THE SILVER CONTENT OF DIOCLETIAN'S EARLY POST-REFORM COPPER COINS

PART 1

BY C. H. V. SUTHERLAND

Heberden Coin Room, Ashmolean Museum

KEENER study of the later Roman imperial coinage is sharpening many problems only dimly perceived in the past. Those which arise from Diocletian's reform of the coinage *c.* A.D. 294 are among the more difficult. Until the middle of the third century the imperial monetary system is reasonably clear. In the second half of the century there was a breakdown and experimental recovery, at first seen most obviously when Diocletian increased the weight of the gold unit *c.* 286. Finally, in or about 294 he introduced a new range of coins struck simultaneously from a number of mints, (a) silver coins weighing 3 gm. or just over — individual mints varied a little in their standard, (b) large copper coins of ±10 gm., sometimes found with 'silvery' surface, (c) smaller copper coins (with radiate-head portraits) of *c.* 3 gm., and (d) still smaller copper coins with laureate-head portraits. Regarded as a new or revised system of interlocking metal-values or coin-denominations, what did this reform really consist of?

The gold coins after *c.* 286 and the silver coins after *c.* 294 may be regarded as having been essentially bullion in small form: they were in some cases specifically marked as being pieces of $^1/_{60}$th and $^1/_{96}$th of a Roman pound of gold and silver respectively. Metal-values and weight-ratios must have linked this gold and silver in a relationship which, while it may theoretically have been formal, probably fluctuated, though normally perhaps only within fairly narrow limits. But the relationship of the gold and silver towards the copper, and the internal relationship between the different issues of copper, have long been debated. It was to help towards a solution of these questions that Dr. E. T. Hall kindly arranged for a number of analyses to be made by Mr. M. R. Harold at the Research Laboratory for Archaeology and the History of Art at Oxford. Silver, as is well known, had been very commonly alloyed with copper (and vice versa) in the middle and later parts of the third century; and if the intrinsic value of a mainly copper coin was affected, as it surely would be, by the proportion of silver which it contained it seemed necessary to determine that proportion beyond doubt. Mr. Harold therefore undertook to investigate the silver-content of categories (b), (c) and (d) specified above . His report is joined to this, and comments on some of the critical principles involved. The present note comments rather on certain of the more purely numismatic factors.

It was realized that the analyses in question should be regarded as a pilot experiment. For this reason the range of coins selected must be limited in number, though concentrated in reasonable density as regards time and place of issue. Accordingly the examination of folles (= (b) above) was based on 20 specimens of Trier (T1—20) and 20 of Rome (R3—23), struck in each case within the first two years after the reform, i.e. *c.* 294—6. The coins in question were selected, from the Ashmolean collection, so as to represent variety both in the *officinae* or mintshops which are explicitly recorded on coins of this period and also in the four co-rulers in whose names the coins were simultaneously produced. These 40 folles were analysed both by neutron activation and by X-ray fluorescence, and the results are as follows:

ROME FOLLES

		N.A %	X-ray %	Mark	Ruler
(i)	R3	4.9	5.1	R/A	Herculius
	R4	4.4	4.4	,,	,,
	R5	3.9	5.7	R/B	Diocletian
	R6	4.7	8.0	,,	,,
	R7	4.0	6.1	R/Γ	Herculius
	R8	3.7	5.6	,,	Constantius
	R9	4.1	4.6	R/Δ	Galerius
	R10	3.6	5.5	,,	,,
	R11	3.3	6.1	R/ε	Constantius
	R12	4.6	5.2	R/Z	Galerius
(ii)	R13	3.8	7.8	R/S/A	Diocletian
	R14	3.4	5.0	,,	,,
	R15	3.6	6.8	R/S/Δ	,,
	R16	3.1	5.9	,,	,,
	R17	3.0	7.5	,,	Herculius
	R18	3.9	4.7	,,	Constantius
	R19	3.4	5.6	R/S/H	Galerius
	R20	3.0	5.6	R/S/θ	Diocletian
	R21	3.9	6.6	,,	Herculius
	R22	3.0	4.1	,,	Constantius

TRIER FOLLES

(i)	T1	4.2	8.0	TR	Diocletian
	T2	4.2	6.1	,,	,,
	T3	5.5	5.1	,,	,,
	T4	4.3	5.6	,,	,,
	T5	4.1	11.0	,,	Herculius
	T6	4.4	7.0	,,	,,
	T7	3.8	5.8	,,	Constantius
	T8	3.7	4.9	,,	,,
	T9	5.6	7.1	,,	Galerius
	T10	3.7	5.5	,,	,,
(ii)	T11	1.8	2.4	A/TR	Diocletian
	T12	4.4	4.3	,,	Herculius
	T13	3.7	4.5	,,	Constantius
	T14	3.4	4.1	,,	Galerius
	T15	4.4	6.7	B/TR	Diocletian
	T16	3.7	5.2	,,	Herculius
	T17	3.3	5.2	,,	Galerius
	T18	3.9	4.5	C/TR	Herculius
	T19	3.4	5.4	,,	Constantius
	T20	0.35	0.54	,,	Galerius

Mr. Harold has observed in his own note that of the two methods of analysis employed neutron activation gave the more accurate results. The following comments are accordingly in terms of the neutron activation figures. Average silver content for the Rome folles as a whole is 3.7%. Broken down, Rome (i) folles

average 4.0%, and those of Rome (ii) 3.4%. *Officina* by *officina* Rome (i) folles show respectively 4.6, 4.3, 3.8, 3.8, 3.3, and 4.6%, while Rome (ii) folles show 3.6, 3.4, 3.4 and 3.3%. The Trier folles as a whole contain an average of 3.7% silver, or (if T20 with its very low figure is disregarded) of 3.9%. Broken down, Trier (i) shows an average of 4.3% and Trier (ii) an average of 3.2% or (disregarding T20) 3.5%. Trier (i) is probably an issue from a single *officina*, as indicated by a mint-mark without any differentiating letters. For the three *officinae* of Trier (ii) the figures are 3.3, 3.8 and (disregarding T20) 3.6% respectively. A summary shows the results as follows:

Rome (i)	4.0%	(10 coins)
„ (ii)	3.4%	(10 coins)
Trier (i)	4.3%	(10 coins)
„ (ii)	3.5%	(9 coins, i.e. excluding T20)

It will be noted in each case that the earlier issue contains slightly more silver than the later. This is particularly noticeable at Trier, where the lowest silver content of Trier (i) (3.7%, T8 and T10) is 0.2 higher than the corrected average of Trier (ii): four out of the ten coins of Trier (i) show between 4.3 and 4.1%. The combined total average of the coins summarized above is 3.87%.

It must be emphasized that these figures are obtained from a relatively small sampling of coins from only two mints at the very outset of Diocletian's 'reformed' copper. Nevertheless 39 coins are no mean sample, viewed as representative issues produced from large and specifically prepared volumes of metal; and the mints in question are the principal mints of Italy and Gaul respectively. On the evidence so far obtained we may therefore put the silver content of the earliest folles of Rome and Trier at an average of 3.87%, between extremes of 4.3 and 3.4%. Further analyses, over a wider range of mints and in greater chronological depth, will doubtless supply some modification and variation of this preliminary result.

The second of Diocletian's 'reformed' base-metal denominations consisted of the radiate-head coin of ±3 gm., category (c) above. Ten Ashmolean examples of Rome (R23—32) were selected for analysis, all falling probably in 297—8, i.e. about two years later than the folles described above. Results were as follows:

ROME 'RADIATES'

	N.A. %	X-ray %	Mark	Ruler
R23	0.077	0.10	A	Herculius
R24	0.091	0.15	B	Diocletian
R25	0.14	0.14	B	„
R26	0.089	0.21	Γ	Constantius
R27	0.13	0.09	Δ	Herculius
R28	0.10	0.10	Δ	Galerius
R29	0.082	0.11	ε	Herculius
R30	0.12	0.16	Z	Galerius
R31	0.13	0.19	H	Diocletian
R32	0.074	0.08	θ	Herculius
Average	0.10	0.13		

Mr. Harold has called attention to the very low (neutron activation) percentage of 0.10, questioning whether so minute a silver-content can be regarded as deliberate.

It seems likely that this 0.10% of silver is in fact not more than a trace which refinement-methods made it uneconomic or very difficult to separate entirely from a given batch of copper. It will be noted that, over all the nine *officinae* employed, the silver content nowhere exceeds 0.14%, often dropping to 0.07 or 0.08%. The sampling, if relatively small, is again (as in the case of the folles) reasonably dense in time and place.

For the two larger of Diocletian's new denominations these preliminary analyses thus suggest (1) that the follis in Italy and the west contained *c.* 3.87% of silver (perhaps diminishing) down to *c.* 296, and (2) that the radiate at Rome contained a trace of silver, around 0.10%, about 297—8. These results are important for the interpretation of the monetary system of the time. S. Bolin (1958), relying mainly (though not entirely) upon a small number of earlier analyses made by chemical methods upon coins not densely sampled by mint or time (Hammer, 1908), determined the average silver-content of the follis as about 3%, with maximum content of 4%. It is clear that immediately after the reform — and presumably as an essential reflection of the reform — the average was nearly 1% higher, with a correspondingly higher maximum — no small increase when an issue in many hundreds of thousands of coins was involved. His view of the radiates is more nearly correct, for although it is not quite true to say that they lacked silver they contained what is a mere trace. I have argued elsewhere (1961) that his determination of the denominational value of the follis and the radiate, though correct in its result, is wrong in its method. But the tariffing, in terms of the denarius, of the follis (= 5) and the radiate (= 2) can and should still stand.

Below the new and nearly silverless copper radiates came the little laureate-head copper coins, category (d) above. They are comparatively rare, and their documentation is by no means ample. Sufficient Ashmolean examples were, however, available for analysis, and these fall into two groups, (i) those struck soon after the reform of the coinage, *c.* 294—5 (R1, R2, R33, TIC1, TIC2, CY1; from Rome, Ticinum and Cyzicus respectively), and (ii) those of later date, struck partly in Diocletian's later years but mainly under his immediate successors (T21—42, all of Trier). The latter will best be studied when some of the later folles have also been examined: for the present, attention will be paid only to the six earlier coins in group (i). These are all coins weighing between 1.6 and 1.0 gm., and possibly intended to conform to a norm around 1.3 gm. Analysis results are as follows:

ROME, TICINUM AND CYZICUS 'LAUREATES'

	N.A. %	X-ray %	Ruler
R1	——	0.22	Diocletian
R2	0.14	0.22	Herculius
R33	——	5.0	Galerius
TIC1	——	0.05	Diocletian
TIC2	——	0.10	Herculius
CY1	——	0.39	Herculius

It is at once apparent that we are here dealing with a coinage which is, to an extent greater than was true of the radiates, intentionally devoid of silver. Such little as there is seems, in the light of the X-ray fluorescence figures, to have been present mainly as a surface-enrichment trace, though the case of R33 invites some other explanation. The importance of these figures lies in the relationship between the immediately post-reform 'radiates' and the immediately post-reform 'laureates'.

The 'radiate', of *c.* 3.0 gm. and containing only a trace of silver, is to be regarded on numismatic and historical grounds as a piece worth two of the *denarii communes* known to have emerged as the lowest denominational value by *c.* 300. If the 'laureate', of *c.* 1.3 gm., contains less than the trace of silver shown by the 'radiate' the diminution is so small that it can scarcely prevent the 'laureate' from being regarded as the half of the 'radiate', i.e. as the *denarius communis* itself.

How long this relationship continued we cannot yet say. Later folles and 'radiates' must be analysed; and already there is the knowledge that later 'laureates' (T21—42) contain a (neutron activation) percentage of about 1.8 silver — an emphatic departure from the composition of the early 'laureates'; this will be the subject of later study. If, however, we are concerned with Diocletian's copper coinage at the time of the reform itself the following may now be put forward as firm observations, based on neutron activation figures:—

A. Folles of Rome and Trier show an average silver-content of just on 3.9%.
B. 'Radiates' of Rome show an average silver-content of only 0.10%.
C. 'Laureates' of Rome, Ticinum and Cyzicus show (with one exception) no silver.

These observations will allow the follis to be regarded as a 5-denarius piece, the 'radiate' as a 2-denarius piece, and the 'laureate' as a 1-denarius piece — the *denarius communis*.

REFERENCES

Bolin, S., 1958: *State and Currency in the Roman Empire* (Stockholm), p. 303.
Hammer, J., 1908: 'Der Feingehalt der griechischen und römischen Münzen', *Zeitschr. f. Numismatik* **26**, p. 137 f.
Sutherland, C. H. V., 1961: *Journ. Roman Studies* **51**, pp. 94 ff.

PART 2

BY M. R. HAROLD

One of the outstanding achievements of the Roman Emperor Diocletian was his reform of the coinage (*c.* A.D. 294). There has long been speculation as to the precise values of the three new denominations of copper struck at this time, very few scientific analyses having been carried out on them. However, at the request of Dr. Sutherland of the Ashmolean Museum about 80 coins of the new denominations have been analysed non-destructively, with a view to determining the amount of silver contained in them. In this way it is hoped to obtain a more accurate assessment of their values. Moreover, by performing the analyses by means of both neutron activation (Emeleus, 1958) and X-ray fluorescence (Hall, 1958) it was hoped to discover whether any large-scale surface enrichment had taken place. Should this be the case, further experiments would be required to determine the mechanism by which the enrichment had occurred.

The coins analysed consisted of 40 of the largest folles, equal numbers of which had been minted at Rome and at Trier (R3—R22, T1—T20); ten of the middle denomination struck at Rome (R23—R32), and 23 of the smallest value, only one

of which was from Rome (R2, T21—T42). After preliminary analyses, blanks of approximately the correct Ag/Cu ratios were made up and used as standards against which to calibrate both the X-ray unit and the neutron activation apparatus. The averaged results are shown in Table 1.

TABLE 1.

Coins	Average percentage of Silver by Neutron Activation	X-ray Fluorescence
R3—R22	3.7	5.8
T1—T20	3.7	5.4
R23—R32	0.10	0.13
R2	0.14	0.22
T21—T42	1.8	2.1

The accuracy of the results in both methods is probably no better than 10%, the principal errors being due to variations in surface conditions (X-ray fluorescence), non-uniformity of the irradiating neutron flux and variations in coin goemetry (neutron activation). However, there seems to be a clear discrepancy in results between the two methods for the largest coins, which have the largest amount of silver per coin and provide the most accurate results. For the remainder of the coins, although the evidence for surface enrichment is hardly conclusive, a number of interesting points arise from the analyses. For example, can 0.1% of silver be regarded as a deliberate enrichment of the coins R23—R32, or is there some other explanation? Again, is R2 typical of its Roman kind, or would the analysis of a further twenty of these coins yield an average silver content equal to that of the Trier equivalents? This last question might, unfortunately, have to remain unanswered, due to the extreme rarity of this type of coin.

It is hoped to extend this investigation to cover the products of other mints at this period, and to provide a far more complete picture of the structure of Diocletian's coinage reform. What is clear even now, however, is that the method of analysis used must be that of neutron activation; only in this way can an accurate estimate be made of the total silver-content of these coins.

REFERENCES

Emeleus, V. M., 1958: Neutron Activation, *Archaeometry* **1**.
Hall, E. T., 1958: Some Uses of Physics in Archaeology, *Year Book of the Physical Society*