straight line, sinking fund, or fixed percentage methods might be used. However, if a firm desires to allocate the cost of a machine on the basis of use the unit of production basis will provide the best basis of allocation.

The adjustment of allocations which are necessitated by a revision of the forecast of either the life or salvage "value" have an important bearing upon cost allocations. The adjustment of the allocations by proper entries in the surplus account and the appropriate property account obtains a better correlation between the allocations based on the forecasts and the pattern of allocation initially chosen than the spreading method obtains. In fact, the illustrative examples show that under certain conditions the pattern obtained from the spreading adjustment is considerably different from the pattern suggested by one of the standard methods of allocation.

The above opinion is not shared by all writers. For example, Kohler selects the spreading method as "most accurate." Without stating a criterion of accuracy, he wrote:

> The above three formulas are so-called "straight-line formulas, as are also the following two variants:
>
> $d = (C-S) \times \frac{1}{Y}$, (4) and
>
> $d = (C-S-R) \times \frac{1}{Y_1}$, (5)
>
> where R is the balance of depreciation accumulated in prior years, and Y_1 the estimated number of years of remaining life <u>including the current year</u>. Each of these variants has its advocates, but in most instances they yield substantially the same results, notwithstanding their theoretical distinctions. Of the five formulas, (5) is probably the most accurate, provided its application can be accompanied by periodic remaining-life studies leading to the correction of Y_1.[1]

In fairness to Kohler, it should be repeated that the sum of the annual allotments by the "spreading" method always equals the cost. In contrast, the sum of the annual allotments by the "surplus" adjustment never equals the cost unless the sum is corrected by the entries to the surplus account.

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[1]E.A. Kohler, op. cit., p. 139-140.

The importance of considering the adjustments as an integral part of the method of allocation was stressed by the AIA and repeated by George May.

> The Research Department of the Institute has recently invited criticism of a definition of depreciation which emphasizes the fact that it is a charge resulting from the application of one of a number of conventional methods of allocation of the cost of property to accounting periods, and suggests that the essential and common characteristics of acceptable methods of allocation are that they distribute a total actual or estimated cost over an estimated life in a rational and systematic manner and that they provide for any revisions that may be found necessary of estimates initially made. (Underlining supplied.)[1]

The method of adjustment has such an important bearing on the distribution of cost based on forecasts that the method of adjustment deserves as careful consideration as does the choice of the method of allocation.

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[1] G.O. May. Financial accounting, op. cit., p. 162-163.

CHAPTER XVII

METHODS OF ALLOCATION FOR GROUP PROPERTIES

Group property methods of allocating the cost of long-lived properties were developed after many of the single unit methods had become established. As a result, instead of a group of property units being considered as an <u>entity</u> which served some functional purpose, the group was considered as a number of separate units each of which contributed its share to the operation of the enterprise. Evidence of the individual unit concept in group property methods is found in the identification of all the additions and retirements in a group. Thus instead of devising group methods for financial accounting which eliminate concern over the individual units, most group methods require that careful attention be given to individual property units which are added to or retired from the group.[1]

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[1]Continuous property records have been adopted by many industrial concerns as an aid in financial accounting and for other reasons. A survey of the methods used by several large corporations is presented by C.V. Armstrong. Industrial property records for accounting and valuation uses. Iowa State College. Eng. Exp. Sta. Bul. 160. 1944.

The composition of a group of property units may range from an aggregation of industrial units to an aggregation including all the properties in the business. Such property groups are generally identified as group[1] properties or composite group[2] properties respectively. The classification of property into groups of like units may be based on either physical or functional character-

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[1]Group rates in effect are special types of composite rates. According to Carroll (N.A.C.A. Bulletin, vol. 23), the group system assumes:

1. An aggregation of homogeneous depreciable units.
2. Determination of depreciation periodically for the entire group of assets as though it were a unit.
3. Maintenance of a single depreciation reserve account for the group.

Theodore Lang. Cost accounts' handbook. New York, The Ronald Press. 1944. p. 1214.

[2]A composite rate is one based on the average life of a plant. More specifically, according to Carroll (N.A.C.A., Bulletin, vol. 23):

> The composite life system contemplates depreciation as a unit, a number of mixed assets assembled to perform a particular service, but with each such unit having a different life expectancy. A simple illustration would be that of a filling station with building, structures, and runways taking one rate, tanks and pumps another, grease racks perhaps another, and office equipment still another.

Ibid., p. 1213.

istics and demands careful attention to obtain the maximum information about all properties at a minimum cost.

The cost-depreciation rate of composite groups generally is less stable over a period of time than the cost-depreciation rate of group properties. Composite group rates may be determined by referring to Bulletin F or to a handbook. To be reasonably accurate composite group rates require an estimate of the life characteristics and number of each kind of property units in the group. If these separate analyses are made, the advantage of the simplicity of calculations for the composite group is minimized. Since the composite group requires a weighting of the life characteristics of the various kinds of property by the number of units of that kind, subsequent changes in the proportionate number of properties affects the composite group rates. Composite group rates are widely used without considering their limitations, because the group methods are not well understood and an understanding of group analysis is a prerequisite to proper use of composite group rates.

Group property analyses may be classified either as original group or continuous group studies. An original group[1] consists of an aggregation of property units

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[1] Winfrey. Depreciation of group properties. op. cit., p. 12.

all installed at the same time. All units have the same age throughout the life of the group. A continuous group[1] is an aggregation of units which have been installed at various times. A continuous group may be maintained at a constant number of units. It may be increased[2], or decreased in the total number of units included in the group. Since the continuous group analysis is an extension of the original group analysis, the original group will be considered first.

Original Group

The fundamental life characteristics of an original group may be presented either in the form of a frequency distribution of the retirements or a distribution of the property units in service throughout the life of the group. The frequency distribution is generally presented as a frequency curve. The units in service are represented by a survivor curve. These curves are illustrated in figure 18. The survivor curve

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[1] Ibid., p. 12.

[2] W.C. Fitch. The influence of growth on the condition per cent of physical properties. Unpublished M.S. Thesis. Ames, Iowa, Iowa State College Library. 1939.

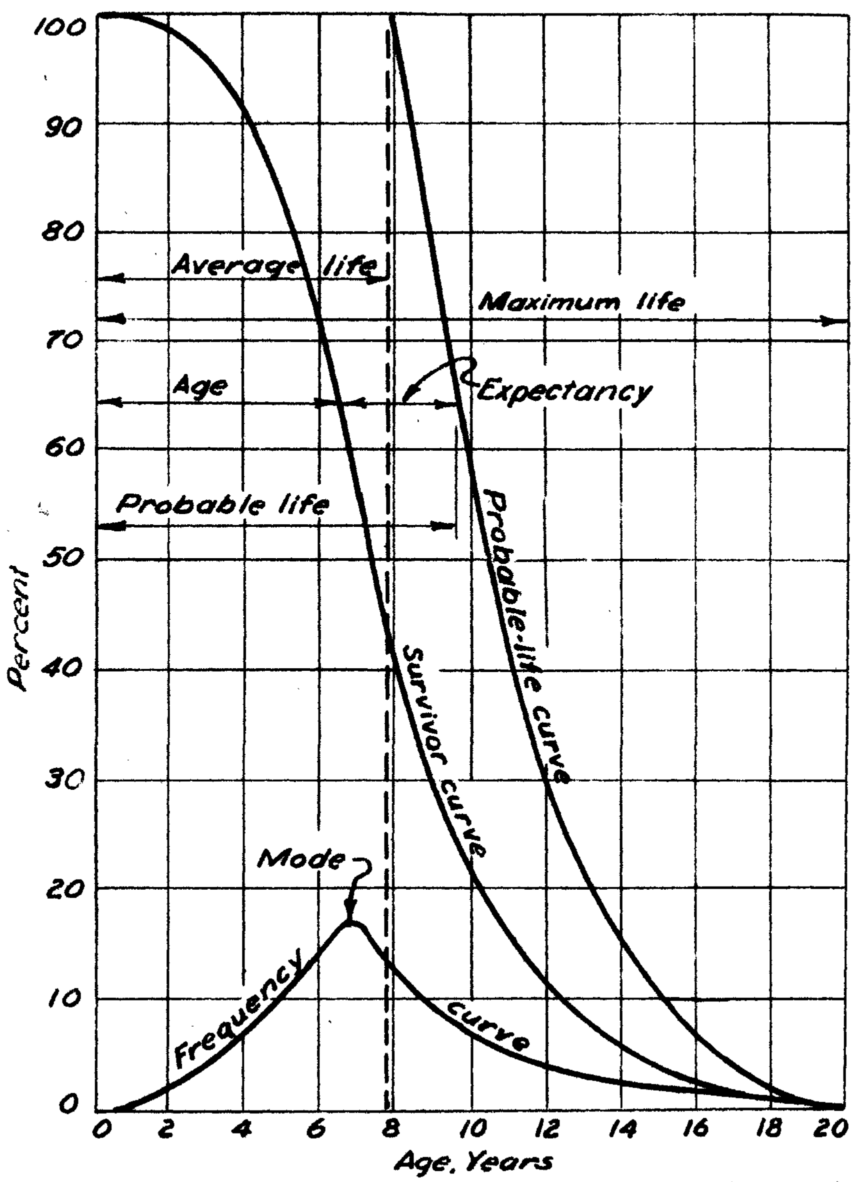

Fig. 18. A typical survivor curve and its derived curves. (from Winfrey, Bulletin 125 op. cit. p 10).

may be obtained by summing the area under the frequency curve from the maximum age to age zero, or what is equivalent, subtracting the area under the frequency curve from the original number of units in the group.

The probable life can be obtained from these fundamental curves. The probable life of the original group at age zero is also the average life of the original group. The average life can be calculated by dividing the area under the survivor curve by the number of units in the original group. When the number of units is expressed in per cent the area under the survivor curve divided by 100 per cent is the average life. The probable life is equal to the age plus the expectancy. The expectancy of the group at any age is equal to the area under the survivor curve from that age to maximum life divided by the number of units in service at that age. The probable life (figure 18) varies from the average life at age zero to the maximum life of the group. The expectancy varies from the average life at age zero to zero at the maximum life of the group.

In order to determine the life characteristics of group properties the number of units retired at each age must be studied. Several methods of analyzing retirement data are presented by Winfrey[1], e.g., the individual unit, original group and annual rate methods. Since the significance of these methods is adequately covered by Winfrey, they are not discussed herein.

Survivor curves to be of use in forecasting the average life of a group must be approximated before the group has been retired. The survivor curves of properties in current use will be incomplete, stub, curves. These curves must be extended to maximum life before the life characteristics can be calculated. Winfrey suggests the use of the 18 "type curves" which were developed by the Iowa Engineering Experiment Station and published in Bulletin 125. Others have suggested the use of the Gompertz-Makeham and Gram-Chalier methods of curve fitting as an aid in the extrapolation of the stub curves. An extensive comparison of the results of these methods is presented in Bulletin 125.

The discussion of the application of the probable life or average life to the methods of cost allocation generally provokes more controversy than the selection of the proper statistical determination of the probable life or average life. Since the reasonableness of the

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[1]Winfrey, Bulletin 125, op. cit.

estimate of probable life or average life can be verified after the group has been retired, errors in forecasting can be ascertained. However, because the reasonableness of any method of allocation is based upon judgment, i.e., conformity with the opinion of individual business men, the propriety of a method of allocation is not subject to the same factual check as the statistical determination of probable life or average life.

At least five methods[1] of allocating the cost of the original group have been applied. The two most frequently used are the average life method and the unit summation method. Less frequently used are two modifications of the average life method in which (1) the total cost of the group is allocated over the average life of the group and (2) the cost of the survivors is allocated at a rate equal to the reciprocal of the average life, only over the average life of the group. The fifth method is the probable life method in which the cost of the group is allocated in proportion to the ratio of the expectancy to the probable life.

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[1]Preinreich considers the first four of these methods in his article The Practice of Depreciation, op. cit. He identifies the methods as the true straight-line method, the method of weighted life units, the economists' straight-line method, and the accountants' straight-line method respectively.

The last three methods can be rejected on the basis that they violate the accepted bases upon which cost is allocated, i.e., on the basis of service rendered or property consumed. The first modification of the average life method, figure 19, allocates the cost over the average life, but it allocates no cost to either the property units in existence or services rendered after average life is reached. The second modification allocates the cost of the survivors at a rate equal to the reciprocal of the average life of the group over only the average life of the group, figure 20. It does not allocate the total cost of the group which is ample reason for rejecting it. In addition, the same objection can be raised against it as against the first modification. Thus, both modifications are rejected because they do not correlate the allocation of cost either to the consumption of the physical property or to the services rendered by the property.

The probable life method allocates the cost of the group over the total life of the group. The equation for the unallocated cost by the probable life method is:

$$\text{unallocated cost} = \text{cost new}\left(\frac{\text{expectancy}}{\text{probable life}}\right).$$

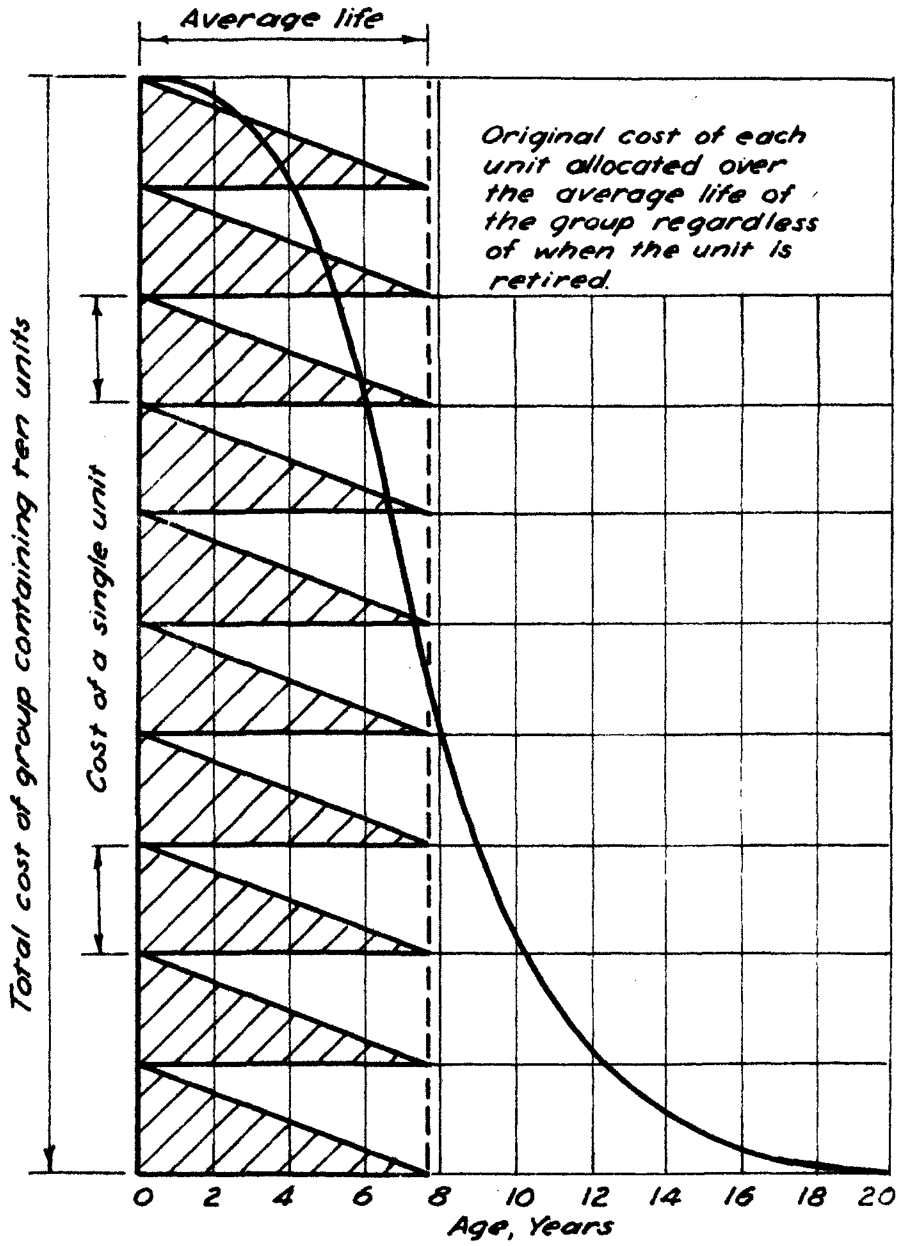

Fig. 19. Modified average life method in which the original cost of the units within the group is allocated over the average life of the group.

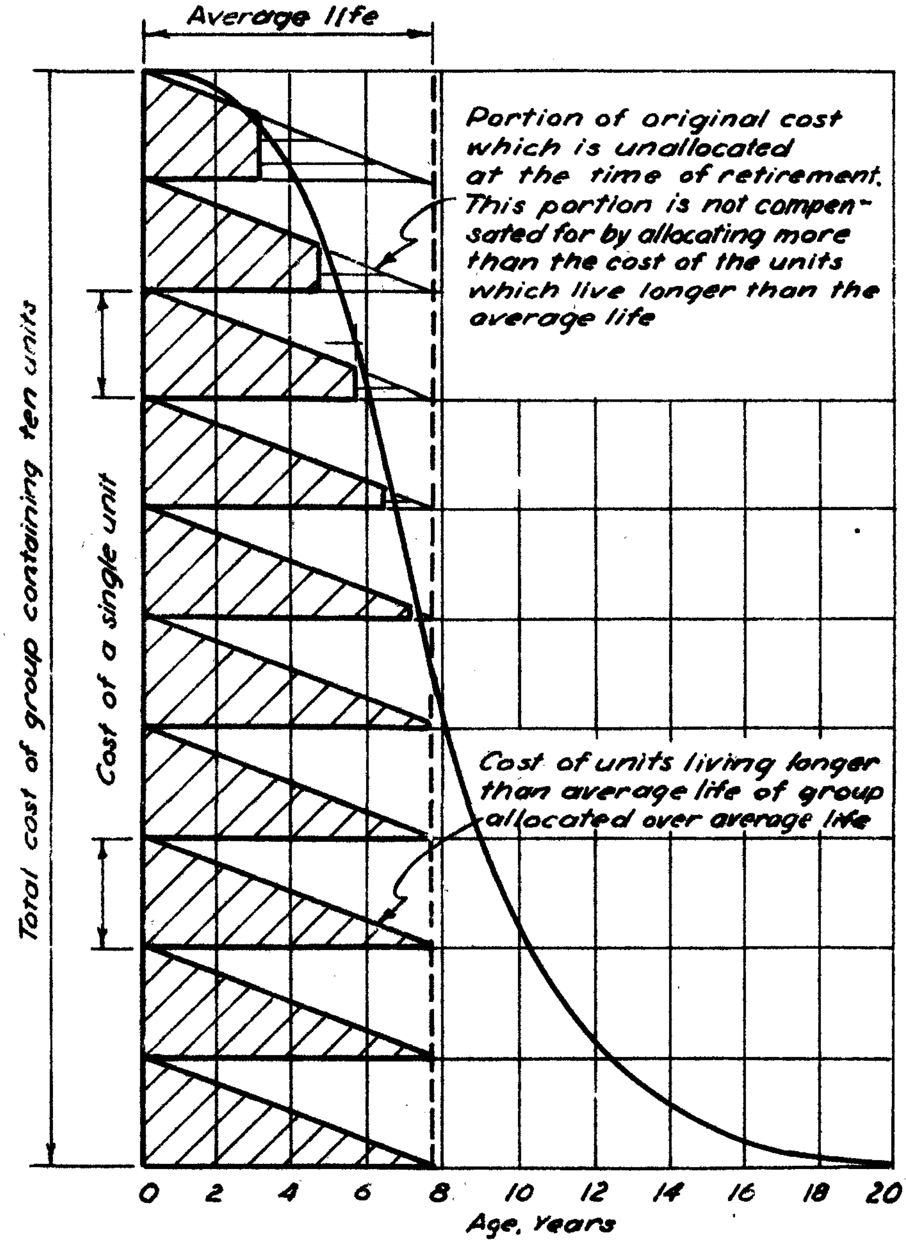

Fig. 20. Modified average life method in which the original cost of the surviving units in the group is allocated over the average life of the group.

Since expectancy = probable life - age,

$$\text{unallocated cost} = \text{cost new} \left(1 - \frac{\text{age}}{\text{probable life}}\right),$$

$$\text{allocated cost} = \text{cost new} \left(\frac{\text{age}}{\text{probable life}}\right).$$

Whatever the units of age and probable life, the increase in age is in part offset by the increase in probable life. Thus, instead of relating the allocation of cost to either the number of property units or to services originally inherent in the group each of which is a constant, the allocation of cost is related to the variable, probable life. Although the probable life method allocated the cost of the group over the life of the group, it must be rejected because the allocation does not conform to any of the accepted bases of allocating cost.[1]

Average life method

A significant advantage of the average life method is its ease of application. An allocation for a life period of the group can be made by determining the average investment during that period and dividing it by the average life of the group. The average invest-

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[1]Although this method has been rejected on other grounds it should be noted that it is one of the few in which the individual unit in the group is not considered. It is strictly a group method.

ment may be approximated by finding the arithmetic mean between the investment at the beginning and the end of the interval. The correct average investment must be equal to the area under the survivor curve for that life period, figure 21b. The arithmetic mean will be greater or less than the area depending upon the shape of the segment of the survivor curve during that interval. The survivor curves in figure 21 represent the same original group expressed in dollars and in physical units. Thus at any age the ratio of the corresponding ordinate on curves 21a and 21b is the cost of a property unit.

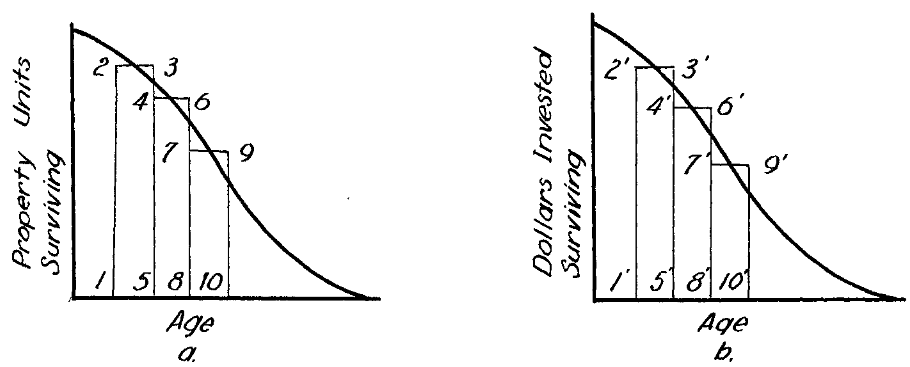

Fig. 21. An illustration of average investment and equal allocation per unit of service as used in the average life method.

The charge per unit of service is equal to the allocation per period divided by the number of units of service utilized during the period. Since the area under the survivor curve in figure 21a represents the units of service and the area under the curve in figure 21b during any single age period equals average investment, the cost of a unit of service is

$$\frac{\text{Area } 1235}{\text{Area } 1'2'3'5' \text{ (average life)}},$$

but Area 1'2'3'5' = cost of a property unit x Area 1235 which results in a unit of service cost of

$$\frac{1}{(\text{cost of a property unit}) \times (\text{average life})}.$$

The cost of a unit of service during any other period may be determined in the same way, e.g.,

$$\frac{\text{Area } 4685}{\text{Area } (4'6'8'5') \times (\text{average life})} =$$

$$\frac{1}{(\text{cost of a property unit}) \times (\text{average life})}.$$

Thus, if the average life is forecast accurately, the cost of a unit of service for all periods will be equal. Thus, <u>when the average life is expressed in service units, the average life method of allocating the cost of an original property allocates equal cost to each unit of service</u>. Therefore, the claim that the average life method results in equal cost per unit of service is based on two assumptions. First, the average life is expressed in service units. Second, the average life can be forecast accurately at age zero.

The fact that the average life method may allocate cost equally to a group of homogeneous service units is presented as ample reason for its acceptance. Disregarding the two restrictions, it is doubtful whether this constancy of cost necessarily corresponds to the trends in the costs of other factors of production which are not subject to cost-depreciation policies. For example, consumable supplies and labor costs do not remain constant throughout the period of time which many of these long-lived properties exist even though these supplies and labor services might be the same throughout the period. However, it is a matter of judgment whether this equality of cost of homogeneous services is representative of the conditions extant. In general, it appears to be a plausible first approximation.

The average life method may be represented graphically in either of two ways. The usual application[1]

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[1] "Under the 'group method' an average service life is estimated for an entire group of similar plant units, and the rate indicated by such estimate is applied to the cost of units in use for the period of average life, or until the amount to be depreciated has been fully accrued. With the emphasis on average life the balance of depreciation allowance at any point is considered to apply to the group as a whole rather than to the particular units of the group. When a retirement occurs, accordingly, the gross book value less salvage is charged to the allowance account with no recognition of retirement profit or loss." W.A. Paton, op. cit., p. 267.

of a constant rate (equal to the reciprocal of the average life) to the average investment is illustrated in figure 22. In this illustration the cost of those units which are retired before average life which is unallocated is compensated for by the allocation of more than the original cost of the units which live longer than the average life. In figure 22 the cost of a group of 10 equally priced property units (with zero or equal salvage values) is represented by 10 equal increments placed one above the other such that the ordinate at age zero represents the depreciable cost of the group and the shaded ordinate at any age represents the unallocated cost. In figure 23 the average life method is represented in a different manner by a group which is assumed to follow a straight-line survivor curve.[1]

The average life method allocates the total cost of the property over the maximum life of the group regardless of the shape of the survivor curve. From the defi-

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[1]A detailed discussion of the properties of the straight-line survivor curve is presented by J.C. Hempstead in Derivations of Renewals and Condition Percent Curves for the Straight-line Survivor Curves and Investigations of Normal Condition, unpublished professional C.E. Thesis. Ames, Iowa, Iowa State College Library. 1942.

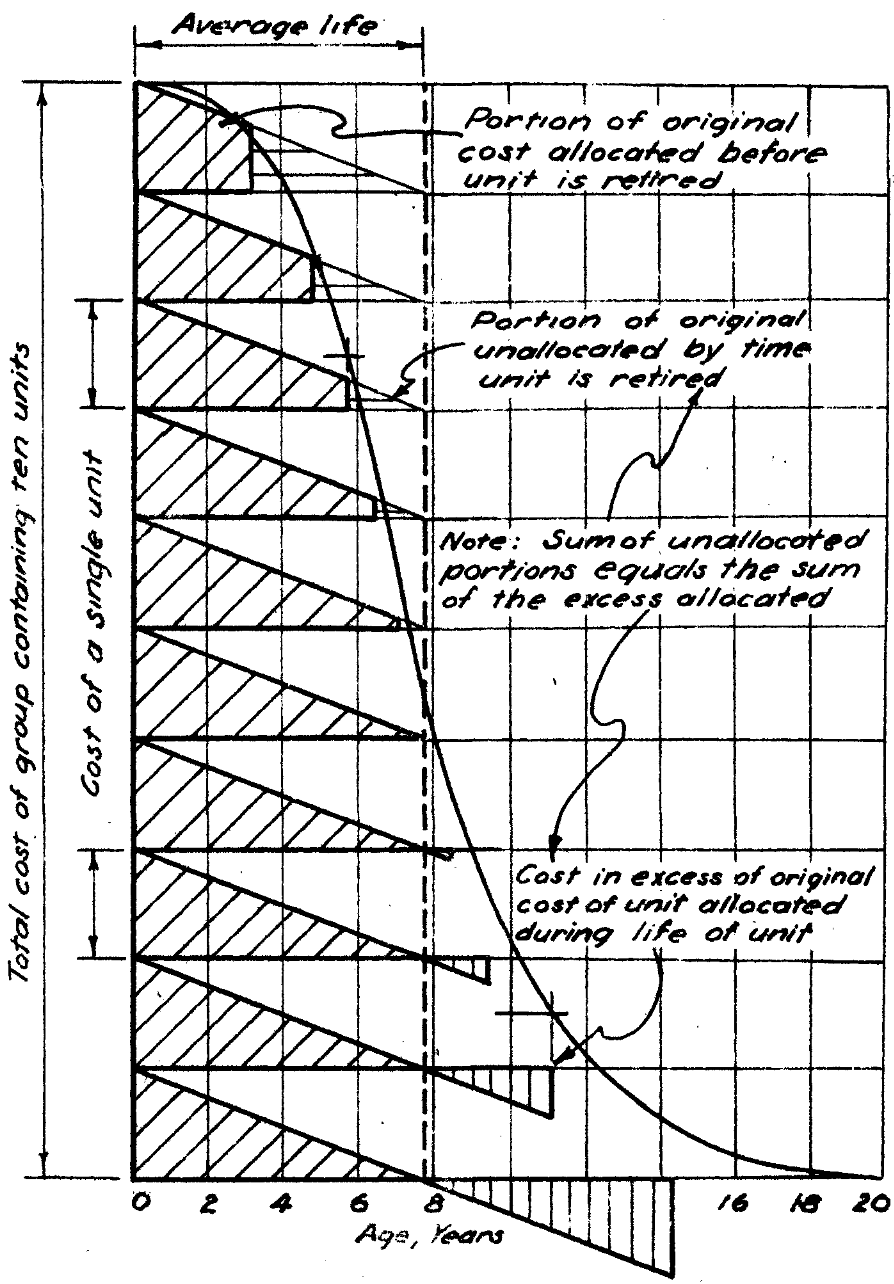

Fig. 22. Customary average life method in which the annual allocation based on the average life is applied over the life of the unit

nition of average life the following relations can be written:

$$\text{Total allocations} = \sum_{0}^{n} \frac{\text{average investment}}{\text{average life}},$$

when average life is constant;

$$\text{total allocations} = \left(\frac{1}{\text{average life}}\right) \sum_{0}^{n} \text{average investment per unit of time},$$

but in figure 21b

$$\begin{array}{c} \text{average investment} \\ \text{for a unit of time} \end{array} = \begin{array}{c} \text{area under survivor curve} \\ \text{for that unit of time;} \end{array}$$

$$\sum_{0}^{n} \begin{array}{c} \text{area under sur-} \\ \text{vivor curve for} \\ \text{a unit of time} \end{array} = \begin{array}{c} \text{area under the survivor} \\ \text{curve;} \end{array}$$

$$\text{and average life} = \frac{\text{area under survivor curve}}{\text{cost new of the group}}.$$

Thus,

$$\text{Total allocations} = \left(\frac{1}{\frac{\text{area under survivor curve}}{\text{cost new of the group}}}\right) (\text{area under survivor curve})$$

$$= \text{cost new of the group.}$$

Regardless of the shape of the survivor curve, i.e., the distribution of retirements, the total cost of the group will be allocated over the maximum life of the group if, at age zero, the average life is forecast correctly. The following quotation from a recent textbook in advanced accounting demonstrates that this principle of group property accounting is not yet well understood.

> This procedure [average life method] clearly involves the assumption of a retirement curve of such a nature that the underdepreciation on early retirements will be offset by the overaccrual on units remaining in service beyond the average life term. To validate such an assumption the retirements must be uniform throughout a period of which average life is the midpoint, or show a symmetrical or irregularly offsetting course on each side of such point.[1]

Kimball[2] suggested that the average life method could be represented by considering that each unit in the group was repriced in proportion to its service capacity. Then the cost-depreciation charges are made according to the expiration of the units of service. If the average life is stated in the dimensions of the service rendered and the consumption of service is the basis of allocation, the variation in the unallocated cost of each property unit will be represented by a straight line.

The graphic representation of Kimball's suggestion in figure 23 assumes that the group is composed

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[1] W.A. Paton, op. cit., p. 268.

[2] B.F. Kimball. The failure of the unit summation method as a group method of estimating depreciation. Econometrica. 13:229. 1945.

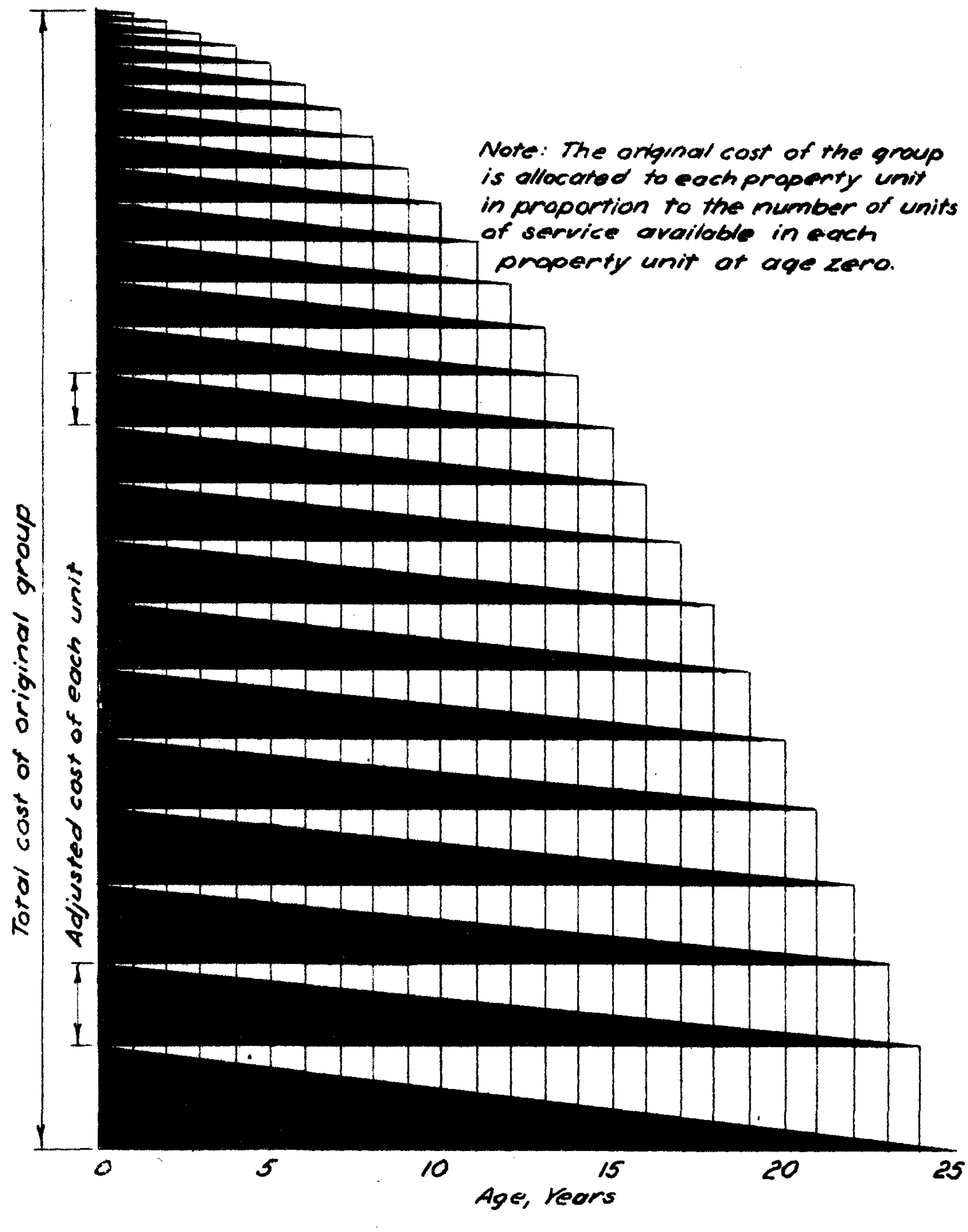

Fig. 23. Average life method in which the original cost is adjusted in proportion to the services available from each unit at age zero and allocated over the life of the unit.

of 25 units whose retirement characteristics correspond to a straight line survivor curve. The cost of each unit after it has been repriced to correspond with its service capacity is represented by the ordinate at age zero. The unallocated cost of the group at any age is equal to the sum of the shaded ordinates.

Unit summation method

The unit summation method is based upon the allocation of the cost of each individual unit within the group over its life. The allocation of the cost of the group is the sum of the allocations of the cost of the individual units. The unit summation method has the significant attribute of yielding the same result as though the property units are considered singly when the forecast of the lives of the individual units corresponds to the mortality characteristics of the group. Since many firms use both individual property accounts and group property accounts, this group method yields cost-depreciation dollars which are based on the same principles as the methods applied to individual units.

The allocation of cost over the life of the individual units may be made according to any of the methods which can be applied to the individual units.[1] If the allocations are based on the straight-line method and the group retirement characteristics follow a straight-line survivor curve, figure 24 represents the unit summation method applied to a group of equally priced units in a group. The costs of the property units are represented one above the other on the zero ordinate. The unallocated cost at any age is equal to the sum of the shaded ordinates. Conversely, the accrued depreciation is equal to the sum of the unshaded ordinates. Regardless of the method of allocation, the cost which is allocated to production for the units of service from the property which is retired before average life will always be greater than the cost which is allocated to production for the units of service rendered by the properties which are retired after average life. Consequently, the units of service from the group will cost more during the early life of the property group than during the later life.

The justification of the unit summation method or the average life method is a matter of judgment as to

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[1]One of the original studies on a method of calculating this allocation was made by M.R. Good in Method of Determining Condition Percent of Physical Properties. Unpublished M.S. Thesis. Ames, Iowa, Iowa State College Library. 1927.

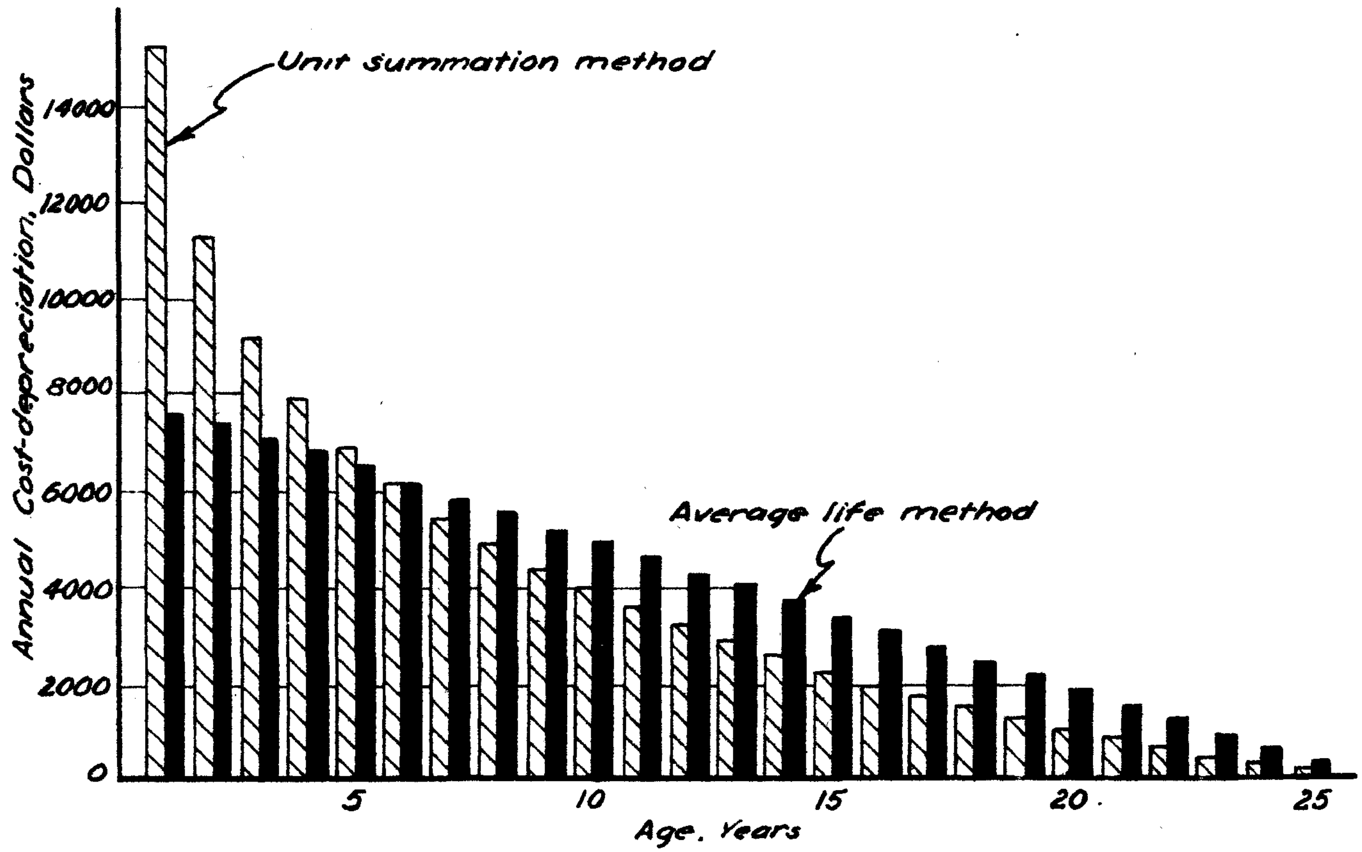

Fig. 24. A comparison of the annual cost-depreciation calculated by the average life method and unit summation method applied to an original group with straight line mortality distribution and straight line allocation, cost of group $100,000, average life, 12.5 yr.

whether each property unit of the group should have its cost allocated over its life or each unit of service should be allocated equal increments of cost. The basis upon which Kimball advocates the average life method and Winfrey advocates the unit summation method are as follows: Kimball states his criteria for group methods as:

> The point of view for testing the validity of a group method of estimating depreciation which will be used in this article will be that of regarding depreciation as a measure of the proportion of production capacity of a group of machines that has been expended at the time that the depreciated value is determined. . . . The essential requirement will be that at the time a given unit of service is performed, it is to be considered irrelevant which machine performs this service, and at what age the machines performs the service.[1]

Winfrey states the following criteria by which he supports the unit summation method:

> The unit-summation procedure ... [is] the only mathematically correct procedure [which] results in the average condition percents of the survivors because it considers separately each surviving unit.[2]

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[1] B.F. Kimball, op. cit., p. 225.

[2] Robley Winfrey. Depreciation of group properties, op. cit., p. 71.

A comparison of the average life method and unit summation method of allocating the cost of an original group reveals certain general relations. First, the cost per unit of service is constant when estimated by the average life method whereas the cost per unit of service decreases in the later life of the group when the unit summation method is used. Second, when the unit summation method is used the estimated annual allotment during the early life of the property is greater than the estimated annual allotment using the average life method. During the later years this relation is reversed. This relation of the annual allocation is true regardless of the retirement characteristic of the group. Figure 24 is a comparison of the two methods when the property retirement characteristics follow a straight-line survivor curve and the cost of the individual units is allocated by the straight-line method. Figure 25 is a similar comparison of a group property whose frequency curve of retirements is symmetrical, and S_2 type curve.[1] Figure 26 applies to a property group whose frequency curve is skewed to the right, an R_3 type curve.[2] Figure 27 applies

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[1]Ibid., p. 130.

[2]Ibid., p. 131.

to a property group in which the retirement characteristics correspond to an S_2 type curve, the same as in figure 25, but the allocation of the cost of the individual units is assumed to follow a curve similar to a six per cent sinking fund curve. The effect of the retirement characteristics on the distribution of the annual cost by either method is apparent from figures 24, 25, and 26 in which a straight line, symmetrical and skewed distribution are illustrated. In addition, the effect of a variation in the allocation of the cost of the individual units over their lives according to either the straight-line or sinking fund curve as applied to an S_2 type curve is apparent from a comparison of figures 25 and 27.

A comparison of figures 28 to 31 of the unallocated cost of the various property groups which have been discussed previously reveals that the unit summation method always produces a smaller unallocated cost at any age than the average life method. This relation occurs because the unit summation allocates enough funds to cover the cost of each property unit by the time it is retired plus the cost-depreciation of the property in service, but the average life method does not allocate enough funds to cover both the cost of all property units

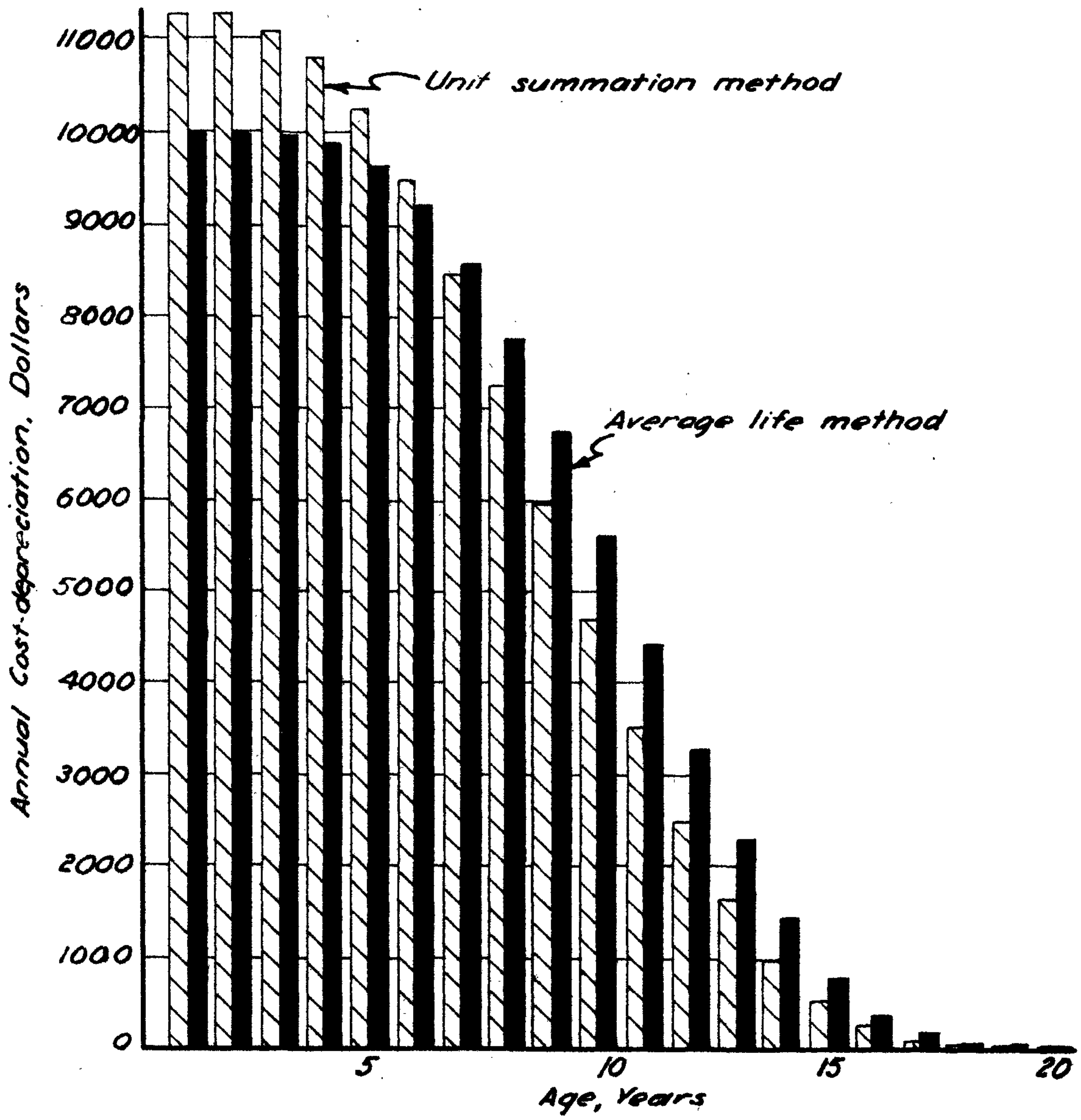

Fig. 25. A comparison of the annual cost-depreciation calculated by the average life method and the unit summation method applied to an original group with an S_2 mortality distribution and straight line allocation, cost $100,000, average life 10 yr. (Winfrey, Bulletin 155 op. cit. p. 94 & 96)

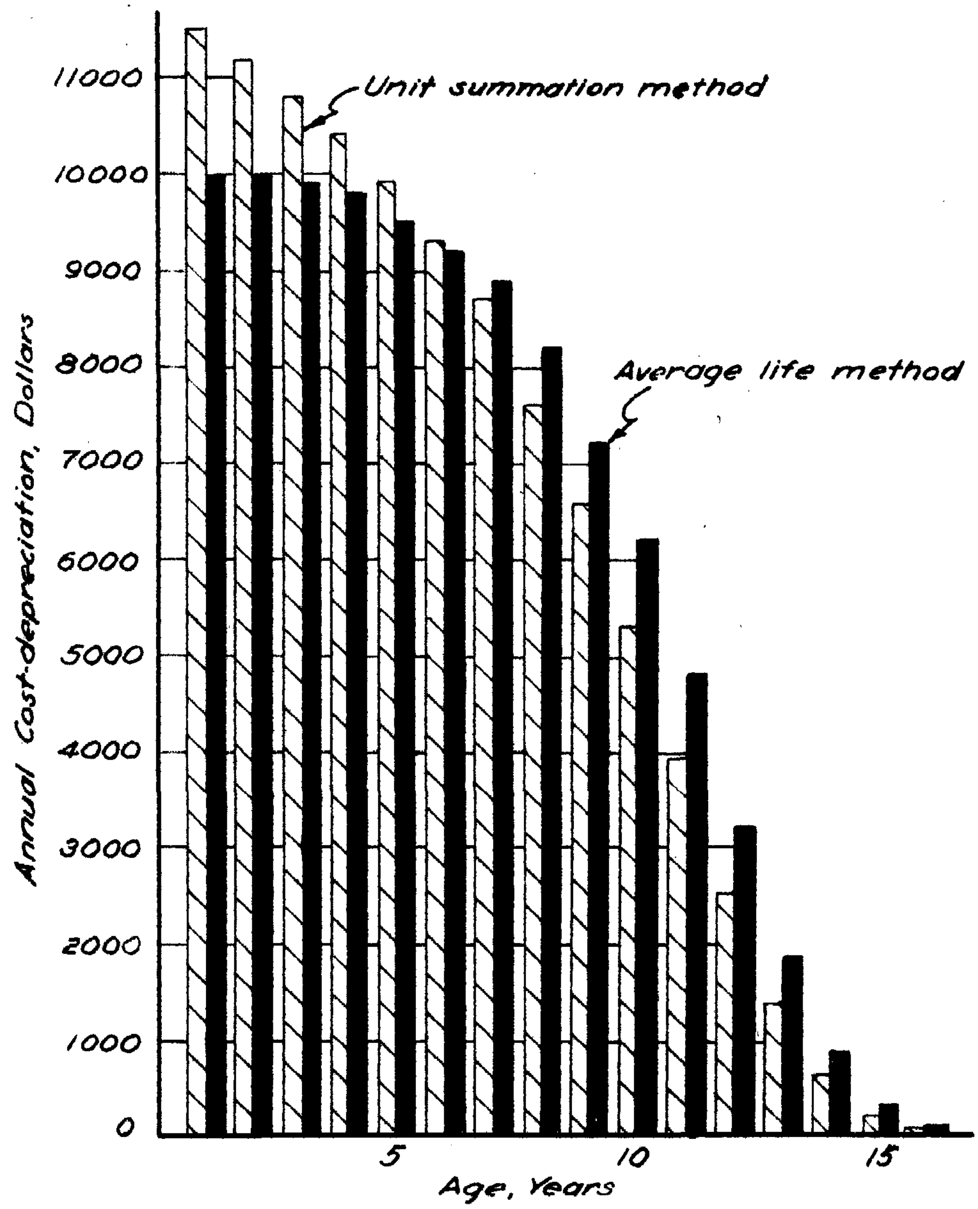

Fig. 26. A comparison of the annual cost-depreciation calculated by the average life method and the unit summation method applied to an original group with an R_3 mortality distribution and straight line allocation, cost = $100,000, average life = 10 yr. (Winfrey, Bulletin 155 op. cit. p. 169)

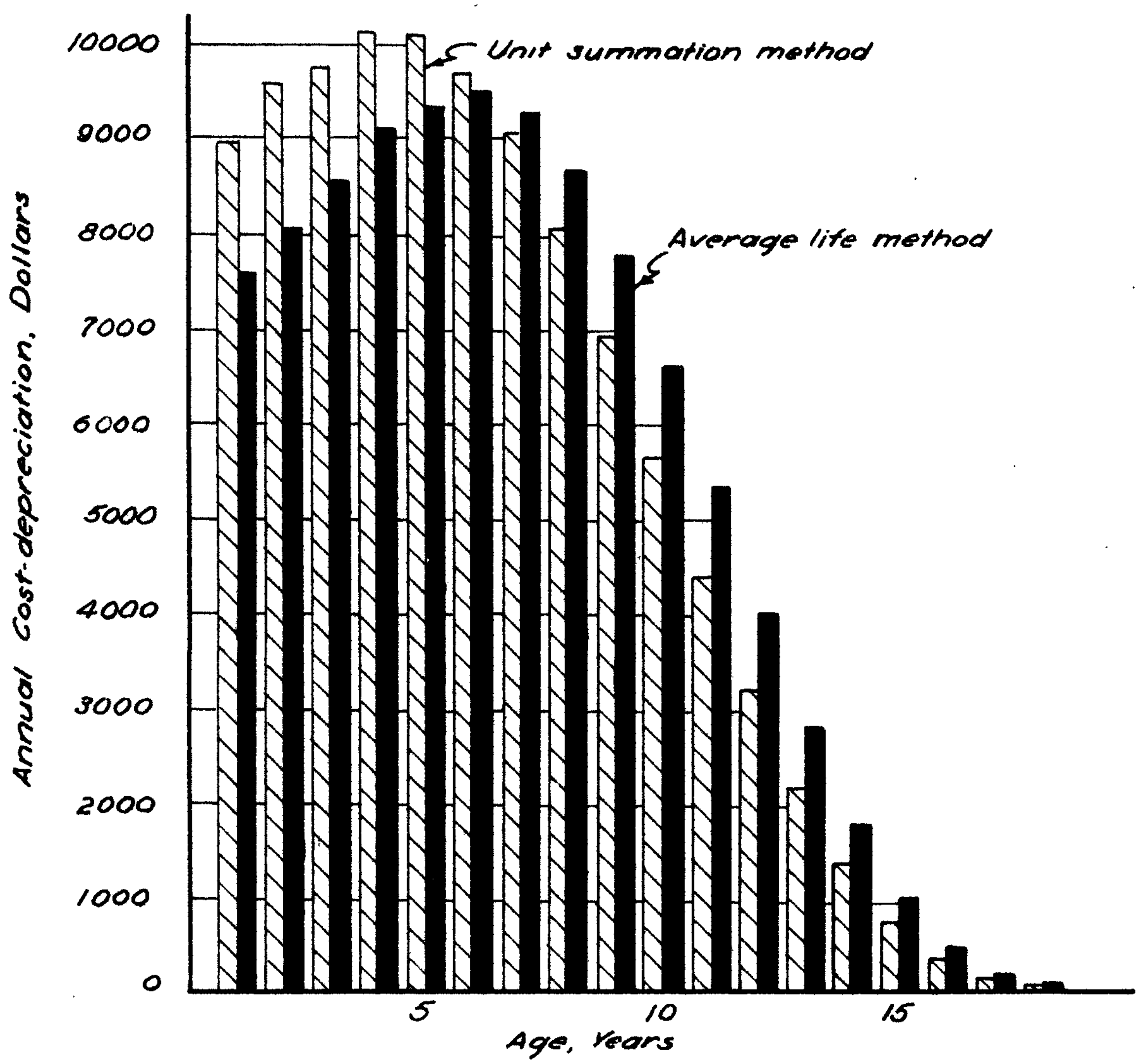

Fig. 27 A comparison of the annual cost-depreciation calculated by the average life method and the unit summation method applied to an original group with an S_2 mortality distribution and sinking fund allocation using 6% interest rate, cost = $100,000, average life = 10 yr. (Winfrey Bulletin 155 op. cit p. 98 & 101).

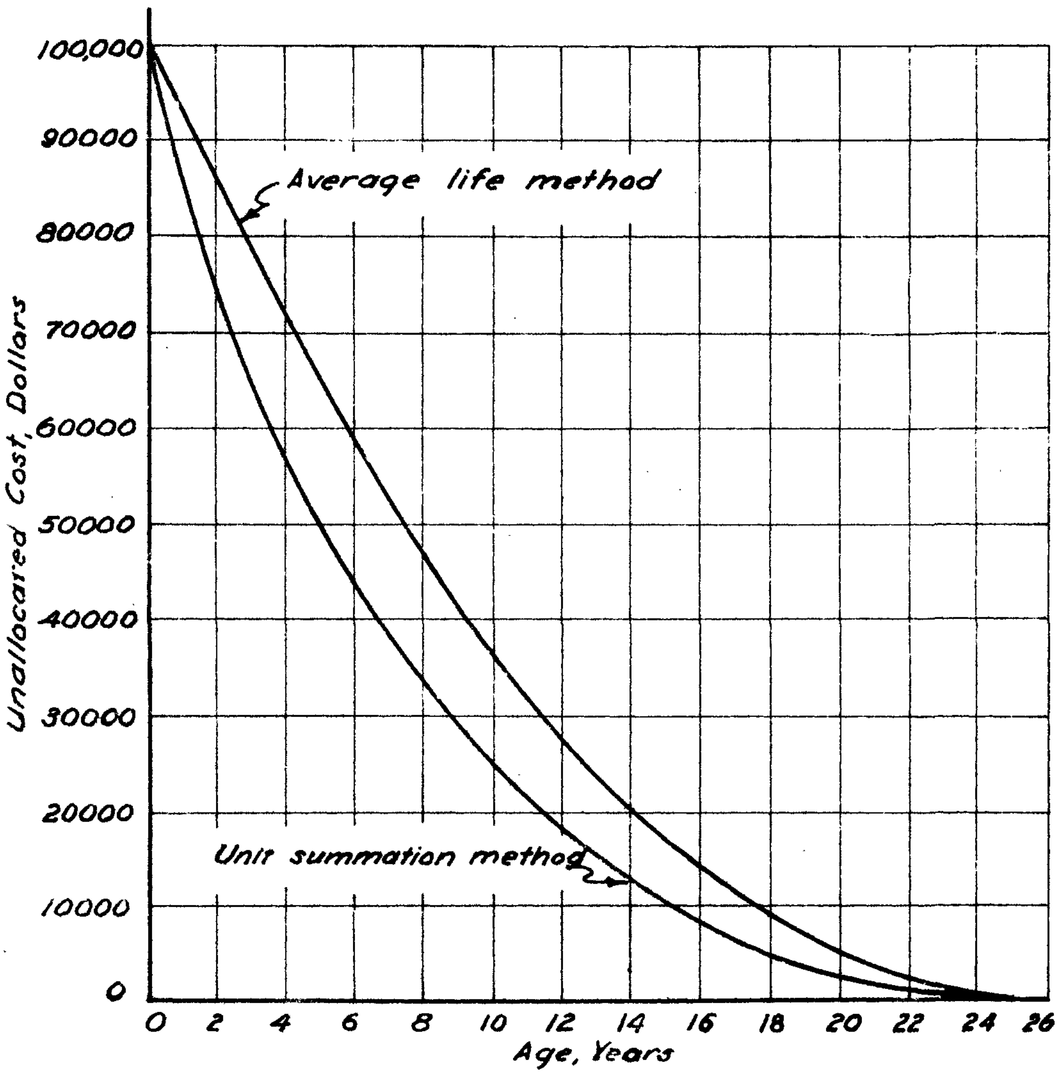

Fig. 28. A comparison of the unallocated cost calculated by the average life method and unit summation method applied to an original group with a straight line mortality distribution and straight line allocation, cost = $100,000, average life = 12.5 yr.

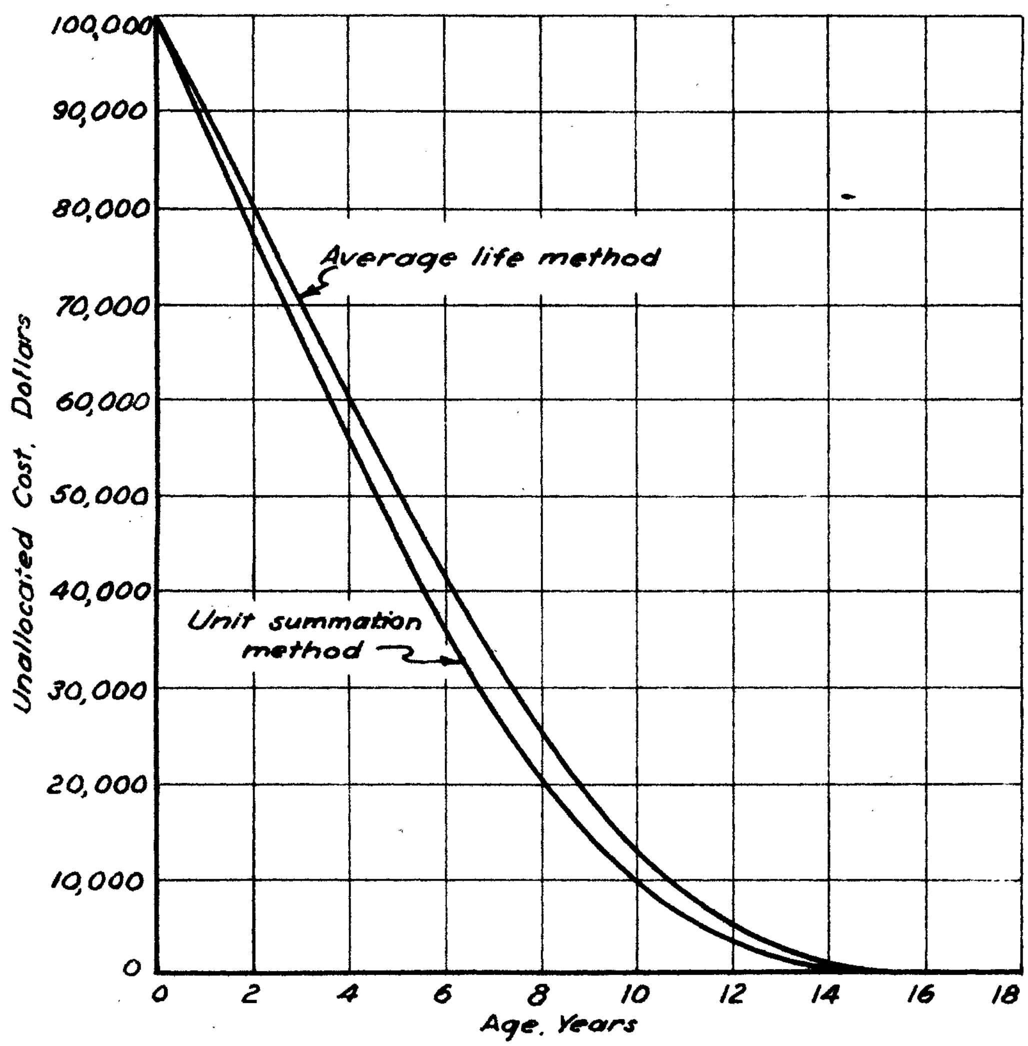

Fig. 29. A comparison of the unallocated cost calculated by the average life method and the unit summation method applied to an original group with an S_2 mortality distribution and straight line allocation, cost= \$100,000, average life = 10 yr. (Winfrey, Bulletin 155, op. cit. p 94 (96).

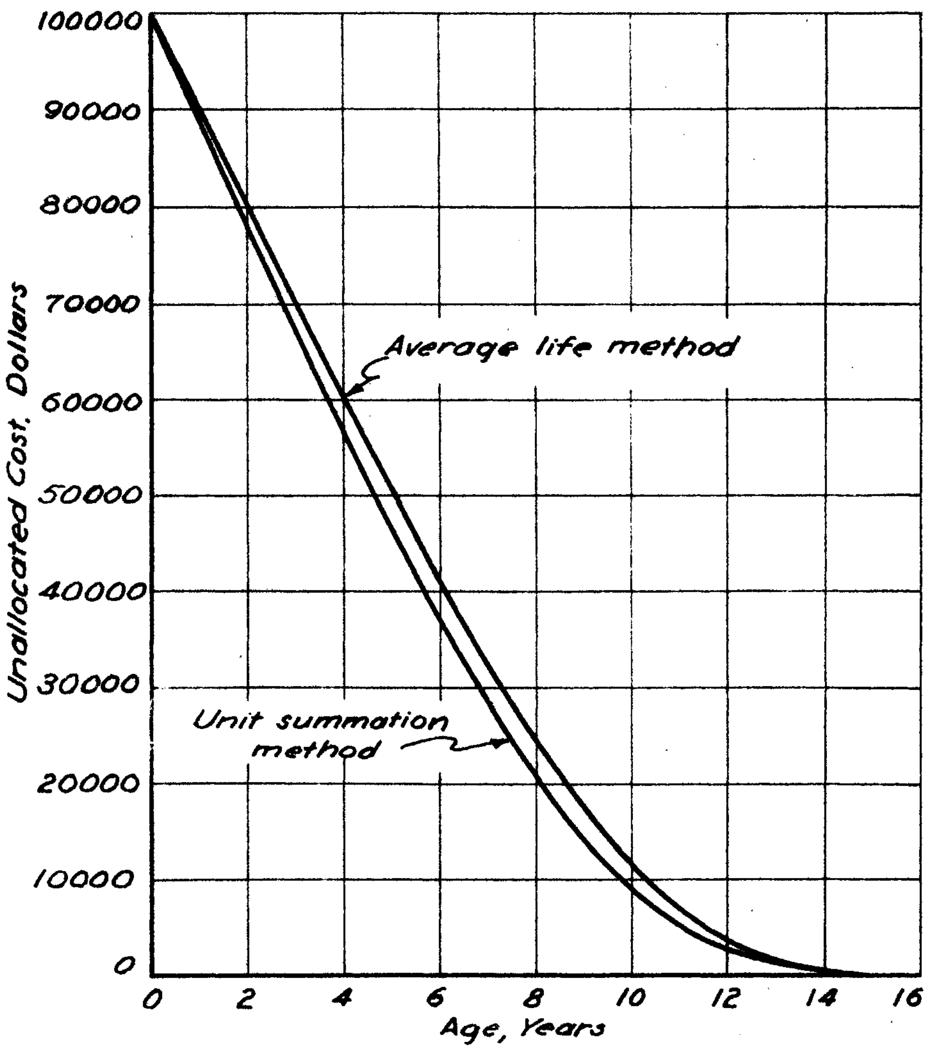

Fig. 30. A comparison of the unallocated cost calculated by the average life method and the unit summation method applied to an original group with an R_3 mortality distribution and straight line allocation, cost = \$100000, average life = 10 yr. (Winfrey, Bulletin 155, op. cit. p 169).

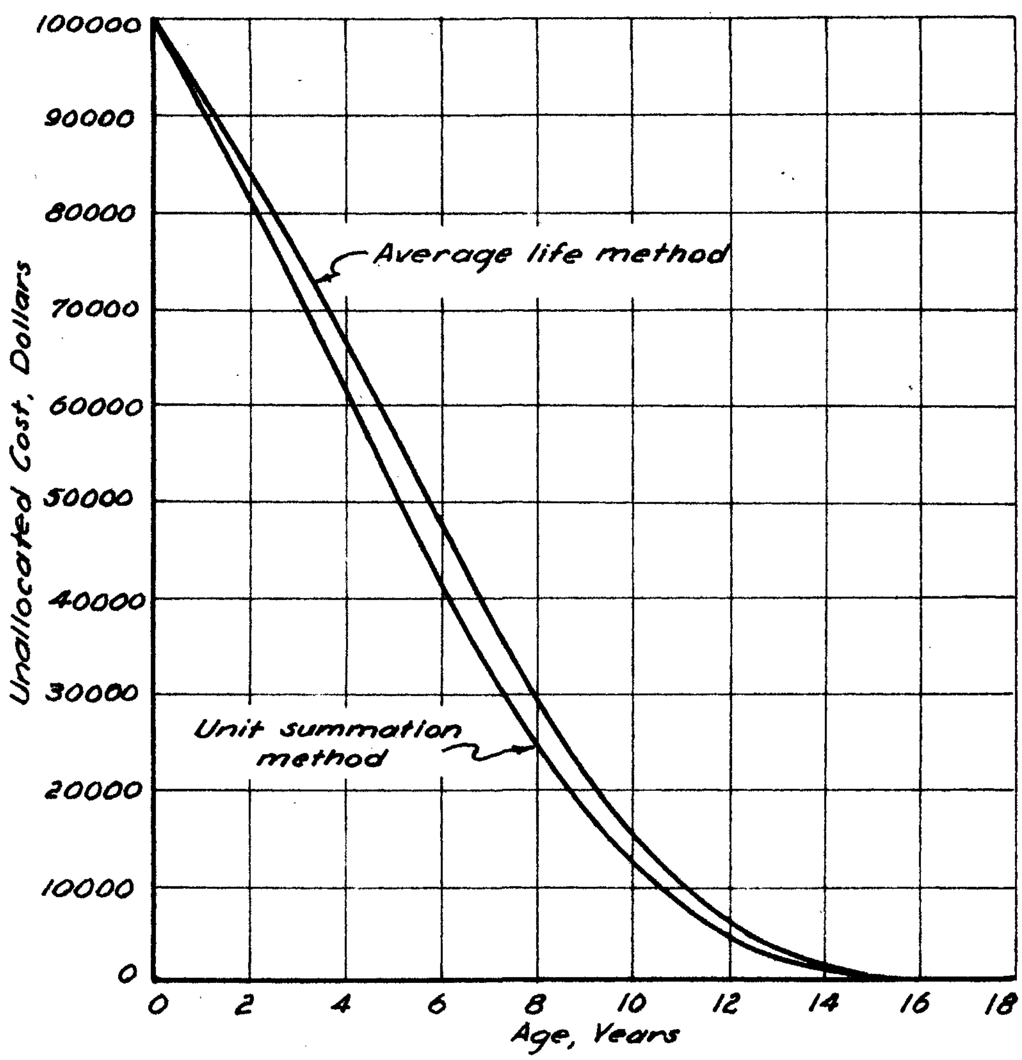

Fig. 31. A comparison of the unallocated cost calculated by the average life method and the unit summation method applied to an original group with an S_2 mortality distribution and sinking fund allocation, using 6% interest rate, cost = $100,000, average life = 10 yr. (Winfrey, Bulletin 155, op. cit., p. 98 & 101).

retired and the cost-depreciation of the units in service until the group is retired. Conversely, the depreciation reserve[1] is always greater when the unit summation method is used. Figure 32 is a reproduction of Winfrey's comparison of the reserves for the S_2 type curve.

The use of a group method in preference to the individual unit method has advantages other than the savings in accounting time. The grouping of similar properties provides a systematic means of providing for the anticipated variation of the lives of the units within the group whereas the lives of similar units considered separately will be assumed to have equal probable lives until the property has aged sufficiently to accentuate the differences between the units. At the same time the inspection of individual units for accounting purposes can be replaced by the analysis of retirement data supplemented occasionally by a personal inspection of the property. When a group of property units is considered as an entity, the resultant allocation of cost to

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[1]The depreciation reserve at any age is equal to the total past cost-depreciation allocations of the cost of the group up to and including that age less the sum of the cost of all units retired up to that age, i.e., the unallocated cost of the group and the cost of the retirements subtracted from the original cost of the group.

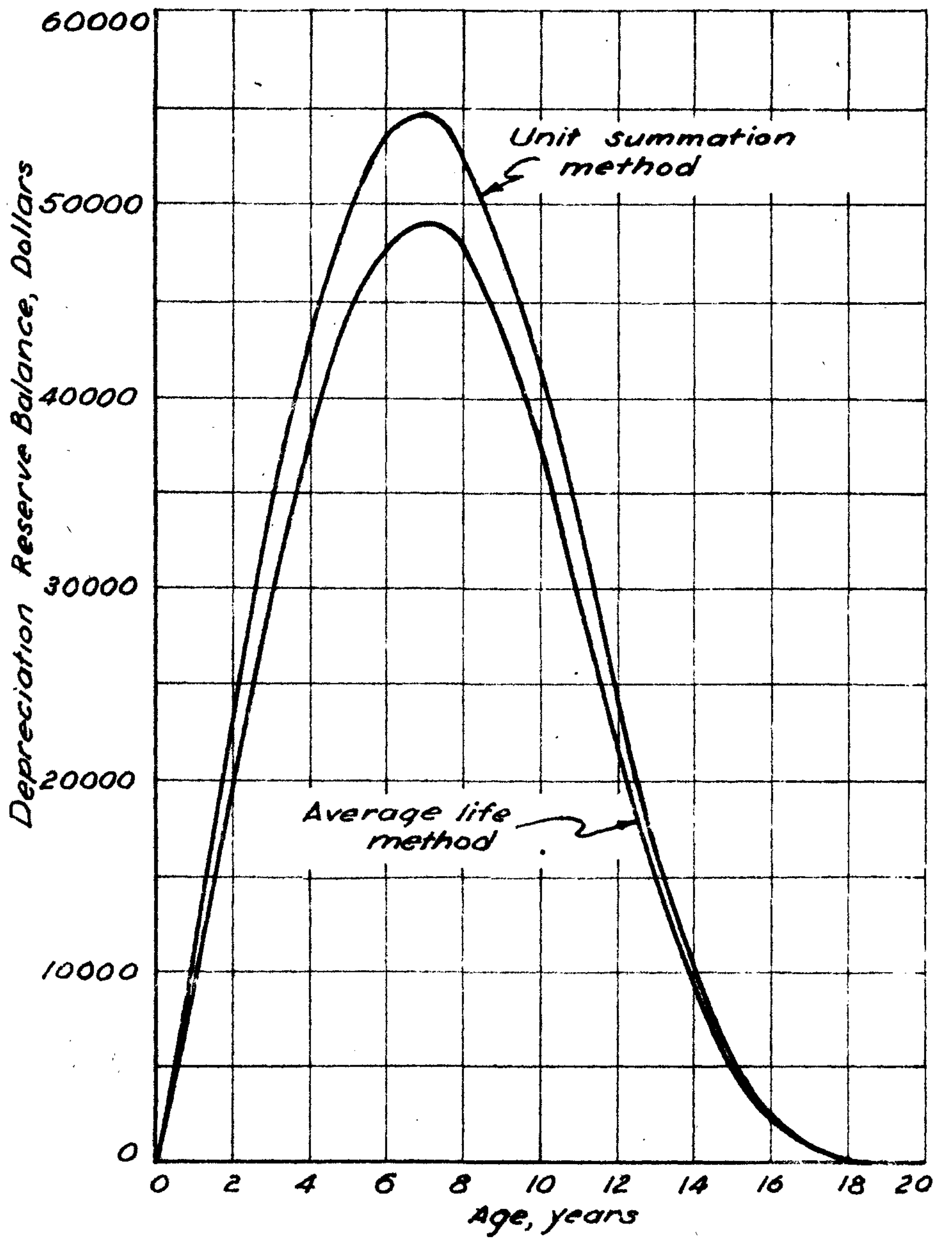

Fig. 32. A comparison of depreciation reserve calculated by the average life method and the unit summation method applied to an original group with an S_2 mortality distribution and straight line allocation, cost = \$100,000, average life = 10 yr. (Winfrey, Bulletin 155, op. cit. p.106).

successive periods generally will decline throughout the life of the group in a manner which can be predicted more reliably than the resultant sum of the allocations based on the cost-depreciation of each unit separately. The unit summation method will always allocate more of the cost to the early periods than either the average life method or the use of separate allocations for each unit of the group. In many instances the sum of the allocations of the cost of the units treated separately will approximate more closely the allocations based on the average life method[1] than the unit summation method.

The use of group methods and individual unit methods for different accounts under the same accounting management necessitates careful consideration of the significance of the result which is desired. If the combination of group methods and unit methods is to have any reasonable interpretation, both the group method and individual unit method should utilize the same basis of allocation. If the allocations are to be based on the equal

[1]The sum of the allocations of the separate units is based on the average investment but the rate will change whenever the estimate of the probable lives of the individual units is revised. In the average life method the base is the average investment but the rate remains constant.

cost of a unit of service, the average life method will yield equal cost per unit of service for group properties and the unit of production (use) method will yield equal cost per unit of service for a single property. However, when a few similar units are present, either they should be treated as a group or the allocations of the cost of the individual units should be averaged before including the allocations with those made by the average life group method and unit of production method. If the allocations are to be based on the allocation of the cost of each property unit over its life, the unit summation method will produce this result for a group of property units. The results of the unit summation method will be compatible with the allocations of any number of similar or different kinds of individual property units provided the same basis of allocation of the cost of the individual units is utilized in the calculation of the unit summation constants.

Adjustment of group property accounts

The correction of the error in forecasting the retirement characteristics for group properties necessitates the adjustment of cost-depreciation allocations. These allocations may be affected by both the forecast of the "type curve" and the average life of the property group. Thus, the adjustment of accounts may be caused by evidence that the average life is changing or the retirements are not following the predicted mortality curve or a combination of these. The accuracy of the forecast of mortality characteristics is comparatively easy to check by comparing the realized survivor curve of the original group with the predicted survivor curve. Since the average life, the retirement frequency curve, and the survivor curve are all interdependent, a deviation from the predicted survivor curve would indicate an error in the forecast and proper adjustments could be made. Consequently, it should be easier to detect an error in the forecast of the life characteristics of a group property than of a single unit.

Ostensibly, the adjustment of the accounts may be made by methods similar to those described for the individual unit. The two methods which will be considered are the surplus method and the spreading method. The surplus method retains the same general characteristics which were presented in the discussion of methods applicable to single units. However, the application of the "spreading method" to group properties, while retaining the characteristics of the average life method or unit summation method, is impossible. Since errors in forecasting the retirement of property units cannot be corrected by spreading, because the number of units in service is a physical fact, this error must be either adjusted abruptly upon discovery or ignored. This is true whether there is an error in the prediction of the average life or the survivor curve. Thus, the spreading adjustment cannot be applied to the unit summation method unless surplus (or profit and loss) adjustments are made at the time of the revision in which case it reverts to the surplus method. The spreading adjustment when applied to group properties can have significance only if the unallocated cost of the actual units remaining in service is "spread" over the forecasted remaining life. The spreading adjustment when applied to the average life method adjusts the cost-depreciation rate (which is determined by the revision of the forecast of the average life) but this revised rate cannot be applied to the average investment in the units in service during the accounting period and distribute the unallocated cost over the remaining life. Thus, the spreading method, as originally conceived for the adjustment of allocations pertaining to single units, is not applicable to the average life method.

The failure of the spreading method of adjustment to provide a satisfactory means of distributing the unallocated cost over the remaining life of a property group can be established by an examination of figure 33. Survivor curve A represents the original forecast of the survivor curve. Survivor curves B and C represent two possible revisions of the forecast at age x. First consider the effect of discovering at age x that the property was following survivor curve B, i.e., that they are actually r units in service at age x, not q units.

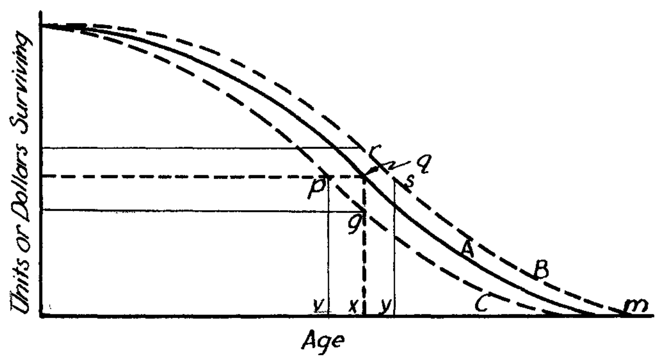

Fig. 33. An illustration of why the spreading method is not applicable when the forecast of the mortality characteristics of a group is revised.

If the average life method is being used, the average life of the remaining units should be based on curve B but a cost-depreciation rate based on this average life will be sufficient to allocate r dollars over the remaining life instead of q dollars. Thus, the adjustment on this basis allocates more than the remaining cost over the rest of the life of the group. If the revised forecast at age x had been curve C the reverse will be true, i.e., the rate will be sufficient to distribute g dollars over the remaining life and therefore will allocate less than the total cost over the life of the group. Another possibility would be to await age y before applying a depreciation rate based on curve B from y to m. However, if the revision had been to curve C this alternative would vanish. Even though the revision is to curve B, the cessation of allocating cost for any period is the equivalent of an adjustment to surplus through the profit and loss statement and should be recognized overtly as such.

If the unit summation method is being used the inapplicability of applying a rate based on the average life and number of units at r or g to q dollars is even more apparent than in the average life case. The reason this conflict in the spreading adjustment appears in a group property when it does not appear in the single unit method is that the physical units which exist at each age is a fact which can be established, whereas the unallocated cost of a single unit cannot be contradicted except by judgment. Thus, the spreading method which was shown to be undesirable when applied to a single unit ceases to have meaning when applied to a group of units.

An illustrative example of the effect of revising the forecast of the probable average life of a group when the type curve remains constant is presented in Table XIV and figure 34. The revision of the forecasts at ages 5 and 10 are accompanied by the following book entries:

Age 5

Average life method:

Surplus	2110.00	
Depreciation Reserve		2110.00

To adjust the depreciation reserve to correspond with the revised forecast of the average life.

Unit Summation method:

Surplus	2110.00	
Depreciation Reserve		2110.00

To adjust etc.

TABLE XV

Annual Cost-Depreciation and Unallocated Cost. Average Life Method and Unit Summation Method. Forecast of Average Life Revised and Adjusted by Surplus Entry

Forecasted Average Life = 11 yr. from age 1-6; 12 yr., age 6-11; 10 yr., age 11-20

	Average Life Method				Unit Summation Method		
Age Yr.	Investment Surviving, $	Depreciation Reserve Ratio, %[a]	Unallocated Cost, $[b]	Annual cost-depreciation allocation, $	Condition per cent	Unallocated Cost, $	Annual cost-depreciation allocation, $
0	100000						
1	99990	9.09	90910	9090	89.70	89700	10300
2	99990	18.18	81820	9090	79.45	79450	10250
3	99960	26.85	73150	8670	69.52	69500	9950
4	99900	35.15	64790	8360	60.16	60100	9400
5	99770	42.80	56670	8120	51.58	51460	8740
5†	97320	39.70	58760		55.02	53570	
6	94550	46.53	50560††	8220	47.65	45050#	8520
7	90300	52.60	42800	7760	41.06	37080	7970
8	84730	58.05	35540	7260	35.25	29870	7210
9	77600	62.94	28760	6780	30.19	23430	6440
10	69260	67.25	22680	6080	25.79	17860	5570
10†	50000	74.66	12670		18.73	9360	
11	38230	78.39	8260†††	4410	15.33	5860##	3500
12	27320	78.74	5000	3260	12.46	3400	2460
13	17960	81.71	2750	2250	10.02	1800	1600
14	10620	87.40	1340	1410	7.92	840	960
15	5450	89.88	550	790	6.12	330	510
16	2290	92.17	180	370	4.56	100	230
17	710	94.30	40	140	3.20	20	80
18	125	96.29	10	30	2.00	0	20
19	6	98.16	0	10	0.94	0	0
20	0		0	0	0.00	0	0

†entry based on revised forecast
††adjustment of surplus, credit $2110
†††adjustment of surplus, debit $10,100

#adjustment of surplus, credit $2110
##adjustment of surplus, debit $8500

[a]Depr.Res.Ratio = Dollars in Reserve / Cost of Survivors (Values from unpublished calculations by Robley Winfrey, Iowa State College, Ames, Iowa.)

[b]Unallocated cost = investment surviving (1-Depr.Res.Ratio)

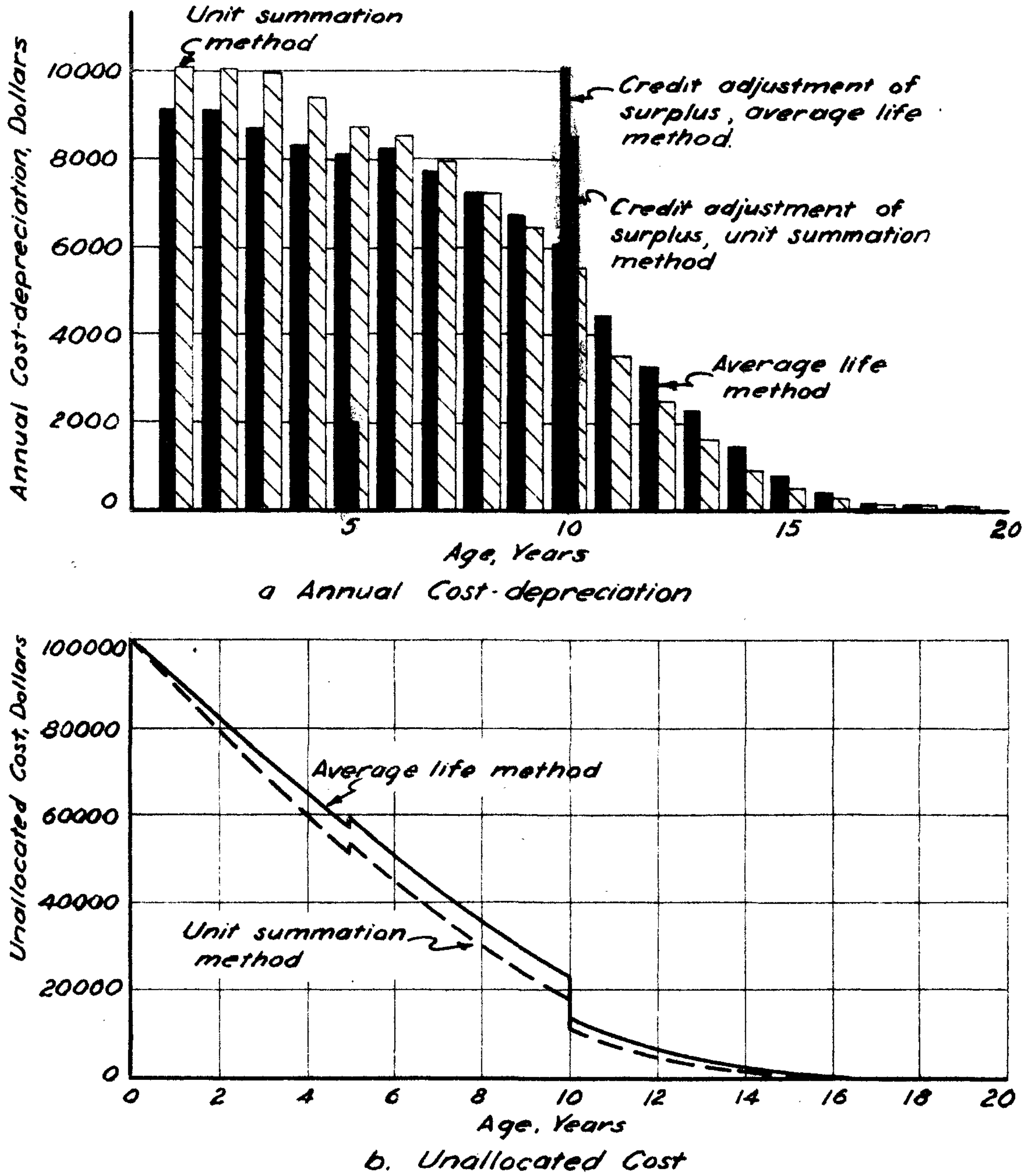

Fig. 34. A comparison of the annual cost-depreciation and unallocated cost calculated by the average life method and unit summation method using a surplus adjustment to compensate for a revision of the forecast of the average life of an original group with S_2 mortality characteristics; cost of group = \$100,000; $m_0 = 11$ yr.; $m_5 = 12$ yr., $m_{10} = 10$ yr.

Age 10

Average life method:

Surplus		10100.00
Depreciation Reserve	10100.00	
To adjust etc.		

Unit summation method:

Surplus		8500.00
Depreciation Reserve	8500.00	
To adjust etc.		

Similar conditions will be encountered if the revision involves a change of type curves or both a change of average life and type curves.

The allocation of the cost of an original group may be based on either of the two following principles, (1) the allocation is directly proportional to the services rendered compared to the total services rendered or (2) the allocation of each of the physical units by the time it is retired. In either case the adjustment of the allocations to successive periods of time and of the depreciation reserve must be made by an adjustment of the surplus (or its equivalent) <u>if the allocations based on the revisions are to continue to be based on the same</u>

principles which govern either the average life method or unit method.

Continuous Group

A continuous group of property is any group of units in which the installation of individual units is made over a period of years. The continuous group is a better representation of most of the group accounts in the average business than the original group. Businesses in general are established on the presumption that they will continue indefinitely. Thus property units are replaced upon their retirement unless a better means of obtaining the same service is discovered or the service is no longer needed.

Even though the analysis of a continuous group involves an original group analysis as an integral part of any study to determine the allocations of the cost of the group, the continuous group has certain inherent advantages. First, the number of accounts required to list the property is reduced. Second, the larger size of the group may aid in forecasting. Third, for stabilized continuous property groups the annual allocation of cost is dependent upon fewer variables.

The size of the continuous group may vary in many different ways. The variations may be caused either by a fluctuation in the number of units, by a fluctuation of the price of the units, or by a combination of these. The variations in the size of the group are classified as non-growing, growing, and declining property groups. Each has its counterpart in the business organizations of today. These trends may be discovered by a study of the placements and retirements which are a matter of record in the accounts of many companies.

The theoretical study of a continuous property group required the development of a method whereby the retirement of the property could be predicted from the original survivor and frequency curves. In order to simulate various conditions which affect the group it is necessary to utilize a technique whereby the size of a property group may be caused to respond to whatever assumptions are imposed upon it. Two ways in which this may be accomplished have been set forth by Preinreich and Winfrey.[1] A renewal function based on the calculus was

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[1]A method similar to Winfrey's is presented by E.B. Kurtz in The Science of Valuation and Depreciation, New York, The Ronald Press, 1937, p. 62-74.

introduced by Preinreich.[1] Prior to this A.J. Lotka contributed much to renewal theory. Preinreich proposes the solution of a Volterra integral equation as a means of representing the renewals of industrial properties. Lotka advocated a Hertz series as an approximation of the renewal series.

A tabular form representing the arithmetical calculation of the renewals based on a known survivor curve is presented by Winfrey.[2] The calculation of the renewals at any period of life by the tabular method requires the calculation of all the previous renewals.

The tabular method and calculus method of renewal calculations have their chief application in theoretical studies. Winfrey's tabular method can be understood by anyone acquainted with algebra. Preinreich's calculus method requires an understanding of advanced calculus. Preinreich's method has the advantage that the renewals function can be represented by a relatively short equation allowing greater ease in manipulation.

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[1] G.A.D. Preinreich. The present status of the renewal theory. Baltimore, Waverly Press Inc. 1940. 29pp.

[2] Winfrey, Bulletin 125, op. cit., p. 41-47, and Bulletin 155, op. cit., p. 44-48.

Winfrey's method is laborious and time consuming to manipulate. However, if the choice between the methods is to be made it will be on the basis of the background of the person using it, the average person will choose the tabular form and the skilled mathematician will choose the integral equation form.

The nongrowing or constant size continuous group provides the simplest approach to a study of continuous property groups. As a first approximation it is assumed that all retirements are replaced by identical units which have the same life characteristics as those retired. For example, if the original units follow an S_2 survivor curve with 10 years average life, the replacements also follow an S_2, 10-year average life survivor curve (figure 35). Calculations of this nature for each of the 18 type curves have been made by Winfrey. From these calculations it is possible to determine at various instants in time the age distribution of all of the property units in service. From these same calculations the allocation of the cost of the group by any of the methods can be made.[1] Also the average age of the property in

[1]Winfrey has calculated the cost-depreciation allocations, depreciation reserve, and possible net return by the average life unit summation, declining balance, and probable life methods in Bulletin 155, op. cit., pp. 107-116.

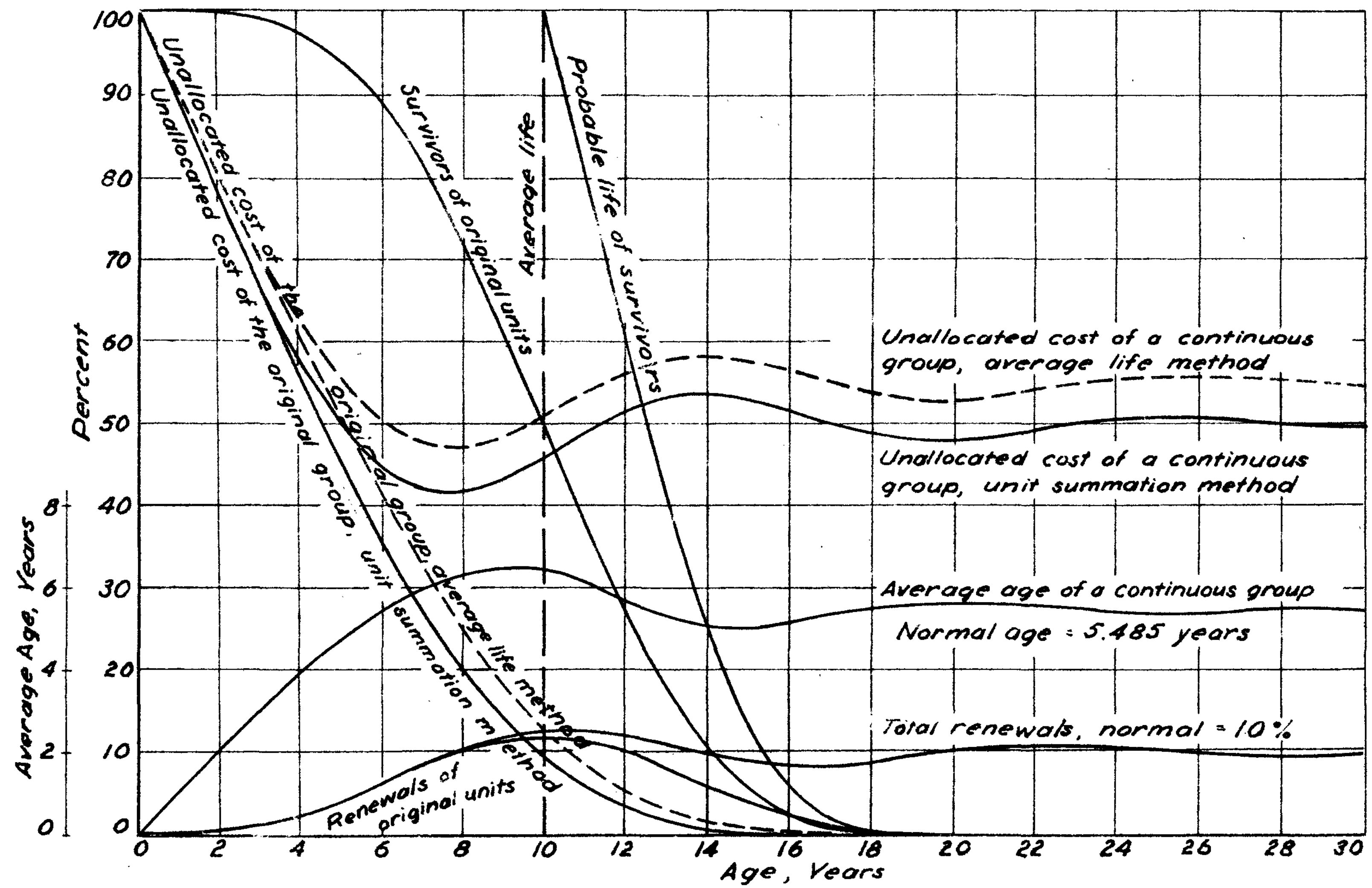

Fig. 35. Typical curves of a continuous property group with S_2 mortality characteristics. (Adapted from Winfrey, Bulletin 155 op. cit., p. 94, 96, 109, 111).

service can be determined. When these calculations are carried through several average life cycles, from 2 to 44 for the 18 type curves depending upon the shape of the frequency curve, the retirements (and renewals) approach within 0.1 per cent a limiting value. In the limit when the retirements have reached this constant the property is said to be stabilized. The stabilized property will have a normal average age, normal unallocated cost (normal cost-depreciation reserve), normal annual allocation for cost-depreciation.

The normal annual allocation for a stabilized nongrowing property is equal to the quotient of the cost divided by the average life which is equal to the original cost of the retirements.[1] This follows from the definition of a stabilized property and is true regardless of shape of the survivor curve or the method of allocation. Since the normal annual allocation equals the cost of the retirements and the cost of the retirements equals the cost of replacement, a continuous property group can be maintained at a constant number of dollars only by

[1]The normal annual allocation is equivalent to the first modification of the average life original group method which Preinreich called the economist's method. It should be noted that this method is applicable only to stabilized nongrowing property groups.

allocating to cost-depreciation an amount equal to the cost of the replacements. It is because of this independence of the annual allocation from all the variables except the average life or retirements that it is convenient to consider similar property units as a continuous property group. Preinreich arrived at this conclusion in his study of the calculus of depreciation theory:

> In the entirely static case, any method of depreciation will ultimately produce the same charge to operations. . . . The amount of profit reported by the books will ultimately be independent of the depreciation method.[1]

The normal average age of a continuous property group is also a constant. This follows from the conditions necessary for stability since the age distribution of the units in service must remain constant before the retirements will remain constant. The average age at which a group will stabilize depends upon the retirement characteristics of the group. The normal average age will be 50 per cent of the average life for a square type survivor curve, i.e., the "one-hoss shay" variety of property which is all retired simultaneously. The normal average age of the 18 type survivor curves varies from 50.3 per

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[1]Preinreich, Annual Survey, op. cit., p. 323.

cent of the average life for a high modal S_6 type curve, which approaches the square type, to 69 per cent for a low modal L_0 type curve.[1]

Unit summation method

The normal unallocated cost or cost-depreciation reserve[2] is dependent upon the method of allocation. The normal unallocated cost or cost-depreciation reserve which is consistent with the unit summation method is independent of the life characteristics of the group. The normal unallocated cost or cost-depreciation reserve which is consistent with the average life method of allocation is dependent upon the life characteristics of the group. Kimball[3] has presented an excellent discussion on the limits of the reserve ratio (the ratio of the depreciation reserve to the original cost of the group) in a recent article on continuous property. In this discussion he presents and proves twelve theorems concerning the plant accounts of a continuous property.

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[1]Winfrey, Bulletin 125, op. cit., p. 81.

[2]The cost-depreciation reserve of a stabilized group is equal to the cost of the group minus the unallocated cost.

[3]Kimball. The general theory of plant accounts subject to constant mortality low of retirements. Econometrica. 11:61-82. 1943.

The normal unallocated cost of a nongrowing continuous group consistent with the unit summation method is 50 per cent[1] of the original cost of the group. The criterion of a 50 per cent reserve has been misinterpreted and offered as proof[2] that the unit summation procedure is the only mathematically correct procedure, whereas the 50 per cent criterion should be applied only to those methods which attempt to depreciate the units individually within the group over their respective lives.

Average life method

The per cent of the normal unallocated cost of the original cost of a stabilized nongrowing continuous group which is consistent with the average life method is equal to one minus the ratio of the average age of the survivors to the probable life of the surviving units. The probable life of the survivors is the average life of the survivors. This ratio is equivalent to a ratio of the units of service given up by the survivors, to the total units of service available from the survivors when new, i.e.,

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[1] J.C. Hempstead, op. cit., p. 71

[2] Winfrey, Bulletin 155, op. cit., p. 50-59; Kimball, The failure of the unit summation method, op. cit., p. 228.

$$\%\ \text{normal unallocated cost} = 1 - \frac{\text{average age of survivors}}{\text{probable life of the survivors}},$$

$$\text{average age of survivors} = \frac{\text{age x number of units surviving at each age}}{\text{total number of units surviving}},$$

$$\text{probable life of survivors} = \frac{\text{total service available from surviving units at age zero}}{\text{total number of units surviving}},$$

thus,

$$\%\ \text{normal unallocated cost} = 1 - \frac{(\text{age x frequency})}{\text{total service available from surviving units at age zero}}$$

$$= 1 - \frac{\text{service available in future from surviving units}}{\text{total service available from surviving units at age zero}}$$

$$= \frac{\text{service of surviving units already consumed}}{\text{services available from surviving units}}.$$

This ratio of the units of service consumed to the total services available is the reserve ratio or one minus the ratio of the unallocated cost calculated by the average life method to the original cost. This relation between the average age and reserve size is verified by the calculations made by Winfrey for the 18 type curves. The average age as a per cent of average life varies from 50 to 70 per cent[1] and the reserve ratio varies from 50 to 30 per cent[2] of the original cost. The sum of the respective average ages as a per cent of average life and reserve ratio is 100 per cent in each case. The development of the relation between average age, average life of the survivors and the unallocated cost or cost-depreciation reserve is not restricted to stabilized properties but holds true regardless of the conditions imposed upon the group. Kimball[3] demonstrates that the cost-depreciation reserve based on the average life method is a function of the dispersion of the retirements and is equal to 50 per cent for a square type survivor curve. This relation is confirmed by Winfrey's calculation in which the reserve approaches 50 per cent as the dispersion decreases, i.e., the type frequency curves have higher modes.

Size of Reserve

In the past most of the interest in the size of the reserve has been displayed by the public utilities.

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[1]Winfrey, Bulletin 125, op. cit., p. 81.

[2]Winfrey, Bulletin 155, op. cit., p. 78.

[3]Kimball, The general theory of plant accounts . . ., op. cit., p. 82.

However, the increases in tax rates since 1940 and the use of the size of a reserve as evidence of the adequacy of the annual allocations has tended to increase the number of persons interested in the size of the reserve. Two schools of thought[1] concerning the size of the reserve of a stabilized group of property exist. First, there are those who believe that at stability the reserve should equal the 50 per cent of the survivors. Second, there are those who believe that a stabilized continuous property requires very little or no depreciation reserve. Many instances of each of these positions can be found in the literature. A few instances where each is supported are quoted in the following paragraph.

The concept of a 50 per cent reserve is held by men in all the professions concerned with depreciation. In the first book written on valuation by Matheson, an engineer, he states:

> A company owning twenty steamers, bought at an average cost of 18£ per ton will not be deemed financially sound, if the average book value at any time exceeds 12£

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[1]There is little evidence of a general recognition that the size of the reserve is dependent upon the method of allocation or that it may be a function of the mortality distribution of the property group.

> per ton. . . their final disposal may be at 6£ per ton or even at 2£ per ton. . .[1]

(If the salvage value is 6£ per ton the reserve ratio would be 6/(18-6) = 0.50 or if the salvage value is 2£ the ratio would be 37.5%)

An economist recently wrote the following:

> Assuming straight-line depreciation accounting, the depreciation reserves of a stable, mature utilities should theoretically approximate fifty per cent of the depreciable property.[2]

An accountant expressed his view on the size of the reserve as follows:

> After the plant has seasoned, the depreciation units are on the average one half depreciated and the minor parts are one half worn out.[3]

An investment adviser stated that a 50 per cent reserve was an easily demonstrated result of straight-line depreciation:

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[1]Matheson, op. cit., p. 109.

[2]E.W. Clemens. The critical issue of depreciation in public utility property. The Southern Economic Journal. 9(no.3):252. 1943.

[3]Carl T. Devine. Deferred maintenance and improper depreciation procedures. The Accounting Review. 22(no.1):42. 1947.

> It is easily demonstrated that a utility which is static in growth, straight-line depreciation under this theory will result in a 50 per cent Depreciation Reserve.[1]

An engineer who has helped develop "the science of . . . depreciation" stated:

> The per cent remainder service life of a system composed of a large number of new units of property is not constant during its early life history, but on the contrary oscillates violently. From its initial value of 100% it drops rapidly to below 50%, after which it rises above and drops below 50% alternately until after many life cycles it gradually approaches the 50% value. At that time the property has reached its ultimate condition, as well as a state of constant normal annual renewals.[2]

These quotations are representative of a widespread belief in the 50 per cent reserve at stability. In general, these opinions which are based on the cost allocation theory of individual units represent intuitive judgment concerning property groups. Generally, these opinions are stated without qualification regarding the method which is used to determine the allocations and reserves.

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[1]Philip L. Warren. Depreciation accounting innovations from the viewpoint of the investor. Edison Electric Institute Bulletin. 12(no.8):263. 1944.

[2]E.B. Kurtz, The science of valuation and depreciation, op. cit., p. 75.

On the other hand, many men have upheld exceptionally low depreciation reserves, i.e., high unallocated costs, for stabilized properties. Bonbright has called this the "plant immortality theory."[1] The claims for high unallocated costs are to be found in the recent writings of such men as Ferguson[2] and Packman.[3] In a recent study of public utility depreciation practices Clemens[4] states that ". . . engineers easily fall into a practice . . . that of identifying accrued depreciation with physical condition and operating efficiency." He amplifies this by saying:

> In fact the same engineers will testify both that the property is in near perfect operating condition and hence subject to no depreciation for the purpose of valuation and also that the property has but a limited life

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[1]Bonbright, op. cit., p. 1127-28; several cases cited.

[2]S. Ferguson. The significance of the term 'net property' as applied to public utilities. Edison Electric Institute Bulletin. 12(no.1):6-10. 1944.

[3]C.S. Packman. The depreciated original cost base, Edison Electric Institute Bulletin. 15(no.6): 169-192. 1944.

[4]E.W. Clemens. The critical issue of depreciation in public utility property. The Southern Economic Journal. 9(no.3):255. 1943.

> expectancy and must therefore be rapidly depreciated by large allowances in operating expenses.[1]

As evidence of this he cites among the references the testimony in Carey v. Corporation Commission, 33 Pac (2d) 788 (Oklahoma 1934) in which an established corporation's engineers claimed the property had a 92 per cent condition but asked for an 8 per cent annual cost-depreciation.

In many of these articles and books the relation between the annual allocation and the unallocated cost is vague because the term "depreciation" is used in an ambiguous sense, i.e., in terms of cost for the annual allocation and value for the reserve. In most books and articles the effect of the method of allocation upon the size of the stabilized cost-depreciation reserve is neglected. Thus, it is not uncommon to read an article by an individual using the average life method of determining the annual allocation and expressing the opinion that the reserve will stabilize at 50 per cent.

The effect of the growth or decline in the size of the reserve is of major importance. By either method of allocation the reserve will decline when a group of property grows and increase when a group of property

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[1]Ibid., p. 257.

declines in size. The size of the reserve resulting from the average life method is proportional to the ratio of the average age to the probable life of the survivors. The size of the reserve resulting from the unit summation method is a function[1] of the average age but not a direct proportion as in the previous instance of the average life method.

Adjustment of a continuous group account

The revision of an evaluation of the life characteristics of a stabilized nongrowing group will always affect the size of the "average life" cost-depreciation theoretical reserve. The same revision will not affect the size of the theoretical "unit summation" reserve. A change in the forecast of average life should not affect the annual allocations which at stability are based upon the retirements. A change in the forecast could affect the calculated allocations which are based on the average life. Property group accounts may require adjustment because of improper analysis of the retirement data or because influential factors controlling the use of the property change.

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[1] W.C. Fitch, op. cit., p. 54-84.

The adjustment of the cost-depreciation for a continuous group should be made by a revision of the annual allocation, if necessary, and a surplus adjustment. The surplus method is preferred for the same reasons it was preferred in the original group method. The spreading method would present the same anomaly when applied to the continuous group as it did in the original group method. An adjustment which is similar to the spreading adjustment and which is widely used is the arbitrary increase or decrease of the rate until the reserve is of proper size. Since the annual allocation of a stabilized property is fixed, the arbitrary change of rate is equivalent to an amortization of the error over whatever period is required to bring the reserve to the proper amount. In such cases, an overt statement of the change and the amortization policy would present a clearer picture of the adjustment.

<u>Summary, continuous groups</u>

The cost of a continuous property group may be allocated by either the average life or the unit summation methods depending upon the objective of the management's policy. For a nongrowing group the annual allocation is unaffected by the method of allocation. <u>The</u>

<u>method of allocation affects only the size of the reserve</u>. For a continuous nongrowing group the reserve resulting from the use of the unit summation method will be 50 per cent of the cost of the surviving units regardless of the life characteristics of the group. The reserve determined by the unit summation method is a reserve based on the cost-depreciation of each unit of the select group of property in service, whereas its reserve determined by the average life method indicates the service capacity of these units compared with the group originally purchased. Thus, the property in service is not a random group upon which the market price was based but a definitely superior group of units which were purchased with the expectation of a greater mortality rate than will occur now that the "weaker" properties have been replaced in part by the "stronger" units.

The accountants apparently subscribe to the principle upon which the unit summation method is based. In the manual "Contemporary Accounting" which was published in 1945 as a refresher course for public accountants who had been engaged in World War II, the following statement was made concerning group accounts:

> When depreciation was calculated on individual units, the accumulated reserve as to each unit was always

determinable. This, of course, was not usually true with respect to units included in a group with an over-all depreciation rate. However, until recent years, it was quite generally the practice to adopt the convenient assumption that, at any given date, the same percentage of cost had been accumulated in the reserve for depreciation with respect to each unit in a group. When any unit was retired, an adjustment was made in the current profit and loss to cover the deficiency or surplus in the accumulated reserve on the item retired on the basis of that assumption. It was later recognized that depreciation rates estimated for any group, even a group consisting of units having identical characteristics, must represent estimates of the average useful life of all units in the group, rather than an identical estimate as to the life of each separate unit; further, when the units did not have identical characteristics, that an estimate for the whole group must, in addition, represent an averaging of the average lives of the various types of units included in the group. Recognition of these facts made a different procedure necessary with respect to units retired. Except in unusual circumstances, a strong presumption existed that a unit had been fully depreciated when the time came for its retirement. In such case no profit-and-loss adjustment was required. The Bureau of Internal Revenue insists on this view.[1]

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[1]William D. Cranstoun. Tangible fixed assets. In Thomas L. Leland. Contemporary accounting. New York, American Institute of Accountants. 1945. Chapter 7, p.9.

The growth or decline in the size of a continuous group affects both the annual allocation and the size of the reserve. The growth of the property will tend to decrease the cost-depreciation rate and increase the ratio of the unallocated cost to the original cost (decrease the ratio of the reserve to the original cost) by either method of allocation. If the property is increasing in size at a constant rate the annual allocation and size of the reserve will stabilize. The decline in the size of the group will have the opposite effect on the allocation and reserve. The unallocated cost should decrease to zero when the last unit of the group is retired. The reserve should approach 100 per cent of the cost of the property surviving as the average age approaches the maximum life of the group. Thus, the size of the reserve for a continuous group may vary from 0 to 100% with the reserves for the nongrowing property groups generally stabilizing between 30 and 50% of the original cost of the group.

PART V

APPLICATIONS OF DEPRECIATION PRINCIPLES

CHAPTER XVIII

FIELDS OF APPLICATION

The manifold applications of depreciation principles may be classified into the following functional groups: managerial policies, governmental regulation, governmental taxation, legal equity, and governmental and quasi-governmental ownership. The evolution of depreciation includes many specific illustrations where these applications of depreciation were considered. The evaluation of depreciation policies and the methods whereby they are applied depends upon an understanding of the objectives of these functional uses.

Managerial Policies

Managerial policies of private corporations depend upon statistics which include many applications of depreciation principles. Financing and dividend policies depend upon proper accounting of the income and expenses and a statement of the assets and liability of the company. Decisions to purchase new machines and retire old ones depend upon competent replacement studies.

The choice between alternative processes or materials depends upon comparable statistics. The pricing of products depends in part upon a knowledge of the cost of manufacture. Each of these depend in part upon cost-depreciation.

Accurate financial statements aid management in the formulation of good policies and provide the investor with a means of checking the results of management. The correct statement of income includes a charge for the cost-depreciation which the corporation has experienced during the period. The statement of investment in fixed assets in the balance sheet is most significant to the investor if the assets which have been partially used are credited with the cost-depreciation which corresponds to the service capacity which was consumed during the fiscal period.

Management's decision to replace an old machine requires an estimate of the future cost-depreciation of both the old and new machines.[1] Similarly, a comparison between the costs of alternative processes requires an

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[1]Frequently the cost estimate of a new machine is based upon an amortization of the original cost over the "pay off" period instead of cost-depreciation.

estimate of the cost-depreciation to be experienced by the properties in both processes.

The determination of the price of goods requires a knowledge of the constant and variable portions of cost-depreciation. A firm may be faced with a decline in demand and wish to cut prices. It may be able to sell in two markets at different prices and wish to know the incremental costs of production. A utility which has an incremental rate schedule has this opportunity. United States Steel has recently cut prices on export steel while raising it on domestic steel. In either case a firm should know what its variable costs are because it cannot afford to sell its goods at less than the incremental cost of producing the goods. Since cost-depreciation is a function of production, it would be desirable to determine the effect of production upon cost-depreciation.

The division of cost-depreciation into fixed and variable elements can be made on the basis that the total cost-depreciation is a function of the amount of the transformation caused by those economic and physical forces which are incident on the property regardless of the amount of use plus the transformation caused by the economic and physical forces which are a result of use.[1] It has been suggested that the unit-of-production method provides an estimate of the part of cost-depreciation which is variable. Although the unit-of-production method provides a way of varying cost-depreciation within any time period, it does not differentiate between the constant and variable portions of cost-depreciation which may be attributed to any production unit. Such a division of cost-depreciation into variable and fixed parts is extremely difficult because the effects of the various forces which cause depreciation are not subject to simple addition. Much investigation of this subject remains to be done.

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[1]It has been argued that obsolescence and wear and tear are not additive in causing retirement. (J.S. Bain. Depression pricing and the depreciation function. Quarterly Journal of Economics. 51:705-15. 1937.) However the retirement of property is based upon the costs of the old vs. the new property. The costs of the old property are definitely influenced by the degree of wear and tear which the old machine has experienced. Failure to understand the principles of replacement has influenced many individuals to make similar statements. For example, E.A. Saliers (op. cit., p. 279) states: "Much accounting literature. . . infer that both depreciation and obsolescence may be operative at the same time. This is impossible, since one or the other is greater, and the greater can be the only effective cost."

Government Regulation

Whether governmental regulation of utility rates is based on fair value, prudent investment or any other base utilizing an estimate of the dollar investment in the property, an allowance for accrued depreciation should be made in computing the fair rate of return. In addition, the calculation of the net income should include a charge for annual cost-depreciation as an expense. In either case the basis for depreciation must be cost if the charge is to be dimensionally consistent with the charges for the other factors of production. Charges which are dimensionally consistent are essential if the totals are to have any significance. The dimension of dollars is not necessarily sufficient evidence that the sum is valid, i.e., the dimension of the book entries may be both dollars-cost and dollars-value and by the rules of addition one of these may not be added to the other.

Government regulation of depreciation practices also may be affected by the Securities and Exchange Commission through its legal responsibility to certify the financial conditions surrounding the issue of securities.[1]

[1]Bernard Greidinger. Accounting requirements of the Securities Exchange Commission. New York, The Ronald Press. 1940. p. 202-228 and Appendix p. 15-17.

Obviously these financial statements include depreciation entries in both the profit and loss statement and the balance sheet. However, since there has been little controversy about depreciation regulations promulgated by the SEC since its creation by the Securities Act of 1933, little evidence of the SEC's position is available.

Income Taxes

The revenue laws which authorize the taxation of incomes also provide for the deduction of expenses including cost-depreciation on "property held for the production of income." The use of cost-depreciation is in accordance with the BIR rulings that depreciation expenses must represent actual outlays of money, goods or services, and that no more than the cost of an asset may be deducted for depreciation.

Legal Equity

The law of damages and eminent domain utilizes the concept of depreciation to aid in the establishment of an equitable measure of the damages which the property owner has or will suffer. In general,[1] the maximum amount which is allowed for business property is the reproduction cost new less cost-depreciation based on the age and life of the property in question. When any property has a sentimental value or is valued without regard to cost, the subject of depreciation does not pertain to the valuation. Value is first determined from the anticipated events. Value-depreciation could then be determined but would contribute little to any settlement.

Government Ownership

Government ownership, whether federal, state, local, or by any agency created by one of these, seldom has recognized the need for overt depreciation charges.[2] Although as early as 1884 Matheson[3] stressed the necessity

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[1]Unusual circumstances may occur in which the business cannot continue because the location or environment is destroyed; in such cases a reimbursement based upon earning value is a more equitable basis for settlement.

[2]Carmen G. Blough. Depreciation accounting for educational institutions. Journal of Accountancy. 83: 329-30. 1947.

[3]Matheson, op. cit., p. 4.

of accounting for depreciation in publicly owned properties, depreciation costs of government properties have generally been ignored. The justification for this failure to consider depreciation is that the method of financing government property does not depend upon the recovery of the investment. For example, licensing policies for motor vehicles generally have disregarded the effect of the traffic of the various classes of vehicles upon the cost-depreciation component of the expense of operating a highway. Electric rates for power from government dams presents the problem of determining the cost-depreciation of the dam, power house, reservoir construction costs and many other items before the cost of electricity can be estimated. With the increase in governmental ownership of productive properties which compete with private companies,the need for careful consideration of the cost-depreciation of such properties is becoming imperative.

Indirect Effects of Cost-Depreciation Policies

The indirect effects of the application of a method of allocation of cost-depreciation may be more important than the manifest effect of a variation in the annual statement of income and the balance sheet. The possible effects of the cost-depreciation upon management's judgments and policies provide evidence of the importance of these indirect influences. Whereas book entries of cost-depreciation have no bearing upon the gross income of the past fiscal period, the business decisions based upon either the unit costs, including cost-depreciation, of the products and the reported net income of the business affect the quantity, quality, and price of future products. The change in any of these has a direct effect upon future income. Similarly, decisions concerning the replacement of property may be influenced by estimates of cost-depreciation. These replacements affect the working capital immediately and in the future affect the expenses of operation. Recent surveys of management indicate that past depreciation policies, which determine accrued depreciation, influence the opinions of management about replacement in spite of evidence from replacement studies to the contrary. Another indirect effect of the estimate of cost-depreciation is its effect upon the declaration of dividends. The disbursement of funds as dividends may vitally affect the financial stability of a business whereas the estimate of cost-depreciation without further action can have no effect upon the financial course of the business.

CHAPTER XIX

COST-DEPRECIATION AND THE FEDERAL INCOME TAX

The direct effects of the estimate of cost-depreciation have caused more controversies than the less apparent effects discussed above. In recent years, the high income tax rates have centered a major part of the discussions about depreciation on its effect upon the tax. In the past, the effect of the estimate of depreciation upon the rates for services rendered by regulated business was the primary concern of those interested in depreciation. In either instance the variation of an estimate of cost-depreciation results in a determinable change in the quantity of money available to the business. For example, an additional dollar of cost-depreciation deduction from individual net incomes of over $200,000 (before the deduction) results in a saving of 91 cents in tax payments. High income tax rates on both individual and corporation incomes during the past decade have placed cost-depreciation estimates under the careful scrutiny of many people.

Two phases of interest in the application of the methods of estimating cost-depreciation to the computation of the income tax are discernible in the literature. First, the desire of business to be permitted to establish whatever rates of depreciation they consider appropriate for their properties. Second, the proposal that replacement cost instead of original cost be used as the base to be allocated. A third phase in the computation of the tax which has aroused little interest but which is of considerable importance is the adjustment of the cost-depreciation estimates to provide for the change in the forecast affecting any of the elements which determine the size of the allocation. It was shown previously that the method of adjustment can be as important in the determination of the size of the allocation as the method of allocation. More study of the means of making this adjustment applicable in tax computation is imperative.

The following observations upon the effect of the present Bureau of Internal Revenue policy regarding depreciation rates (or the equivalent, the probable life of the property) are based upon the assumptions that future tax rates will remain constant, the net income before depreciation will remain constant, the company will have some net income after depreciation and taxes, and that taxes should not be paid from capital. Although some of these assumptions are unrealistic in the short run, an attempt on the part of business to manipulate depreciation allocations in such a way that some advantage is gained from the fluctuations of either income or tax rates amounts to speculation and hardly represents an estimate of depreciation based upon the services rendered. The evaluation of the policy of the BIR is based upon the effect upon the total taxes paid by a business over the life of its property and upon any indirect effects which the policy has upon the conduct of the businesses affected by it.

Probable Life and Depreciation Rates

The policy of the BIR with regard to the acceptance of probable lives other than those recommended by the Bureau only when supported by adequate proof is unnecessary to assure the government that all income will be taxed. The continuance of the policy started under T.D. 4422 will cause taxes to be paid out of capital if the agents of the Bureau insist upon requiring estimates which are longer than the realized life of the property. The prerogative to establish depreciation rates should be returned to business within the restrictions which already exist. In general these restrictions are: first, the taxpayer is allowed to deduct only the cost of the property;[1] second, the taxpayer must maintain a consistent cost-depreciation policy; third, the deduction of "allowable" cost-depreciation may be made only at the time it occurs (the cost-depreciation which is claimed and "allowed" may be less than the "allowable") and the taxpayer may not claim cost-depreciation which was "allowable" but not deducted in the past as a present or future deduction.[2]

The result of a policy permitting business to use estimates of property lives which it considers appropriate should encourage these estimates to approach the realized life of the property closely. Either an overestimate or an underestimate of the life of a property usually will increase the total taxes paid during the life of the property. If a concern underestimates the life of a property the immediate effect is a decrease in the taxes. However, when the property is fully depreciated the taxes will increase by an amount more than the original decrease

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[1]Detroit Edison Company vs. Commissioner of Internal Revenue, 319 US 98 (1943).

[2]With regard to allowed and allowable depreciation as a deduction in income tax returns. Columbia Law Review, 40:540-544. Also see the following court cases: Washburn Wire Co. v. Commissioner of Internal Revenue, No. 2834, CCA 1st, 1933; Virginian Hotel Corporation v. Helvering, Commissioner of Internal Revenue, 319 US 523 (1943).

because of the progressive tax rates. If a concern overestimates the life of the property, the taxes will obviously be greater than necessary throughout the life of the property with the possible exception of the last year when the concern may be able to claim a loss. The possibility that a loss will be allowed is small unless the taxpayer can show unusual circumstances which could not be foreseen which caused early retirement.

An example of the effect of various estimates of probable life upon the tax payments of an individual who owns a single unit of property can be observed in the following situation. An individual receives $150,000 per year taxable income before a deduction for depreciation from a building whose original cost was $1,300,000. Depreciation is calculated on the straight-line basis of allocation and zero salvage value. Assume that estimates of probable life of 20, 25, and 26 years are applied during the entire life of the property or until the property is fully depreciated, and that the realized life of the building is 25 years. The annual tax based upon the individual income tax rates for 1949 will be as follows:

20-year probable life -

Annual tax for the first 20 years	$54,420
Annual tax for last 5 years	$111,820
Total tax for 25 years	$1,647,500

25-year probable life -

Annual tax for the life of the property	$60,360
Total tax for 25 years	$1,509,000

26-year probable life -

Annual tax for the life of the property	$67,300
Total tax for 25 years	$1,680,000

If interest is considered the results will generally have the same relation which existed above. For example, if the taxes in the 20- and 25-year examples were invested at two per cent they would yield $2,070,000 and $1,930,000, respectively. Such a relation would be maintained because the rapid increase in the progressive tax rates more than compensate for the interest earned by the early taxes.

An example of the effect of estimates of cost-depreciation based on group property methods upon the size of an individual's tax payments depends upon the kind of group method used. The use of original group methods will result in a variation in tax payments similar to the single unit method examined above. This similarity obtains from the concrete evidence of under or over cost-depreciation at the time of the retirement of the last unit of the group. If either the unit summation method or the average life method is used the anticipated annual cost-depreciation will be greater during the early life of the group than if each unit were considered separately. The spreading adjustment becomes progressively a less desirable means of correcting an error when the forecast of the probable life is too short because the high early charges leave only a small amount to be spread in the later life of the group.

Since continuous groups more closely represent many of the business properties, the use of continuous group methods of allocations for estimating the cost-depreciation deduction in income tax computations is desirable. The use of a continuous group method introduces the additional complication of determining whether the cost-depreciation rates are correct without recourse to hindsight at the time of retirement. The rates must be judged according to their effect upon the size of the reserve.

The proper size of the cost-depreciation reserve is dependent upon the method of allocation which is dependent upon the choice of the basic unit to which cost-depreciation is assumed to be related. For example, if the cost of each physical property unit in the group is to be allocated over the life of the unit the unit summation method should be used. When the unit summation method is used the cost-depreciation reserve for a non-growing continuous property group is 50 per cent. If the cost of each unit of service rendered by the group is to be equal, the average life method should be used. When the average life method is used the cost-depreciation reserve for a non-growing continuous property usually varies between 30 and 50 per cent depending upon the mortality characteristics of the property. Either the increase or decrease in the size of the continuous group will result in a decrease or increase respectively in the size of the reserve. Thus, the basis upon which cost-depreciation rates for continuous properties is judged is complex, and without agreement as to the fundamental basis upon which cost is to be allocated, agreement upon the proper size of the reserve is unlikely. Without agreement on the proper size of the reserve, there is no criterion whereby the cost-depreciation rates can be judged until they result in some absurd reserve size.

When it is apparent that a cost-depreciation rate, as applied to a continuous group, is in error, the change in the rates and consequently the taxes is dependent upon the method of adjustment. The adjustment using a surplus entry will provide the best estimate of the current taxable income. The adjustment which spreads the remainder of the unallocated cost always incorrectly estimates the current taxable income because the adjusted rates must always compensate for past errors, i.e., when past rates are higher than the realized rate, future rates must be lower than the realized rate. Because of the compensating method of determining rates and the impact of progressive tax rates, the size of the total tax payment over one life cycle of the property will generally be a minimum when the average life is forecast correctly.

An example of a simplified case in which the effect of various estimates of average life of a continuous group follows. A nongrowing stabilized continuous property composed of many units originally cost $1,300,000 and has a net income excluding cost-depreciation and taxes of $150,000. Assume that the reserve for cost-depreciation should be 50 per cent of the original cost.[1] Consider the effect of estimating the average life of the group to be either 20 or 30 years when the realized average life is 25 years. Since the annual allotment should equal the retirements, this allotment should be $52,000. If the 20-year average life is used, the annual allotment will be $65,000. If the 30-year average life is used the annual allotment will be $43,333. The size of the reserve will increase when the 20-year life is used and decrease when the 30-year life is used. If the error in the estimate of average life is discovered after 10 years and the compensating spreading rate is based upon distributing the correction over the following 10 years, the following tax payments for the 20-year period will result if the computations are based upon the 1949 tax rates for individual incomes:

20-year forecasted average life -

Annual tax first 10 years	$54,420
Annual tax next 10 years	$77,120
Total taxes for 20 years	$1,315,400

25-year realized average life -

Annual tax first 10 years	$65,580
Annual tax next 10 years	$65,580
Total tax for 20 years	$1,311,600

[1]The assumption of a 50 per cent reserve is not intended to imply the author's preference for the unit summation method, but it is a matter of convenience because the reserve size for this method is independent of the mortality characteristics of the group.

30-year forecasted average life -

Annual tax first 10 years	$73,250
Annual tax next 10 years	$58,340
Total tax for 20 years	$1,315,900

The choice of the period over which the adjustment is made will affect the size of the adjusted rates and therefore the size of the tax payments. The same minimum total tax for the realized life is apparent in this example as obtained in the example of the single unit of property.

From a cursory examination of the above situations it appears that the government cannot lose if business is allowed to select its own rates of depreciation within the stated restrictions. However, business will be forced to estimate depreciation rates (probable lives) as accurately as possible to minimize the income tax payments. If business uses any factor of safety in these estimates, it should operate to reduce the estimate of probable lives because an error of estimating the probable life to be less than the realized life usually results in a lesser increase in the tax than the corresponding percentage overestimate of probable life. Whenever cost-depreciation is underestimated and the estimated net income is entirely disbursed as taxes and dividends, either the taxes, the dividends, or both are paid out of capital.

Whenever either taxes or dividends are paid from capital, both business and government may lose.

The present policy of the BIR inaugurated by T.D. 4422, requiring business to justify depreciation rates other than those acceptable to the Bureau, should be revised and returned to the status whereby business is allowed to fix its own rates under the three restrictions previously mentioned. The result of such a revision would be to increase the flexibility of the application of cost-depreciation throughout the nation without decreasing the total revenue available to the government. It would minimize the payment of taxes out of capital. It would free business from operating under the arbitrary rates imposed by Bulletin F. Indirectly it might encourage modernization of industry by removing the psychological barrier of unallocated costs extant on properties which are economically unfit for further use but not fully depreciated.

Original v. Replacement Cost

The choice between a replacement cost or an original cost base for the allowance of cost-depreciation in the federal income tax should be judged with respect to the purpose of the tax. The overt purpose of the income tax is to levy taxes on the ability-to-pay principle. The base should also be judged on its indirect effects. The effect upon the managerial decisions as to the level of production should be examined, as well as the effect upon the stability of governmental income.

The effect of short run and long run considerations on the ability to pay may differ. In the short run the ability to pay will have little effect on the choice of original or replacement cost as a basis for depreciation except as it may indirectly affect managerial decisions. The money available to pay taxes in any particular year is the same regardless of the depreciation allowance since this allowance is a book entry which involves no transfer of cash outside of the business. In the long run the use of ability to pay presents a better case for the adoption of the replacement cost basis. The use of the replacement basis will mitigate the possibility of taxes being paid out of capital since during either inflation or deflation a firm will be able to provide a substitute plant from the cost-depreciation allowances.

If the gross income minus all other expenses except depreciation is greater than either a depreciation charge based on reproduction or original cost, the choice of original cost would permit business to recover its investment in terms of dollars but during the periods of inflation would necessitate outside financing if the _identical_ plant were to be replaced. However, if replacement cost were allowed, the firm would be able to allocate sufficient funds to replace the _identical_ unit at present prices. (Replacement cost is used throughout this discussion in the sense of the present cost of an _identical_ unit.) It would be possible for an inflation (or deflation) to change the value of the dollar to such an extent that an extremely small (or large) dollar allowance based on original cost would actually be causing a payment of taxes out of capital (causing an evasion of taxes). For example, if the business were liquidated during an inflationary period, the owners, although they had recovered their dollar investment, might actually be paupers. The fact that the standard of value, the dollar, does not have a _constant_ value causes much of the trouble in attacking this problem. The question of whether it is fair to tax an individual's property on the basis of real or variable dollar values is the one which must be decided.

Another argument for a replacement cost base is that it more nearly approaches the conditions of competition since the entry or exit of firms from a market is based upon current and future prices. Similarly, incremental costs which may include cost-depreciation are based on spot prices.

The effect of using a replacement cost basis on managerial decisions with regard to the expansion of production is more difficult to determine. However, if profits are to be maximum in the long run and depreciation were the only cost item, it would be wise to buy property in periods of low prices and decrease new investments in periods of high prices. The reverse is generally the situation since the much larger demand for goods when prices are high makes expansion desirable, and inversely so when prices are low. The effect of interest also may be influential. If the properties are purchased at a low price and held for considerable time it is possible that the addition of interest might offset the advantage of the earlier purchase. One result of a replacement cost base would be that it would place most companies in a better financial position during periods of inflation.

The stability of tax receipts will depend upon the manner in which gross income and replacement costs vary. It is conceivable that the replacement cost basis could provide a stable income return if the gross income and replacement costs were closely correlated. For example, if during periods of recession gross income declines and prices of replacement declines, there would be less violent fluctuations of receipts if the replacement base were used. Here again it is hard to predict what the result would be without extensive study of these relations.

The administrative ease of fixing a tax on an original cost base probably will continue to outweigh these less real advantages (if they prove to be advantageous) of replacement cost. Certainly the frequent estimation of replacement costs would be more expensive. It would undoubtedly result in more litigation which would increase government expenses.

This brief survey of the applications of cost-depreciation is intended to emphasize the need for a more careful consideration of the concepts which have been discussed previously. The application of the elements of cost-depreciation methods in a manner which is of greatest significance demands a thorough understanding of the implications of the basic methods and the assumptions which have been made in order to apply these methods. This dissertation has attempted to provide a small part of the background upon which the theory and application of depreciation is based in the hope that future investigations may further clarify and extend these observations.

CHAPTER XX

RECAPITULATION

In conclusion, the significant aspects of depreciation theory and its application which have been discussed are summarized without amplification.

(1) The concept of a charge for the use of long-lived property was ambiguous long before the word "depreciation" was introduced to signify this concept.

(2) An individual's concept of depreciation is generally influenced by his business environment and the application in which depreciation is used.

(3) The meaning of the word "depreciation" must be set forth clearly in all cases where it is used in a specific sense.

(4) The objectives which depreciation is intended to accomplish should be clearly stated.

(5) The methods used to estimate depreciation should be compatible with the objectives.

(6) Depreciation is nearly always used in reference to an allocation of cost. Depreciation in the sense of value has little use.

(7) Service rendered by the property is generally regarded as the best basis for the allocation of the cost of the property.

(8) Cost-depreciation is the proportionate cost of the property which corresponds to the service rendered by the property.

(9) Annual and accrued cost-depreciation are interdependent.

(10) Retirement of property is the resultant of many economic forces. The separation of the effects of the individual forces caused by wear and tear, obsolescence, inadequacy, and changes in demand has not been achieved.

(11) The inclusion of interest in the allocation of the cost-depreciation through a method involving an interest rate suggests a degree of refinement in the calculations which even though it may be desirable is not warranted by the data available.

(12) If interest is included in the method of allocation based upon equal charges for similar units of service, the allotment per unit of service will be greater than if interest is neglected.

(13) Replacement is related to depreciation <u>only</u> because the decision to replace determines the date of retirement of properties.

(14) The method of allocation is the most controversial of all elements included in the estimation of cost-depreciation because it is least susceptible to any verification.

(15) Group methods generally will provide a better estimate of the cost-depreciation allotment than comparable single unit methods for the same properties.

(16) Comparable results from single unit methods, and group methods require careful consideration of the assumptions upon which each of these methods is based.

(17) The _average life method_ of allocating the cost of a group property _allocates equal cost to each unit of service_.

(18) The _unit summation method allocates the cost of each unit within the group over its own life_.

(19) The annual cost-depreciation of a stabilized continuous property group will be the same _regardless of the method of allocation_.

(20) The reserve for cost-depreciation for a nongrowing stabilized continuous group resulting from the use of the unit summation method is always 50 per cent of the depreciable cost of the property.

(21) The reserve for cost-depreciation for a nongrowing stabilized continuous group resulting from the use of the average life method varies between 30 and 50 per cent of the depreciable cost of the property depending upon the mortality characteristics of the group.

(22) The increase (decrease) in the dollar size of a continuous property group will either decrease (increase) the ratio of the reserve to the original cost.

(23) The pattern of allocations may be affected as much by the method of adjustment of errors in the forecast of probable life and salvage "value" as by the method of allocation.

(24) The adjustment of errors in forecasting by adjusting the surplus more nearly corresponds to the anticipated pattern of allocation resulting from the method chosen than if the adjustment is made by spreading the remainder of the unallocated cost over the remaining life of the property.

(25) The policy of the BIR with regard to the acceptance of the probable lives recommended by business only when supported by adequate evidence should be reexamined.

(26) If the taxable income excluding cost-depreciation and tax rates remain constant, the total

income taxes paid by the businesses generally increases when the life of the property is incorrectly estimated.

(27) The use of original cost as the basis for the allocation of cost-depreciation results in an income tax paid from capital during inflation and an exclusion of some taxable income during periods of deflation.

(28) Since the Bureau of Internal Revenue depreciation policies are followed by business for other than tax purposes, the Bureau has a responsibility for using the best available depreciation policies.

(29) Of prime importance in the application of cost-depreciation methods is the consistent application of whatever method is selected.

Mr. Justice Jackson, in a recent dissenting opinion, so aptly stated the necessity for a consistent application of depreciation policies that it is a fitting conclusion to this dissertation.

> I am less inclined to lay down a rule that will permit the Government to make inconsistent corrections in the matter of depreciation because consistency in the matter of depreciation is one of the few important principles of its application. . . . What is important for the protection of revenue is that the accrual for depreciation be applied to property that is properly depreciable, that it be stopped when the property is fully depreciated, and that the

rate be consistently applied so that the taxpayer cannot choose to take only a little depreciation when he has a little income and a lot of depreciation when he has a large income.[1]

[1] Virginian Hotel Corporation v. Helvering Commission of Internal Revenue, 319 U.S. 523. 1943.

PART VI

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