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Methods of Estimating Depreciation in Valuation of Public Utilities for Rate Making Purposes *

EVERY property engaged in the public service will be composed of property which does not depreciate, land for example, in the normal instance, and property which does depreciate in value through physical deterioration or functional changes. I cannot do better than quote Mr. Adams,¹

“‘Depreciation’ means the shrinkage in value of properties because of deterioration from use and because of enforced abandonment by reason of functional changes and obsolescence. For purposes of illustration, an iron pipe laid underground, through a gradual process of physical deterioration fails in the course of a period of years and must be replaced by a new one. For purposes of illustrating what is meant by ‘functional depreciation’ the growth of a city frequently makes necessary changes in the method of distributing the water, calling for the abandonment of pumping stations on certain sites and the construction of others elsewhere. The pumping station of this particular property located in 1904

* The opinion of H. M. Wright, Esq., Standing Master in Chancery, in his report in the case of *Contra Costa Water Company v. City of Oakland*, pending in the District Court of the United States for the Northern District of California, Second District, discusses many questions of interest respecting the basic principles of rate regulation. Through the courtesy of Mr. Wright we are enabled to print a portion of his opinion dealing with the matter of depreciation.

¹ Quoting from the transcript in the case (p. 99).

and 1905 at the Broadway Reservoir is an illustration in point. This pumping station was built subsequent to 1900, was in use in 1904 and 1905, and two years thereafter it was entirely abandoned and another one built in its place on another site. As an example of depreciation through obsolescence one may cite pumping machinery, which, though it may after many years of use, be in excellent working condition, may have become obsolete and no longer economical of use, leading to its enforced abandonment and replacement by machinery of greater capacity or of better economy in steam consumption. In speaking of depreciation one should carefully distinguish between the two general classes ordinarily designated as matured and unmatured depreciation. Matured depreciation relates to structures that have wholly failed and must be replaced or abandoned, or to properties which have entirely failed through functional changes or obsolescence. Unmatured depreciation is shrinkage in value of properties and structures not new, but still serviceable in use and which will in the course of time have to be abandoned or renewed. Matured depreciation represents total shrinkage in value because of the structures' having served out the entire period of their usefulness. Unmatured depreciation represents shrinkage in the value of structures because they have partially served out their total period of usefulness."

It obviously follows that if a water works is to have a fair return for its service to the community, the rates charged must afford a revenue from operation sufficient to make good this inevitable depreciation in value of certain of its elements, as well as other costs of operation, plus the profit which induces the operation. Depreciation is thus, for any future period, a problem in cost accounting. That this apparent fact, now generally admitted, was not always understood is shown by the decisions of the Supreme Court of California in *Redlands Water Company v. Redlands*,² and *San Diego Water Company v. San Diego*,³ where an annual return in the rates for depreciation was denied. In the latter case Mr. Justice Garoutte said:⁴

"Such a thing is all wrong, for it results in the consumers of water buying the plant and paying for it in annual installments."

² (1898), 121 Cal. 312, 53 Pac. 791.

³ (1897), 118 Cal. 556, 50 Pac. 633.

⁴ Id. p. 583.

On this basis, the owner of a plant costing \$100,000 with an assumed life of twenty years would receive income on his investment for the life of the plant, and would then be out his investment save for its scrap value. This would be like satisfying a loan by paying interest on it.

It is only within the last few years that methods of accounting for depreciation in relation to the problem of rate fixing have been the subject of thorough study by those most competent to speak. The impetus to that study seems to have been the decision in *Knoxville v. Knoxville Water Company*.⁵ I am assured by counsel that in this case certain opposing theories have for the first time been presented for judicial determination. Certainly the exposition of these questions in the record, both by the witnesses, engineers of high standing and fitness, and by counsel has been most exhaustive and able.

The law on this question may be considered as fairly well settled by the decision in *Knoxville v. Knoxville Water Company*.⁶ It would be interesting to consider that case at some length with reference to the specific facts there disclosed, and to certain possible limitations on the generally received doctrine of the case. It is not here necessary. That case may be considered to stand for the following propositions, namely: That the depreciated value of public service property is the proper rating base for determining fair return; that the rate-payers must pay for the depreciation of public service property; and that such a company is entitled to earn its depreciation annually as the depreciation accrues.

In the *Minnesota Rate Cases*,⁷ the court disapproved the master's action in finding that the depreciation which had in fact happened was more than offset by appreciation, and thus adopting the cost of reproduction new as his rating base. The property in question was a railroad, and here, as in the water works of the *Knoxville* case, the court held that the extent of existing depreciation should be shown and deducted, saying:

"It must be remembered that we are concerned with a charge of confiscation of property by the denial of a fair return for its use; and to determine the truth of the charge

⁵ (1909), 212 U. S. 1, 53 L. Ed. 371, 29 Sup. Ct. Rep. 148.

⁶ *Supra*, n. 5.

⁷ (1912), 230 U. S. 352, 456, 57 L. Ed. 1511, 33 Sup. Ct. Rep. 729.

there is sought to be ascertained the present value of the property."

In other words, the Supreme Court identifies value for rate fixing purposes with value in exchange, the value that would be paid for the property upon sale or condemnation. In such cases loss of condition or diminished life would inevitably be reflected in a diminished value.

In approaching the problem before us it is necessary to bear in mind that the question of depreciation presents itself in two aspects. The one, its financial aspect, concerns the method of amortizing the value of a structure, of fulfilling the ratepayers' duty of paying for wasting value as it progresses. It is discussed primarily in terms of money, and rates of interest for the use of money. It is a problem of bookkeeping, of cost accounting, applying mathematical principles and methods. It is most appropriate in considering the problem of depreciation for the future life of a new plant or, perhaps, the remaining life of particular structures of an old plant. The other aspect has to do with the *facts* of depreciation, for example, the percentage of present condition and therefore the present remaining value, the rate at which as a fact, depreciation has gone on, the rate at which it may be expected to go on hereafter, and like concepts. We are here considering a plant in the middle of the lives of its units. Now, if under methods of accounting agreed upon by the company and the city, books had been kept to show a depreciation account, the only problem to arise would be as to whether the basis of cost accounting should be changed in view of money costs, interest rates and the like, in the light of actual replacement requirements. Here no depreciation account has been kept and no reserve for accruing but unmatured depreciation laid by. In ratefixing proceedings under the Knoxville decision as generally received, and certainly in the event of sale, the company must stand this loss.

"It is obvious, however, from what has been stated that we must first understand depreciation from the theoretical standpoint,—the different methods of amortization of capital. I shall consider four such methods which have been discussed in the evidence in this case, viz:—the replacement method, two curve line methods, founded upon the principle of the sinking-fund, which graphically depicted forms a convex curve, and the straight line method so-called from its graphic form.

In the discussion and in the illustrative tables which follow it

will be assumed that the plant is a normal plant as regards its cost and its relation to the community demand; that it consists of a single structure whose original cost was \$100,000, and whose life is ten years; that original cost represents value new, both at the time of installation and at the time of replacement. For illustration, we will assume that a proper investment return throughout the life of the plant sufficient to induce the building and operation of the plant is six per cent.

In this simple situation it must be admitted by everyone that the owner of the plant must receive as his reward six per cent per annum throughout the period, a total of \$60,000, and must also at the end of the period have received enough from the rates charged to keep his investment intact, that is, to make good the waste of depreciation. In other words, his total return on account of interest on investment and depreciation combined must reach the sum of \$160,000. This may be effected in several ways.

Another and underlying principle which must not be lost sight of is that in any business situation money is always to be deemed as earning interest at a compound rate for the benefit of its owner, the one in whose hands it is at any time.

As stated before, for the purpose of this discussion I assume that original cost of any unit of plant is the measure of its capital value, and that replacement will be made at the same cost.

REPLACEMENT METHOD.

By this method, capital lost by depreciation is returned when depreciation matures and only then. When the unit reaches the end of its life and is renewed or abandoned, an allowance is made in costs for that year of the full value of the unit. There is no annual return to offset depreciation. It is unnecessary to consider the estimated life of the plant. The percentage rate of return to the investor must obviously be based on undepreciated value; otherwise capital is currently used up without income return, and confiscation results. This will be clear from the following table.⁸

⁸ Column 4, in table 1, might better be entitled, Rating Base. It is the amount of capital unamortized; but as depreciation progresses it of course does not represent present value of capital, the value in exchange.

TABLE 1.
Replacement Method.

Original cost equals value new, equals replacement value, \$100,000; life of ten years; rate of return to the investor six per cent throughout.

1 Age in years.	2 Capital paid in.	3 Depreciation re- turned.	4 Capital remain- ing, resid- ual or present value.	5 Annual return on capital re- maining.	6 Total of com- bined returns by year.
1	\$100,000	0	\$100,000	\$6,000	\$6,000
2	0	0	100,000	6,000	6,000
3	0	0	100,000	6,000	6,000
4	0	0	100,000	6,000	6,000
5	0	0	100,000	6,000	6,000
6	0	0	100,000	6,000	6,000
7	0	0	100,000	6,000	6,000
8	0	0	100,000	6,000	6,000
9	0	0	100,000	6,000	6,000
10	0	\$100,000	100,000	6,000	106,000
11	0	0	100,000	6,000	6,000
12	0	0	100,000	6,000	6,000

If capital remaining were valued each year as depreciated, say, for example, at an equal amount of \$10,000 a year, the value of plant during the tenth year would be \$10,000, and return that year \$600; dividends would be paid at one-tenth the proper rate, and it is seen that a progressive confiscation of capital has resulted.

This method does not conform to the Knoxville decision *supra*, in that it necessarily bases return on undepreciated value, or original investment, and in that it does not return depreciation in annual installments. Its advantage is that it is a simple method easily determined. If as regards any particular public service property it should appear as a fact that it was composed of a great number of depreciating items, having comparatively short lives, and of comparatively small cost, installed at different times, it might well come about as a matter of history and experience that replacement requirements each year would be approximately the same, or would reach such a total figure as combined with the investment return would make the combined return for replacement and investment approximately equal each year,—the ideal condition. It may be conceived, for example, that this might apply in the case of a railroad. If such were the case it would be a just and proper method, both to the company and to the rate-payer. In any case where such conditions do not obtain, especially as seen in the table, the method has practical disadvantages that are obvious. Compliance with the method requires an enormous

advance in rates during the tenth year, which would work great hardship on the consumers of that year, to the advantage of the consumers of other years. From the standpoint of the owner of the plant also it involves possible, indeed, probable, injustice in that the extraordinary rate, if imposed by the rate-making body, would probably be impossible of collection; and, furthermore, since no legislative body may bind its successors, might not in fact be enacted.

SINKING FUND METHOD.

By this method the rate fixed assumes that there will be returned to the water company annually in addition to other costs and profit, such a sum of money as placed at interest will, by the operation of compound interest amount to the wasted capital at the end of its life. This sum or annuity would be obtained from sinking fund tables. The probable life must first be estimated, taking into account both physical and functional depreciation, and the sinking fund interest rate determined. Here, as in the replacement method, the return to the investor must be based on undepreciated value. Every sinking fund payment and its interest is of such an amount that there is no surplus to provide an intermediate return of capital. As in the replacement method, the fund is not ripe for its intended purpose until replacement is necessary; it earns interest only for the benefit of the sinking fund, and not for the benefit of the owner of the plant. The rate-payer pays each year only the sinking fund increment, and not any sinking fund interest. If a strict sinking fund were established in the hands of a trustee, payable only when depreciation matured, it would be evident that, as in the replacement method, return must be made on the full investment throughout to avoid a confiscation of capital. The method does not, however, imply that such a trusteeship should be established, or even that the fund be kept locked up, say in outside securities. It is conceived that it may be paid to the owner of the property and may be used by him for capital purposes, for example, new additions to the plant. The result is not changed, however, because in such instance the rate-payer has not paid the sinking fund interest, but only the sinking fund annuity, and in the instance given the diversion from sinking fund to capital additions must be made good by new capital from the owner's pocket when the time comes for replacement of the original unit in question. Indeed, such use of the sinking fund is usual in

practice. It is deemed desirable because it avoids dead capital, and because also it allows the employment of a higher rate of interest for the sinking fund, viz., the rate on the business investment instead of the lower rate on prime securities. Thereby this practice diminishes the rate-payer's burden of annual contribution. On the same assumptions as above, and also assuming that the rate of interest which the sinking fund earns will be six per cent, a table illustrating the sinking fund method may be constructed as follows:⁹

TABLE 2.
Sinking Fund Method.

Capital value \$100,000; life ten years; rate of return on investment, and on sinking fund six per cent.

1 Age in years.	2 Capital paid: Cost: Value (new): Replace- ment Value.	Sinking Fund		5 Depreciation re- turned.	6 Capital remain- ing Residual or Present value.	7 Return on In- vestment.	8 Combined Re- turn.
		3 Annual Sink- ing Fund Payment.	4 Interest on Sinking Fund				
0	\$100,000				\$100,000		
1	0	\$7,587		0	100,000	\$6,000	\$13,587
2	0	\$7,587	455	0	100,000	6,000	13,587
3	0	7,587	938	0	100,000	6,000	13,587
4	0	7,587	1,449	0	100,000	6,000	13,587
5	0	7,587	1,991	0	100,000	6,000	13,587
6	0	7,587	2,566	0	100,000	6,000	13,587
7	0	7,587	3,175	0	100,000	6,000	13,587
8	0	7,587	3,821	0	100,000	6,000	13,587
9	0	7,587	4,505	0	100,000	6,000	13,587
10	0	7,587	5,230	0		6,000	13,587
		\$75,870	\$24,130	\$100,000	\$100,000	\$60,000	\$135,870

The rate-payer thus provides each year the sum of \$13,587, composed of \$6,000, return on capital available for dividends, and \$7,587, for sinking fund to amortize depreciation.

The sinking fund method conforms to the Knoxville decision, *supra*, in that it takes care of depreciation by annual installments, but it does not conform to that decision in that the rate of return is estimated on undepriciated value. Nevertheless it is obvious that it is a just method to the investor and to the rate-payer in that it conforms to the primary principles referred to at the outset of this discussion; it gives the investor his interest on his investment

⁹ Here also, as in table 1, *supra*, column 6, would better be entitled Rating Base.

throughout, provides in the rates for the accruing depreciation of the structure, and complies with the principle that the money contributed in advance of the necessity of replacement is made to earn interest in the hands of the company, a credit to the rate-payer.

Residual or depreciated value would obviously in any year equal the value, new, less the aggregate sinking fund payments and their accumulations of interest. Whether the residual value thus found would be the sale value or the present value in fact would of course depend upon whether the sinking fund interest rate corresponded with the rate of depreciation in fact.

MODIFIED SINKING FUND METHOD: ADAMS METHOD: EQUAL
ANNUAL PAYMENT METHOD.

It is obvious that if you mark off each year from the value of a structure an amount equal to its depreciation in value, and rate the return to the investor upon the depreciated value as a base, you must concurrently return that amount to him in full, or confiscation results. This is the doctrine of the Knoxville case. Now it is a fact that with all long-lived structures in a waterworks, actual depreciation follows approximately a sinking curve; in other words, it is not uniform each year, but is progressive, small in the early years and progressing largely as final dissolution approaches. On this theory the experience of engineers will enable them to adopt a rate of progression and a life expectancy that will enable them to approximate the facts of loss of value as it progresses, and to amortize the value in the rates, on the principle of the sinking fund. The annual depreciation each year would be equal to the sinking fund annuity plus interest on the sinking fund in hand. This sum would each year be deducted from the capital value to get the new rating base. In Table 3 below, at the end of the first year the owner will receive from the rate-payer \$6,000 interest on capital value of \$100,000 and \$7,587 to cover depreciation, being the amount which will equal \$100,000 in ten years if contributed each year with compound interest at six per cent. The capital thus repaid being deducted, the return to the investor is \$5,545, being six per cent on \$92,413 capital, and in addition, to cover depreciation, the annuity of \$7,587 plus six per cent interest for one year on the \$7,587 repaid the first year. In other words, column 3 in Table 3 is for each year the sum of columns 3 and 4 in Table 2, *ante*. Column 4 of Table 3 is found by adding all prior payments of column 3 of the same table, and column 5

is determined each year by a subtraction of the amounts in column 4. It is plain that here we have a modification of the sinking fund method producing equivalent results, which meets the rule in the Knoxville case and provides a plan of amortization which approximately conforms to the facts of depreciation. Table 3, upon the same assumption as Table 2, is as follows.

TABLE 3.
Modified Sinking Fund Method.

Investment \$100,000; life ten years; investment rate of return six per cent; sinking fund rate of return six per cent.

¹ Age in years.	² Capital Invested Cost = Re- placement value.	³ Annual Depre- ciation Return- ed.	⁴ Total Deprecia- tion Returned = Depreciation at end of year.	⁵ Capital Remain- ing = Residual or Present Value.	⁶ Return on In- vestment for year.	⁷ Combined Re- turn for year.
1	\$100,000			\$100,000		
2	0	\$7,587	\$7,587	92,413	\$6,000	\$13,587
3	0	8,042	15,629	84,371	5,545	13,587
4	0	8,525	24,153	75,847	5,062	13,587
5	0	9,036	33,189	66,811	4,551	13,587
6	0	9,578	42,767	57,233	4,009	13,587
7	0	10,153	52,920	47,080	3,434	13,587
8	0	10,762	63,682	36,318	2,825	13,587
9	0	11,408	74,090	24,910	2,179	13,587
10	0	12,092	87,182	12,818	1,495	13,587
		12,818	100,000		769	13,587
		\$100,001			\$35,869	\$135,870

The method illustrated above is one favored (December, 1913) by a committee of the American Society of Civil Engineers of which Mr. F. P. Stearns, a witness in this case, was chairman. The committee calls it the equal annual payment method, referring to the fact that here as in the pure sinking fund method shown in Table 2, the combined return made by the rate-payer to the water company to cover investor's return plus depreciation allowance, is constant each year for the same capital value. This is a good thing for both parties, avoiding fluctuations in the rates. It is also

equitable, because as Mr. Adams says: "A structure, no matter what its age, so long as it is serviceable, renders just as valuable service to the consumer of water as though the structure were new." The name is not well-chosen, for if the rates of interest adopted for sinking fund and for investment are not the same, the combined return will not be the same for the different years. I have constructed a table to illustrate this but it seems unnecessary to burden the report with it.

In 1909 Mr. Adams, in collaboration with Mr. Stearns and Mr. Hawgood, constructed and applied to this case a formula which embodies what is called in this record the "Adams Third Method." Where the two interest rates are the same it is identical throughout with the method of the engineers' committee shown in Table 3 above. The Adams method, however, is a true equal annual payment method, for the combined return for interest and depreciation is the same, regardless of differing interest rates. His formula is framed on that basis. I need not follow the theory into its refinements.¹⁰

STRAIGHT LINE METHOD.

The straight-line method, (so-called from the plotted result) as distinguished from the last three methods, which are "curve-line," takes care of depreciation on the assumption that deterioration of all kinds wastes the capital in use an equal amount each year of the estimated life. It is, therefore, like the Adams and the Equal Annual Payment methods, a method which returns capital in installments, here equal each year. Obviously, to avoid injustice to the rate-payer, depreciated value is necessarily the basis of return, since otherwise the utility owner would be getting interest on his full principal, and an installment upon which he could earn further interest. It accords with the Knoxville decision on the assumption that amortization of an equal proportion each year equals depreciation each year. No interest rate is here needed in the calculation

$$^{10} \text{ The Adams formula is } P = \frac{R + A}{R A^1}, \text{ where}$$

P = percentage of new value of a structure having a useful life of N years, at any age N—Z years.

R = Rate of interest on capital.

A = Sinking fund annuity for the first year.

A¹ = Sinking fund contribution at end of any given year (N—Z), which will amortize the residual value if contributed with compound interest for each year of the residual life. The values A, A¹ are found in sinking fund tables.

to determine annual depreciation installment or depreciated value of capital. In the following table I will, as before, use six per cent for illustration, on the investment value to show the combined return on account of investment and on account of accruing depreciation.

TABLE 4.
Straight Line Method.
Investment \$100,000; life ten years; rate of interest on
investment six per cent.

1 Year.	2 Capital Paid = Cost = Value new = Replace- ment Value.	3 Annual Depre- ciation Return- ed.	4 Total Capital Returned = Ac- crued Deprecia- tion.	5 Remaining Cap- ital = Residual or Present Value.	6 Return on In- vestment.	7 Combined Re- turn.
1	\$100,000			\$100,000		
2	0	\$10,000	\$10,000	90,000	\$6,000	\$16,000
3	0	10,000	20,000	80,000	5,400	15,400
4	0	10,000	30,000	70,000	4,800	14,800
5	0	10,000	40,000	60,000	4,200	14,200
6	0	10,000	50,000	50,000	3,600	13,600
7	0	10,000	60,000	40,000	3,000	13,000
8	0	10,000	70,000	30,000	2,400	12,400
9	0	10,000	80,000	20,000	1,800	11,800
10	0	10,000	90,000	10,000	1,200	11,200
		10,000	100,000		600	10,600
		\$100,000			\$33,000	\$133,000

The straight-line method is the one used by defendant's witnesses to value. The advantage of this method is its simplicity and comparative ease of application. It conforms with the Knoxville decision in that it returns depreciation in installments while it is accruing, and it bases investment return on the depreciated value thus found. In speaking of simplicity of application it must be remembered that in each of these methods, except the pure replacement method, in other words, in each method where estimated life of the unit of plant is taken into consideration, the computation as to annual depreciation and as to depreciated value must be made for *each unit* of the plant, and not for the plant as a whole. In any event, therefore, the computations for this purpose are

complex and of some difficulty; it is obvious, however, that the straight-line method is the easiest in application.

Speaking now of disadvantages of the straight-line method, and viewing the matter now purely in the light of a comparison of methods to be pursued from the beginning to end of a plant, the chief disadvantage of the straight-line method is that the money return to be made each year on account both of investment return and depreciation allowance is largest in the earliest years of the plant when it is least likely to make adequate returns, and smallest in the later years when it has become fully established. Of course, this theoretical objection applies only when the plant as a whole is new; when the plant is established with structures coming in and going out all the time it loses its force to a considerable extent.

Another disadvantage of this method, if we assume that the law, whether expressed in the Knoxville decision or otherwise, requires that the annual depreciation installment should approximate the course of depreciation in fact, is that as a general rule depreciation in any structure does not occur in an equal amount each year, but is progressive, that is, tends to follow a sinking fund curve. Defendant's witness, Dockweiler, admits this. An elaborate and rather labored attempt was made by defendant's witnesses to prove that the depreciation of the plant as a whole, taking into account some items that depreciate more rapidly at the beginning, would tend to approximate the straight-line method. Defendant's witness, Mr. Mulholland, who, however, does not profess to have given much thought to the subject of depreciation as an accounting problem, favors the straight-line method, because he believes that experience would show that in an established plant the depreciation of all items would be about equal each year. The obvious defect in all of this evidence is that in our investigations of methods of depreciation we are discussing single units of structure, and not the plant as a whole. I have said before that if the plant were sufficiently complex, the differing values and differing lives might, as a matter of experience, be shown to result in equal installments for depreciation purposes, even under the pure replacement method. If we could plot the results of any of the curve-line methods it might appear that there was a straight-line depreciation of the plant as a whole. But in order to determine the matter with entire accuracy, and in that view to determine which method most nearly approximates a just and correct result, it is obviously necessary to test the method by its application to a single structure.

Therefore, if the assumption is true that depreciation payments should approximate the actual course of depreciation in fact, the straight-line method is imperfect and unjust to the rate-payer in that it requires him to pay for depreciation in advance of its accrual.

Another objection, and a valid one, is that it does not conform to the rule that payments each year throughout the life of the plant on account of the two elements of investment return and return for depreciation should be equal. This is very well shown by Mr. Dockweiler in his argument for the straight-line method. He was there arguing that the method should be preferred because it meets the rule of equal annual payments in that the payments on account of depreciation each year are equal under this rule. Curiously enough he entirely overlooked the fact that it is the total return for service which should be equal each year, and that this return covers the entire amount paid by the rate-payer, viz, the combined return of interest on investment and depreciation installment.

Another disadvantage of the method is shown in the fact that it takes no account of the principle that money should be considered as earning interest wherever it is. In this connection it is here appropriate to examine the defendant's contention as to the comparative cheapness of this method to the rate-payer.

COMPARATIVE CHEAPNESS TO RATE-PAYER OF FOREGOING METHODS.

In this connection I shall, for convenience, compare only the four methods referred to in this record, namely: Replacement, Sinking Fund, Adams, and Straight-Line methods. The following table shows in comparative form the total amounts paid by the rate-payer to the utility owner on account of depreciation and investment return.

TABLE 5.
Comparison of Total Payments.
Six per cent for both rates of interest.

	1 Depreciation.	2 Investment Return	3 Combined Return	4 Interest earned by Depreciation Payments
Replacement Method	\$100,000	\$60,000	\$160,000	-----
Sinking Fund Method	75,870	60,000	135,870	\$24,130
Adams Method.	100,000	35,870	135,870	24,130
Straight Line Method	100,000	33,000	133,000	27,000

These tables have been assembled from the tables preceding. The first three columns of figures, or specifically the third column shows the total amount of money paid by rate-payers under the different methods.

Mr. Dockweiler for defendant argues at great length and with elaborate tables, that the straight-line method is the cheapest for the rate-payer, and that it is chiefly for this reason that he prefers it. Now, it must be evident upon reflection that such a thing is impossible. All of these methods are correct methods, (I have omitted similar methods upon unsound hypotheses that are incorrect), whose purpose is to return to the investor the waste represented in depreciation of physical structures, and at the same time to assure him a fair return in the way of profit for his service to the community in the form of interest on investment. All of them, if pursued from beginning to end, according to their hypotheses will work out these results correctly in the long run. It is, therefore, impossible that one should be cheaper than another.

This is clearly shown upon an inspection of the above tables. No method shows the return of depreciation and of profit more clearly than the pure replacement method, and yet upon Mr. Dockweiler's theory this would be the most expensive method, since the total rate-payer's payment is \$160,000. Obviously, on the same theory, the straight-line method would be the cheapest because its total return on the six per cent basis for interest would be \$133,000. The fact is that the replacement method and the straight-line method are of equal cheapness if we consider the fact that money is always earning interest. Under the replacement method \$100,000 is not paid over by the rate-payers until the structure is fully depreciated and goes out of use. But during the ten years life which we have assumed, that \$100,000 in the hands of the rate-payer has not been locked up in a safe deposit box, but has been earning interest for the rate-payer. The only way to calculate this interest would be by the pure sinking fund method. On general principles of elementary arithmetic this is seen by the table to amount to \$24,130, which the rate-payer has earned while he was waiting to hand over the \$100,000 to the owner of the utility. The net amount which he has paid, therefore, considering this fact is only \$135,870, the amount shown by the various curve-line methods. On the other hand, under the straight-line method the rate-payer has not kept his money earning interest in his own hands, but has handed it over in installments of \$10,000 a year

which would be worth in interest to the company, calculating at six per cent, the sum of \$27,000, as a simple calculation would show. Thus, considering the worth of money, the rate-payer pays the same sum, \$160,000, to the company under either method. The fact that money paid is worth interest is clearly recognized and taken account of in the sinking fund method and in the Adams method.

SUMMARY OF METHODS AND CONCLUSIONS AS TO DEPRECIATION.

After this elementary discussion we are in a position to draw conclusions upon the question of depreciation, first viewed as a problem in cost accounting, and, secondly, from the standpoint of actual condition,—the facts of depreciation, and the annual amount to be allowed to amortize the remaining value during the remaining lives of the units of the plant.

All of the methods described will work out justly if consistently applied from the beginning to the end of each unit of plant. The replacement method is conveniently applied in the case of a very large property, having varying units of short lives which come in and go out of use with substantial uniformity. In such a case, however, the fundamental mathematics of the method requires that the rate of return be calculated upon undepreciated value, and so, of course, the method cannot consistently stand with the letter of the Knoxville decision. For the latter reason also the pure sinking fund method may be dismissed from consideration.

Both the straight-line method and the modified sinking fund or Adams method, are consistent with the doctrine of the Knoxville case. In the case of a plant having units of short lives, as, for example, ten years, and especially where the values of the units are small, the straight-line method would naturally be preferred on account of its simplicity. It has already been pointed out, however, that there are serious objections to this method, viewed purely as an accounting method, because of heavier payments on account of depreciation in the early life of the unit, and secondly, because the method does not realize the ideal condition of equal annual payments each year on account of the combined total of depreciation payments and payments for interest on the investment. The modified sinking fund or Adams method meets these objections perfectly. The objection to these methods in turn is the difficulties and complexities of the computation. An objection to be made against both methods is that they involve the necessity of esti-

mating the lives of the units, a difficult thing to do, since engineering is not an exact science, and since experience cannot be applied uniformly where physical conditions surrounding each plant may be expected to differ.

It should be here stated that this comparison of methods has followed somewhat academic lines. It is quite possible in any particular problem in estimating the amortization of depreciation that a method may be selected, preferably on a curve-line basis, and adjusted from time to time according to experience. In the course of time that experience, though founded upon a curve-line basis of progression, may, for convenience, dictate for short periods an annual depreciation reserve built up on the straight-line basis subject to future correction.

H. M. Wright.

Standing Master in Chancery, U. S. District Court
for the Northern District of California.