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TREASURY STAFF STUDY

OF

SILVER AND COINAGE

UNITED STATES TREASURY DEPARTMENT

1965

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TREASURY STAFF STUDY OF SILVER AND COINAGE

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FOREWORD

This study has served as a basic document assisting in the development of policies to insure the adequacy of the United States coinage.

It is the result of research and analysis that has extended over the past 2 years. The objective was to consider all aspects and possibilities of the silver and coinage problems.

The study is made public as an informational service. In using it, account should be taken of the fact that since it was undertaken questions as to wear, and procurement, of some materials, then uncertain, have been answered.

One of the central aims of the study was the application of objective criteria for the development of a modern coinage system. The new coinage recommendations contained in legislative proposals being sent to the Congress meet the criteria for a modern United States coinage set forth here.

A critical part of the study was a thorough exploration of the silver supply and demand situation. This exploration provided the substance for the most basic decision that had to be made with respect to our coinage system: had it become unavoidably necessary for the United States to turn away from the large-scale use of silver in its coinage?

The conclusion of the Treasury Staff Study of Silver and Coinage is that there is not a sufficient supply of silver to warrant the retention by the United States of its traditional silver coinage is supported by an independent study, commissioned by the Treasury, of the Battelle Memorial Institute, also being made public at this time, and by other inquiries into this subject.

Responsibility for the study was concentrated in the Treasury's Office of Financial Analysis. However, the study has been a cooperative undertaking to which personnel in the Bureau of the Mint, Office of Domestic Gold and Silver Operations, the Treasurer's Office, and the Office of the General Counsel have all contributed.

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Digest of the Treasury Staff Study of Silver and Coinage

[NOTE.—The study's final conclusions are summarized here, followed by a brief review of each of its sections]

I. Summary of Conclusions and Recommendations

1. The fundamental finding of this study is that the world and the U.S. silver supply and production situation and outlook do not warrant continuation of the large-scale use of silver in the U.S. coinage.

2. Cupronickel is the best permanent material for a new subsidiary coinage, ignoring the vending machine problem. However, cupronickel coins would require "factory" adjustment of the coin rejectors in some 6 million coin-operated vending machines, entailing significant costs and public inconvenience.

3. Since extensive experiments confirm that cupronickel clad on a copper core operates successfully in unaltered vending machine rejectors, preferable options are available. Cupronickel-clad coins can be used during a transition period, or permanently. An overriding requirement with cupronickel-clad coins is the production feasibility of the strip and the assurance of an adequate supply for processing in the Mint.

6. Subsidiary silver coinage of reduced content, such as silver-copper alloys clad on a low-content silver-copper core, suffers both from difficult transitional problems and incomplete assurance that the subsidiary coinage would not be imperiled again within a fairly short period of time, due to the shortage of silver. If any silver is to be retained in the subsidiary coinage system, it should be limited to a clad silver 50-cent piece of 400 fineness. There is no suggestion that the silver content of the silver dollar be changed.

7. During the installation of any new coinage system, it will be obligatory to hold the market price of silver at its current level of $1.29+ in order to protect the existing coinage. Since this will remove the incentive to melt the existing coinage, controls over melting would probably not serve any useful purpose. Effective controls on the hoarding of coin appear impractical. Controls on the export of coin may serve a useful purpose during the transition period. There is something to be said for having standby authority to invoke controls. A prompt transition to base alloy coinage would make the actual use of controls unnecessary.

8. New coins should be placed in circulation through normal channels. Every effort should be made as soon as possible to prepare for extremely high rates of production of the new coins.

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II. Criteria by Which a New Coinage Can Be Judged

Summary of Criteria

The criteria are listed in the order in which they are discussed rather than in descending importance. However, it is felt that *the single most essential objective must be the facilitation of the orderly flow of financial and commercial transactions.*

A new coinage should meet the following principal criteria:

1. No interruption of essential medium of exchange function.
2. Promise of requiring minimum changes for a long period of time.
3. Assured access to raw materials.
4. Public acceptability in terms of—
   a. Need for the change.
   b. Technical characteristics of the coins.
   c. Degree of inconvenience the new coinage imposes.
   d. Absence of extreme hardship to any group or region.
5. Minting characteristics and coinage costs:
   a. Assurance of high levels of production.
   b. Minimization of dollar cost.
   c. Minimization of any adverse impact upon balance of payments and international financial position.
6. Compatibility with present coinage:
   a. Probable need for side-by-side circulation.
   b. Vending machines usage.

III. Silver Market Trends

The discussion of silver market trends is divided into two parts. First, the dimensions of the growing imbalance in world silver markets are established and the implications for Treasury policy are discussed briefly. Second, the extent to which production and consumption of silver would adjust to higher prices is examined in order to reach a preliminary judgment as to the feasibility of reduced content silver coinage. [*To avoid misunderstanding, it should be stressed that while this preliminary examination of silver markets does not definitely rule out the possibility of a low-content silver coinage system, that possibility is ruled out by a later examination* (*Section V*) *of the specific difficulties of achieving a safe transition.*]

1. Recent years have seen the development of an enormous gap between Free World production and consumption of silver. The overall deficit, inclusive of coinage demands, was 200 million ounces in 1963 and almost 340 million ounces in 1964. Even if all coinage demands, United States and foreign, are subtracted, a deficit remains.

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2. U.S. Treasury stocks of silver declined to 1,218 million ounces by the end of 1964 and may be down to 1,000 million ounces or less by mid-1965. Legislative action by 1965 on a new coinage system is essential while Treasury stocks of silver are still large.

3. On the basis of past experience, higher silver prices and increases in base-metal production promise to increase world silver production. The independent influence of higher silver prices cannot be estimated with any precision, but there is no reason to doubt that substantially higher prices would lead to some expansion in silver output. However, the current production deficit is so large that it cannot be closed from the production side.

4. During the last 15 years, most of the growth in the industrial consumption of silver has occurred in foreign countries; U.S. consumption has grown more slowly. There were some signs that the recent increases in silver prices had checked the overall growth in world industrial use of silver, but only temporarily, and in 1964 there was a sharp advance in silver consumption, here and abroad.

5. A simple extension of the postwar trend of silver prices suggests that $2 an ounce might easily be reached by 1980 or 1985. Analysis of supply-and-demand factors does not yield any precise estimate of the level that silver prices might reach in a free market. The analysis does suggest that there is a very appreciable risk that the price could reach $2 an ounce then, or even much sooner. Battelle's detailed quantitative projections of the rate of exhaustion of Treasury stocks lead to an even more pessimistic appraisal since with coinage of 50 percent silver content they can foresee the complete exhaustion of Treasury silver as early as 1969.

6. In view of these considerations, it does not appear that reduction of silver content to 800, 700, or 600 fineness would constitute a longrun (20- to 25-year) solution to the coinage problem. On the basis of longrun supply-and-demand factors, *there is an unmistakable risk that a rising market price of silver would soon imperil coinage of 500 fineness. That risk would be overwhelming even for lower silver contents if future U.S. coinage demand could not be met exclusively from Treasury silver holdings.*

IV. Metallurgical and Technical Characteristics of Alternative Coinage Alloys

This section divides the possible coinage alloys into those that are acceptable *on technical and metallurgical grounds* and those that are not acceptable. Findings are summarized in the tables that follow.

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Acceptable Coinage Alloys

TABLE 1.—*Summary of Coinage Alloys Meeting Minimum Standards of Metallurgical and Technical Acceptability*

Material	Public acceptability				Operation in vending machines
	Weight	Color	Wearing qualities	Examples of foreign use	
Cupronickel or nickel silver clad on a copper core.	About the same as straight cupronickel or nickel silver.	Acceptable if the red edge of the coin is not regarded as objectionable. Test coins are very attractive.	Very good. Wear tests indicate an expected 20–30-year life. Only cupronickel cladding has been tested.	None	Exhaustively tested by Mint and rejector industry. Coins are expected to operate better than present silver coinage in existing, unaltered vending machines.
Nickel silver (65 copper, 18 nickel, and 17 zinc).	Good. Slightly lighter than pure nickel and cupronickel.	Excellent when minted but develops some yellow tarnish with age.	Good. Somewhat inferior to cupronickel.	Portugal, Philippines, Taiwan.	Practically the same properties as cupronickel and would operate in machines adapted to accept cupronickel.
Cupronickel (75 copper-25 nickel).	Good. Density, 8.9	Very good	Very good	Very widely used including U.S. 5-cent piece. Notable foreign users: United Kingdom, Spain, Norway, New Zealand, Australia.	Resistivity of 32.0 is too high for coins to work in 10-, 25-, and 50-cent channels.
Nickel (95 nickel- 5 silicon with magnetic core).	Same	do	Excellent	None	Not successful in achieving an acceptable success ratio under actual operating conditions despite intensive effort.
Silver-copper clad on copper or on low-content silver-copper core.	About the same as 500 silver-500 copper.	Acceptable. Low-content silver core removes or reduces the reddened edge of the coin.	Satisfactory	None	Will work alongside existing coinage. In the case of a pure copper core, minor modifications in alloy or adjustment of rejectors would be required.

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Acceptable Coinage Alloys—Continued

TABLE 1.—*Summary of Coinage Alloys Meeting Minimum Standards of Metallurgical and Technical Acceptability*—Continued

Material	Public acceptability				Operation in vending machines
	Weight	Color	Wearing qualities	Examples of foreign use	
Silver (United Kingdom alloy: 500 silver, 400 copper, 50 nickel, 50 zinc).	Very good. About the same as 500 silver-500 copper.	Very good when minted but develops dark tarnish and mottled appearance in circulation.	Fair. Addition of nickel and zinc improves wear characteristics somewhat.	Still circulates alongside cupronickel in United Kingdom. Formerly used very widely in British Commonwealth.	Because electrical resistivity is raised to 6.8, these coins would not work in most machines.

Material	Counterfeiting potential		Ease and certainty of production	Cost and availability of raw materials	Conclusion
	Actual counterfeiting	Vending machine			
Cupronickel or nickel silver clad on a copper core.	Very low potential. Red edge of coin is an advantage since clad materials are not readily available to the public.	Same as with present coinage.	Mint purchase of strip would be required at least for a time. Tests on production-sized lots indicate that no serious minting problems should be encountered.	Readily available. Cost of clad strip will be substantially higher than straight cupronickel or nickel silver.	Acceptable as coinage material which will work in existing vending machines.
Nickel silver (65 copper, 18 nickel, and 17 zinc).	More counterfeiting potential than cupronickel, since nickel silver is readily available to the general public.	Same as cupronickel	Much the same as cupronickel.	Zinc is substituted for copper and some nickel in the cupronickel alloy. Zinc is cheaper and readily available.	Acceptable but would not work in 10-, 25-, and 50-cent vending machine channels.
Cupronickel (75 copper-25 Nickel).	Low risk	Appreciablei risk—foreign coins.	Excellent	Cheap and readily available.	Acceptable. An excellent coinage material easily fabricated by the Mint. However, will not work in 10, 25, and 50-cent vending machine channels.

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Nickel (95 nickel-5 silicon with magnetic core).	do	Same as silver	Purchase of annealed blanks would be required pending completion of new Mint.	Cost per pound of strip might be estimated at $1.50.	Acceptable but a hard material difficult to stamp. Could not be manufactured with existing Mint facilities. Does not work in vending machines consistently under actual operating conditions.
Silver-copper clad on copper or on low-content silver-copper core.	Low potential	Same as present coinage	If production requirements exceeded Mint's melt-roll capacity, purchase of strip would be required. In any event, Mint would have to have all bonding operations performed in private plants until new facilities provided.	Availability is clouded by uncertainty as to size of Treasury stocks, if any, left after the period of transition.	Acceptable on technical and metallurgical grounds. While the bonding operation is no more difficult than in the case of cupronickel clad, existing melt-roll capacity limits the feasible output of the silver-copper clad on low silver-copper alloys. The silver supply situation remains as an overriding difficulty, as in the case of any silver alloy.
Silver (United Kingdom alloy: 500 silver, 400 copper, 50 nickel, 50 zinc).	Some eventual encouragement as worn coins become common.	The wider resistivity range needed to accept these coins and existing coins would encourage the use of slugs made from such materials as zinc.	Much more difficult to produce than 500 silver-500 copper. Would require double melting.	Some reduction in present raw materials cost because of lower silver content. Availability of silver is clouded by uncertainty as to the size of Treasury stocks left after the period of transition.	Barely acceptable because of bad appearance when worn and need for vending machine changes. The silver supply situation remains as an overriding difficulty, as in the case of any silver alloy.

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Not Acceptable Coinage Alloys

TABLE 2.—*Summary of Coinage Alloys Not Meeting Minimum Standards of Metallurgical and Technical Acceptability*

Material	Public acceptability				Operation in vending machines
	Weight	Color	Wearing qualities	Examples of foreign use	
Aluminum	Very poor. Density, 2.71	Good	Fair to poor	Low denomination coins in poor countries. Also some use in Austria, Japan, Italy.	Resistivity of 2.65 is near to that of present coins. Hardening agents raise resistivity. Coins too light to work in vending machines.
Columbium	Fair. Density, 8.6	Good. Silver-gray	Very good	Not used anywhere	Resistivity of 12.5 to 16 is unlike that of most other coinage materials. Rejectors would have to be adapted unless columbium metal were clad on a copper core. No satisfactory material of this sort has been presented to Battelle or the Mint for testing.
Nickel (pure)	Good. Density, 8.9	Very good to excellent	Excellent	Canada, France, and South Africa.	Magnetic and will not be accepted by existing coin rejectors. Complete redesign of rejector units would be required.
Silver (500 silver and 500 copper).	Very good	Excellent at first if given acid bath.	Very poor. Wear quickly exposes yellowish and reddish areas beneath the silver surface coating.	None. South Africa was the only country still using it and is now substituting pure nickel.	Coins work with only very minor adjustments needed on some machines.

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Stainless steel	Fair. Density range, 7.8 to 8.0.	Good	Excellent	Italy, Turkey	Won't operate in existing 50-, 25-, and 10-cent vending machine channels.
Titanium	Poor. Density, 4.5	Whitish-gray	Very good	None	Won't work. Too light.
Zirconium-hafnium	Fair. Zirconium density, 6.49.	Good	(?)	do	Zirconium resistivity, 40—Hafnium, 35.
Also rejected: Copper 98-zinc 2, plastics, and steel coins with cladding.					

Material	Counterfeiting potential		Ease and certainty of production	Cost and availability of raw materials	Conclusion
	Actual counterfeiting	Vending machine			
Aluminum	Very great risk	Very great risk	Very good	Cheap and abundant. Coinage requirements negligible proportion of total consumption.	Rejected. Poor weight and appearance. Vending machine and counterfeiting problems.
Columbium	Very low risk	Very low risk	Probably OK	Prohibitive cost and uncertain supply outlook.	Rejected. Prohibitive cost and uncertain supply plus need to adapt vending machines.
Nickel (pure)	do	No basis for judgment	Very difficult problem for the Mint. Purchase of strip would probably be required pending completion of new Mint.	Relatively cheap at $0.79 a pound. Would involve dependence upon imports from Canada or use of excess nickel from strategic stockpile.	Rejected. Magnetic, hence won't work in vending machines. Difficult to fabricate.
Silver (500 silver and 500 copper).	Some eventual encouragement as worn 500 coins become common.	Very little different from present situation.	About a 10 percent increase in operating cost over present levels. No really new problems would be encountered and high levels of production could be achieved.	Some reduction in raw materials cost because of lower silver content. Availablity is clouded by uncertainty as to the size of Treasury stocks left after the period of transition.	Rejected because of very bad appearance when worn.

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Not Acceptable Coinage Alloys—Continued

TABLE 2.—*Summary of Coinage Alloys Not Meeting Minimum Standards of Metallurgical and Technical Acceptability*—Continued

Material	Counterfeiting potential		Ease and certainty of production	Cost and availability of raw materials	Conclusion
	Actual counterfeiting	Vending machine			
Stainless steel	Very low risk	Considerable risk on the basis of what is known at this time.	Very difficult minting process. Strip would have to be purchased.	Low cost and assurance of required quantities. No domestic production of chromium.	Rejected: Doubtful acceptability, vending machine and difficult production problems.
Titanium	do	Uncertain	No Mint experience	Strip is estimated to cost about $5 per pound. Supplies probably adequate for Mint requirements.	Rejected: Too light, too expensive, and no vending machine work done to date.
Zirconium-hafnium	Negligible risk	do	do	Zirconium strip would cost $8 per pound. Suggested addition of hafnium would raise cost near that of silver.	Rejected: Prohibitive expense and need to adapt vending machines. No work done on the problem.
Also rejected: Copper 98-zinc 2, plastics, and steel coins with cladding.					

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V. Problems With a Changeover to Reduced Content Silver Coinage

The present section examines the feasibility of achieving a successful transition to a new coinage system using low-content silver alloys. An appendix considers the possibility of a silver 50-cent piece of 400 fineness. Major conclusions can be summarized as follows:

1. The transition to silver coinage of reduced content would be an extremely risky undertaking, and Treasury silver stocks would probably be depleted within a relatively short period of time. If there is a partial and limited exception to this overall conclusion, it arises with 400 fineness where a high proportion of the existing coinage is recovered at a rapid rate.

2. Even there the risks would have to be judged intolerably great unless there were clear evidence, at the time a decision was reached, that the coin shortage had ended and subsidiary coinage was temporarily redundant.[1] No one could be sure in any case that the price of silver would not be driven again to the melting point of subsidiary coinage; this might not occur within the immediate future. *In general, analysis of the special problem of the transition to reduced content silver coinage suggests that attention can appropriately be concentrated from this point in the study upon the base alloy alternatives.*

VI. The Relative Merits of the Base Metal Alloys

This section first considers the respective merits of the four remaining alloys: cupronickel, nickel silver, 95 percent nickel (Inco coin), and cupronickel clad on a copper core. The nature of the production effort required for a smooth transition is described and the possible use of controls is examined, and largely rejected. Major conclusions are summarized below.

1. Assuming that vending machine rejectors were to be modified, the choice of permanent coinage material lies primarily between cupronickel and nickel silver. The difference between these homogeneous alloys is not great, although in most respects cupronickel is slightly superior. The preference would be for cupronickel subsidiary coinage with the present 5-cent piece unchanged.

2. The cupronickél (or nickel silver) clad on a copper core has the great advantage of avoiding the need for modification of vending machines. The Inco coin does not work acceptably, and, even if it did, it would be superior to the clads only on the basis of appearance. The clad coin is to be preferred since it would lead logically and easily to a permanent coinage of cupronickel, or nickel silver, or, as seems equally desirable, could be retained as the permanent coinage material.

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[1] This is clearly not the case at the present time.

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3. Full replacement of the existing subsidiary coinage with straight cupronickel could be achieved in less than 3 years with existing and planned Mint capacity, even more rapidly if capacity were expanded further. The Mint is conducting an exhaustive investigation of the supply situation in the case of cupronickel clad on copper.

4. Standby authority to impose controls on the melting and export of coin might be a useful backstop. A prompt transition to base alloy coinage would make the use of controls unnecessary.

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TREASURY SILVER AND COINAGE STUDY

I. Introduction

This study examines the silver coinage problem and evaluates ways in which that problem can be resolved. It draws upon a range of previous Treasury studies and memoranda in arriving at its specific recommendations for a new coinage system. Some sections of the present study, particularly those dealing with the metallurgical and technical characteristics of alternative coinage alloys, have also benefited from findings of a parallel study for the Treasury by the Battelle Memorial Institute. Other sections of the present study incorporate information that has been made available to the Treasury by private groups and by other government agencies. The published literature dealing with the silver situation and with suggested changes in our coinage system has been examined.

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II. Discussion of the Criteria by Which Any Future Coin Program Should Be Judged

The selection of a set of criteria by which alternative coinage systems are to be judged necessarily involves a prior view as to what a coinage system should do and how it should do it. This study takes it to be axiomatic that, under modern conditions, the primary and essential function of a coinage system is to assist the unimpeded flow of transactions throughout the economy, by acting as a medium of exchange.

There are collateral objectives; for example, the preservation of historical tradition, the minimization of costs to the private sector of any transition to a new coinage system, the avoidance of strain upon the balance of payments, the maximization of Treasury "profit" (seigniorage) on coinage operations. No single plan for a new system will be able to achieve fully all of the ends that are desirable in themselves.

The importance of the coinage system to overall economic and financial activity is so great that any compromises should be between the attainment of the various subsidiary objectives, and not at the expense of the major objective of continuing to provide a reliable medium of exchange.

A. Permanence of the Program

No alteration in our coinage system is likely to guarantee complete immunity from the possible future need for modification. An ideal program should offer assurance against a shortage of coinage materials for a long period into the future. The likelihood of any disruption within 5 to 10 years should be regarded as disqualifying.

B. Raw Material Requirements

The raw materials needed in a new coinage system should be readily available, preferably from domestic production or excess stockpiles. *Silver and base-metal alloy systems* pose somewhat different problems in this respect. With silver coinage of reduced content, the major problems are the extent to which a higher silver price would deter industrial uses, encourage exploration activity, and stimulate mine production; the degree to which existing Treasury silver stocks at the time of the transition would be conserved by lower silver content per coin; the effective addition to Treasury silver supplies made possible by the capture of higher content coins in circulation at the time of

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the transition; and the extent to which the existing silver coinage might be lost from circulation at the time of the transition; and the extent to which the existing silver coinage might be lost from circulation by being hoarded, melted down, or exported. *With base-metal alloys*, the questions are the relatively less complex ones of the availability of whatever raw materials are required as an input into coinage manufacture, and the strength of competing demands in relationship to prospective supplies.

In the case of silver as well as base-metal alloys, there is the question whether a coinage system is acceptable only if its materials can be found domestically at reasonable cost, or if imported materials could be used. From the standpoint of security, it would probably be sufficient if there were substantial domestic, or even North American, supplies relative to maximum potential coinage demand and other vital uses during an emergency period. It is true that for a time during World War II silver had to be used in the 5-cent piece because of the shortage of nickel and copper, and the 1-cent piece was made of zinc-coated steel. Certainly, it would be unwise for a coinage program to involve a major continuing dependence upon a foreign source for raw materials if there were strong indication that supplies might be interrupted because of revolution, expropriation, strikes, etc.

C. Public Acceptability

The feasibility of a change in our coinage system rests upon the general agreement of the public that such a change is necessary and desirable, and upon the reasonableness of the proposed change. It seems probable that the main element in public acceptability will be (1) demonstrated necessity of the change, (2) characteristics of the new coins, (3) degree of inconvenience to which the public is subjected by the change, and (4) absence of extreme hardship suffered by any particular group or industry as a result of the change.

1. Need for the change

In view of the silver situation, present and prospective, the existing system of subsidiary coinage cannot possibly be continued for much longer.

2. Characteristics of the new coins

The new coins should be similar in size, weight, ring, and color to present coinage. It seems probable that in the new series as in the old only the 1-cent piece should be red in color. New coins should have wearing qualities not greatly inferior to those of the present coinage, and any increase in durability would be a valuable dividend.

It is assumed from the outset that the existing diameter and thickness of U.S. coinage will be continued. On the assumption that it is desirable to retain some continuity with the past, it can also be argued that the retention of silver in our subsidiary coinage is desirable. Cer-

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tainly, there is no question that continuation of subsidiary coinage of the present silver content would offer many advantages. Because that is not possible, the main choice comes down to subsidiary coins of lower silver content and coins of no silver content.

3. Degree of inconvenience

Inconvenience to the public would be minimized if new coins have desirable technical characteristics, are readily available in requred amounts, and can be used with confidence in present coin-operated devices.

Inconvenience will also be reduced if new coins can be placed into circulation through normal channels in the ordinary way, rather than by requiring the public to exchange old coins for new. The exchange approach would involve complications such as having large numbers of exchange locations; an adequate inventory of new coins for exchange purposes at each location; educating the public regarding the exchange, etc. New legal prohibitions should be held to the irreducible minimum consistent with the protection of existing coinage and the achievement of a smooth transition to the new system.

4. Absence of extreme hardship

A new coinage program should avoid inflicting a demonstrably serious hardship upon a particular group or industry. The coin-machine industry could claim such hardship if new coins did not work in its machines. The manufacturers of rejector devices could claim a serious hardship if a proposed period of transition to the new system were too short to allow an orderly adaptation of existing equipment, if adaptation is required. A considerable hardship to the public at large would arise if the usefulness of coin-operated devices were seriously impaired over a long period of time. Silver producers could claim that a new coinage system that threatened to lead to a sharp fall in the price of newly mined silver would place an undue burden upon them. Silver users could claim that a new coinage system that promised to lead to a sharp increase in the price of refined silver would be inequitable.

D. Minting Characteristics and Coinage Costs

Relative ease and certainty in the manufacturing process for new coins is particularly desirable in view of the current coin shortage. There are some signs that the coin shortage has been alleviated to a certain degree. Even so, the need will remain for an assured transition to high levels of output for the new coins, particularly since large amounts of any new coin are likely to be taken out of circulation temporarily by the public. However, feasibility from the production side would have to be clearly demonstrated if new materials or new processes were to be used.

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The minimization of the manufacturing cost of a given system of coins of acceptable quality is desirable as a simple matter of efficiency. There is general agreement that within the limitations with which they have had to work, Mint operations have been conducted very efficiently. A slightly broader aspect of the cost question is whether or not the Treasury should seek to achieve the lowest possible total coinage cost, inclusive of materials used. Unless it can be shown that higher cost does for some reason make coins more acceptable, there would seem to be reason to favor low-cost coinage.

The possibility must be examined that the potential scope for counterfeiting would thereby be encouraged, although this does not appear likely to be of consequence in the case of any alloy that would be acceptable on other grounds. Aside from seeking the minimum level of materials and manufacturing costs consistent with coinage of acceptable quality, there is a case under present circumstances for holding the foreign exchange cost of coinage to reasonable proportions. It will also be essential to insure that the transition to a new system of subsidiary coinage does not have harmful side effects on the international position of the dollar.

E. Compatibility with Present Coinage

The production requirements for a new coinage system can be eased if there is side-by-side circulation of new and old coins during the period of transition. The only exception would arise if it were believed that an entire set of new coins could be produced and the substitution of new for old coins made in one step. This does not appear to be an available alternative at the present time. Because of the coin shortage, it is necessary to keep Mint facilities fully employed on the production of coins of the present type. Therefore, it is particularly desirable that a new coinage system provide for a high degree of side-by-side circulation of new and old coins.

In addition to minimizing production problems and protecting the existing coinage, it would be desirable that new and old coins be compatible in the sense of working in existing coin machine rejectors. If this is not possible, problems will be eased to the extent that the required modification of rejectors can be made within a reasonably short period of time at an expense that is not prohibitive.

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III. Silver Market Trends

The present section discusses recent trends in silver markets and the implications of these trends for a new coinage system. The discussion falls into two major divisions. First, recent developments in silver consumption and production are examined at world, foreign, and U.S. levels. This concludes with a review of what has happened to Treasury silver stocks and what is likely to happen to them in the near future. Second, with this background established, the discussion turns to the special problem of the effects that higher silver prices might be expected to exert upon world and U.S. consumption and production of silver.

World Production and Consumption

Since World War II, and particularly since 1958, there has been a widening gap between Free World silver consumption and production. Continuing pressure upon U.S. silver stocks is basically attributable to that gap between Free World production and use of silver, although in any given year imbalances have been met from a variety of sources including use of silver stocks, demonetized coin, liquidation of private holdings of silver, and, for a time, sizable sales by Red China.

The relatively sluggish expansion of silver production in the face of rapidly expanding consumption may be seen in Table 1 which estimates Free World silver consumption and production since 1949. It will be noticed that Free World silver production has risen only moderately since 1958, and has averaged about 205 million ounces annually over the entire period 1958–64. In that same period, world consumption of silver, for coinage and industrial use taken together, has just about doubled. As a result, the sizable annual deficits of 65 to 70 million ounces that were the rule from 1949 to 1958 had tripled to a massive 205 million ounces by 1963, when silver usage grew to twice new silver production, despite an appreciable production increase in 1963. Data for 1964 are still subject to revision but they suggest an overall deficit of 325 to 350 million ounces, with estimated total usage up to more than two and one-half times the estimates of total new production.

The "indicated deficits" of table 1 are gross measures of the degree of disequilibrium that has existed in world silver markets. They

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considerably overestimate the excess demand that has actually impinged upon world markets, chiefly because of the inclusion of U.S. coinage demand in overall consumption. U.S. coinage demand has been met from official stocks, not from new production. From some standpoints, it is the balance between production and industrial demand, alone, that is of interest. Therefore, the indicated deficit in Table 1 is also shown exclusive of total coinage demand, and U.S. and foreign coinage demands are shown separately so that other measures of the deficit can readily be computed. Foreign coinage demand is, by and large, met in the market. But, in terms of the overall balance between world consumption and production, inclusion of all demands is the indicated course to follow, whether met from existing stocks or current output. Indeed, it might even be argued that U.S. coinage demand should be increased to include the amounts of old silver dollars placed in circulation during recent years. To do so would raise 1963's indicated deficit by more than 50 million ounces.

Although the indicated deficits cannot be interpreted literally as measures of excess demand, these gross statistics do show most clearly the drastic alteration that has taken place in world silver consumption and production, and the overall dimensions of the Free World production deficit. It is particularly significant that in each of the last 6 years the use of silver in industry and the arts has, itself, exceeded new production.

TABLE 1.—*Estimated Free World Silver Consumption and Production, 1949–64*

[In millions of fine troy ounces]

	Industry and the arts (1)	U.S.A.	Coinage demand, foreign (2)	Total	Total consumption (3)	New production (4)	Indicated deficit (−) (5)	Deficit excluding all coinage demand (−) (6)
1949–53 average	153.1	36.5	48.2	84.7	237.8	173.9	−63.9	20.8
1953–57 average	190.1	37.5	36.0	73.5	263.6	191.0	−72.6	.9
1958	190.5	38.2	41.3	79.5	270.0	205.8	−64.2	15.3
1959	212.9	41.4	45.0	86.4	299.3	188.4	−110.9	−24.5
1960	224.6	46.0	57.9	103.9	328.5	206.9	−121.6	−17.7
1961	239.5	55.9	81.2	137.1	376.6	203.0	−173.6	−36.5
1962	247.8	77.4	50.2	127.6	375.4	206.9	−168.5	−40.9
1963	252.2	111.5	55.5	167.0	419.2	213.8	−205.4	−38.4
1964	285.9	203.0	61.5	264.5	550.4	215.5	−334.9	−70.4

Source: Columns (1) and (2) are from Handy and Harman, *Annual Reviews*. Column (4) is derived from the world totals published in the *Annual Reports of the Director of the Mint* and compiled by the Bureau of Mines. Production for the following countries has been subtracted from the world totals: Czechoslovakia, East Germany, Hungary, Rumania, Poland, U.S.S.R., China, and North Korea. The world production estimate for 1963 is from the Bureau of Mines, *Mineral Industry Surveys*, August 21, 1964; and that for 1964 is from Handy and Harman, *Annual Review*, 1964, adjusted on the basis of the 1958–63 relationship between the Handy and Harman and Bureau of Mines estimates.

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This strongly suggests the possibility that, even if coinage demand for silver were to dry up entirely, there would still be an appreciable gap between the world's industrial consumption of silver and prospective levels of silver produced at current prices. Since U.S. coinage requirements have been met from existing stocks of silver, market demand would not be directly affected if the United States were entirely to discontinue the use of silver in coinage. If other countries were also to abandon the use of silver for coinage, and if their demands had previously been met from current production, there would be some resulting effect upon market demand. But, total consumption requirements would still appear quite likely to continue to exceed current production at the price-cost relationships now existing in the silver industry. In 1963, for example, it will be noticed from Table 1 that there was an indicated Free World deficit of about 40 million ounces wholly aside from coinage demand, and this deficit appears to have widened to 70 million ounces, or so, in 1964 when speculative purchases of silver again became important, as they were in 1961.

The possibility that a sharp reduction in coinage demand would still find silver in relatively short supply in world markets does not take into account the effect on silver prices of any ultimate disposition of existing official stocks. World silver stocks in official hands outside of the United States are believed to be quite modest in size. On the basis of the statistics presented in the *Annual Report of the Director of the Mint*, they would appear to total little more than 100 million ounces. As for this country, at current rates of U.S. coinage demand and bullion redemptions, the question is scarcely one of how to dispose of any residual U.S. official stocks without disrupting the market. Existing U.S. official stocks of silver are likely to be no more than adequate for the short-run stabilization of world silver prices which the United States will find essential in making an assured, trouble-free transition to a new coinage system. Even if the decision is to replace silver subsidiary coinage with a base alloy, some silver might be required after the transition period for stockpile or other purposes.

Unless one envisions some radical departure from the recent pattern of world industrial consumption and production of silver, demand for silver appears certain to be strong over the long run, even if silver is very largely abandoned as a coinage material.

Free World Silver Production and Consumption Outside the United States

Until recent years there had been approximate balance between silver production and consumption outside of the United States, but, in the last few years, overall deficits of some size have begun to ap-

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pear. Table 2 estimates foreign silver production and consumption, 1949–64.

Consumption

The rise in foreign use of silver in industry and the arts has been very great. It is estimated that Free World foreign industrial use of silver may have amounted to something like 60 million ounces prior to World War II. That level had been regained by 1953. A period of rapid growth in silver consumption then led to more than doubling of the 1953 level by 1961. Industrial demand in Canada, United Kingdom, France, West Germany, and Japan rose more or less steadily from an average 35.8 million ounces in 1949–52 to an average 96.4 million ounces in 1959–62. The increase in the industrial use of silver has been most striking in West Germany and Japan. There was some indication of a reduced rate of growth in Free World industrial use of silver outside the United States during 1962 and 1963, probably due to the effect of the increasing price of silver in those years. However, as the price of silver remained at the ceiling imposed by the monetary value of the U.S. silver dollar during 1964, the growth in foreign industrial use of silver was very sizable, some 20 million ounces on the basis of preliminary data.

Foreign coinage demand remained relatively stable through 1959, averaging about 40 million ounces annually. It then rose appreciably in the period from 1960 through 1964, when it averaged some 65 million ounces annually, with a good part of this increase accounted for by the French coinage program. Future coinage demand in the Free World outside of the United States is difficult to estimate, but few observers see much likelihood of any marked further expansion from present levels. Foreign coinage demand might very possibly decline.

Production

Production of silver in the Free World outside the United States increased fairly steadily until 1958. It then reached a temporary plateau, before increasing by about 8 million ounces in 1963. Preliminary reports suggest that foreign production in the Free World did not rise by a similar amount during 1964. As a result of relatively slow overall growth in production and rapidly increasing demand, the surplus of new production over consumption, which had already begun to narrow sharply after 1964, disappeared altogether in 1960. Deficits have been substantial since that time. The indicated deficit, including coinage demand, has averaged a little less than 30 million ounces annually in the last 5 years. The deficits were larger in 1961 and 1964, partly, it would seem, because of some speculative purchases of silver in each of those years. Excluding coinage demand, production of silver in the Free World outside the United States has exceeded consumption by an average 32 million ounces during the last 5 years, but this surplus fell in 1964 to 13 billion ounces.

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TABLE 2.—*Estimated Foreign Silver Consumption and Production, 1949–64* [1]

[In millions of fine troy ounces]

	Average, 1949–52	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
Industrial uses:													
Canada	4.7	4.7	3.9	4.6	3.8	5.8	4.6	4.5	4.3	4.5	4.6	4.6	4.8
United Kingdom	12.4	11.9	12.6	14.2	13.8	14.7	14.8	17.5	16.5	20.0	20.0	20.0	23.0
France	[2] 7.4	14.5	15.0	15.7	15.9	17.9	14.1	10.6	13.0	14.0	13.5	13.9	14.8
West Germany	8.5	11.9	24.2	28.1	31.5	33.1	31.1	33.3	40.2	43.5	41.8	40.5	46.3
Japan	2.2	5.6	5.8	6.3	7.9	8.8	8.2	13.6	21.6	19.1	19.6	20.0	20.0
Other countries	12.3	14.7	14.3	23.9	43.0	37.3	32.7	30.4	29.0	33.4	38.3	43.2	54.0
Total: Foreign industrial uses	47.5	63.3	75.8	92.8	115.9	117.6	105.5	109.9	124.6	134.5	137.8	142.2	162.9
Foreign coinage demand	48.3	48.0	30.2	44.4	35.4	32.2	41.3	45.0	57.9	81.2	50.2	55.5	61.5
Total foreign consumption, industrial and coinage	95.8	111.3	106.0	137.2	151.3	149.8	146.8	154.9	182.5	215.7	188.0	197.7	224.4
Total foreign production	131.4	148.8	146.3	154.9	153.7	158.6	169.0	165.4	170.1	168.1	170.6	178.6	179.5
Indicated deficit (−)	35.6	37.5	40.3	17.7	2.4	8.8	22.2	10.5	−12.4	−47.6	−17.4	−19.1	−44.9
Surplus, excluding coinage demand	83.9	85.5	70.5	62.1	37.8	41.0	63.5	55.5	45.5	33.6	32.8	36.4	16.6

[1] Estimates exclude the Sino-Soviet bloc.
[2] Average, 1950–52.

Source: Handy and Harman *Annual Reviews*, *Annual Reports of the Director of the Mint*, and Table 1.

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U.S. Production and Consumption

Consumption

In contrast to the very rapid growth in foreign silver consumption, industrial consumption of silver in the United States has not changed greatly in the postwar period. As shown in Table 3, industrial consumption averaged about 100 million ounces during 1949–52 and had only risen to about 110 million ounces by 1963, although it apparently increased to more than 120 million ounces during 1964. There is some evidence of a cyclical pattern, with declines in 1954 and 1958, but not much sign of the sharp upward trend that has characterized foreign silver consumption in most of the postwar period.

Detailed statistics on the uses of silver consumed in industry are scarce especially in the case of foreign countries. However, the U.S. data presented in Table 4 give some indication of the relative importance of silver in various uses and of the changes that have taken place since 1959. The general picture is one of relatively rapid expansion in newer uses—batteries, electrical and electronic components—and some contraction in more traditional uses—silverware and jewelry. Photographic use remained about constant from 1961 through 1963, before increasing substantially in 1964. These end-use statistics suggest a slightly higher level of U.S. industrial consumption in 1964 than the 123-million-ounce Handy and Harman figure used elsewhere in this study.

U.S. coinage demand averaged a little under 40 million ounces annually from 1949 through 1960. Coupled with relative stability in the industrial use of silver during the same years, this meant that total U.S. silver consumption remained relatively constant. For example, U.S. industrial demand plus U.S. coinage demand was 148.8 million ounces in 1953 and 148.0 million ounces in 1960. Subsequently, silver requirements for coinage have grown at a tremendous pace, most recently because of the Treasury's efforts to overcome the shortage of subsidiary coin. Accompanied by a moderate increase in industrial demand, the result has been more than a doubling of overall U.S. consumption of silver in the 4 years since 1960. On the basis of available statistics it appears that U.S. industrial consumption plus coinage use during calendar year 1964 amounted to about 325 million ounces; it was less than 150 million ounces in 1960.

Production

Production of silver in this country has remained remarkably constant during the postwar period—a fact which suggests that there may be no dramatic increases in the offing. During the individual years covered in Table 3, production fluctuated narrowly between 35 and 40 million ounces except for a 1959 decline to 23.0 million caused by a prolonged copper strike. Early indications are that 1964 refinery production of silver may amount to about 36 million ounces. From 1949

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Table 3.—*U.S. Silver consumption and sources of supply, 1949–64*

[In millions of fine troy ounces]

	Average, 1949–52	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
Industrial consumption	99.9	106.0	86.0	101.4	100.0	95.4	85.5	101.0	102.0	105.5	110.4	110.0	123.0
New production	39.2	37.7	35.6	36.5	38.7	38.7	36.8	23.0	36.8	34.9	36.3	35.0	36.0
Difference	60.7	68.3	50.4	64.9	61.3	56.7	48.7	78.0	65.2	70.6	74.1	75.0	87.0
Add: U.S. coinage	35.0	42.8	53.2	8.2	31.4	52.0	38.2	41.4	46.0	55.9	77.4	111.5	203.0
Equals: Indicated deficit	95.7	111.1	103.6	73.1	92.7	108.7	86.9	119.4	111.2	126.5	151.5	186.5	290.0
Accounted for by—													
Net commercial imports	−95.4	−92.9	−88.1	−56.5	−68.5	−50.1	−71.2	−55.3	−29.5	−9.1	−63.3	−30.2	+45.0
Lend-lease, returns (−)				−23.2	−88.8	−89.8	−103.4	−45.0	−15.7	−10.4	−8.3		
Change in Treasury stocks	−3.0	−14.9	9.2	−4.8	+51.1	+33.6	+91.9	−46.3	−67.7	−129.5	−94.4	−184.0	−366.3
Total acconnted for	−98.4	−107.8	−78.9	−84.5	−106.2	−106.3	−82.7	−146.6	−112.9	−149.0	−166.0	−212.5	−321.3
Discrepancy ((−) values imply net additions to domestic inventory)	−2.7	+3.3	+24.7	−11.4	−13.5	+2.4	+4.2	−27.2	−1.7	−22.5	−14.5	−27.7	−31.3

Source: Consumption, coinage, and production data from *Annual Reports of the Director of the Mint*, except for 1964 when consumption and production are from Handy and Harman's *Annual Review*. Preliminary estimates suggest that U.S. mine production of silver in 1964 was about 37 million ounces. Net commercial imports from Handy and Harman, *Annual Reviews* and *Minerals Yearbooks*. Lend-lease returns from *Annual Reports of the Director of the Mint*. Change in Treasury silver stocks from Treasury *Daily Statements*.

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through 1960, approximate constancy in production and relatively stable consumption held the U.S. silver deficit around an average of about 100 million ounces annually, or about 65 million ounces exclusive of coinage demand. However, the deficit has widened with the precipitous increase in the coinage demand for silver and probably totaled more than 290 million ounces during calendar year 1964.

TABLE 4.—*Estimated U.S. Silver Consumption, by Field of Use or End Product, 1959–64*

[In millions of fine troy ounces]

Field of use or end product	1959	1960	1961	1962	1963	1964
Batteries	3.5	3.5	5.0	6.0	6.2	9.0
Brazing alloys and solders	10.5	10.5	11.0	13.0	13.0	15.8
Dental and medical	4.8	4.8	4.9	5.0	5.1	5.2
Electrical contacts and other electrical uses; Electronic components	20.5	19.5	24.0	25.0	26.0	30.3
Mirrors	3.0	3.0	3.1	3.1	3.1	3.1
Missiles	------	------	------	1.0	.2	1.0
Photographic film, plates, and sensitized paper	30.8	31.7	32.3	33.3	33.3	40.3
Silverware and jewelry	28.0	29.0	25.0	22.0	22.0	22.5
Miscellaneous	------	------	.2	2.0	1.1	------
Net industrial use	101.0	102.0	105.5	110.4	110.0	127.1

Source: U.S. Department of Commerce estimates published in the *Congressional Record*, Apr. 23, 1965, p. 8069.

The lower section of Table 3 summarizes briefly the way in which the indicated deficit between U.S. silver consumption and production has been met. An excess of commercial imports over exports, ranging from 50 to 100 million ounces, has typically met a substantial part of industrial needs. The decline of net imports in 1961 reflects higher silver exports and during 1964 there was a net export of silver because of the sharp increase in bullion redemptions, some of which were undoubtedly for foreign account. Lend-lease returns of silver are shown separately in the next line of the table, and the change in Treasury stocks of silver is the last entry for which direct information is available.

A final line in the table shows the discrepancy between the indicated deficit and the amount accounted for by net imports, lend-lease returns, and changes in Treasury stocks. While this discrepancy contains residual errors and Treasury sales of silver to Government agencies, it may also provide a rough measure of changes in domestic inventory. Beginning in 1959 the residuals are consistently nega-

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tive in sign which would be the case where there were net domestic accumulation of privately held inventories of silver.

Analysis of Changes in Treasury Stocks of Silver and a Projected Rate of Depletion

The dominating feature of the world silver situation is the existence of a massive production deficit. As noted earlier, the indicated world deficit in 1963 was about 210 million ounces, 25 million ounces in the Free World outside the United States, and 185 million ounces in this country. During 1964 the overall world deficit widened to 325 to 350 million ounces, chiefly because of a sharp increase in U.S. coinage demand. As Table 3 shows, the indicated U.S. deficit of 185 million ounces in 1963 was almost exactly matched by a decline in the Treasury's stock of silver. In 1964, U.S. silver consumption (both industrial and coinage) exceeded production by about 290 million ounces, and Treasury stocks fell by an even larger amount because of increased redemptions of silver certificates. In 1965, the consumption deficit seems likely to be substantially larger than in 1964.

The past decline in Treasury stocks of silver is detailed in Table 5. A rough indication of the possible rate at which remaining Treasury stocks might be depleted can be obtained by simple extension of the rate of loss in recent years. It is true, of course, that any projection of that nature is limited in its value by uncertainty as to the shape that future developments will take. The single most important future influence in 1965 will be the nature and timing of the Treasury's own legislative recommendations and subsequent developments in Congress. Additional factors are the extent to which the existing coin shortage can be overcome by the much higher levels of coin production now underway, and the point at which declining Treasury stocks of silver would cause a sustained acceleration in the demand for the redemption of silver certificates.

The data of Table 5 for past years have mainly come from Treasury *Daily Statements* and *Circulation Statements*. In the interests of simplicity in presentation, a number of relatively minor influences upon the Treasury silver stock have been grouped into the single category "other causes of change." It should be noted that the total silver stock figure shown in Table 5 includes the four *Daily Statement* categories: "Silver," "Silver dollars," "Subsidiary coin," and "Other silver bulion." This overall figure customarily exceeds the single *Daily Statement* entry for "Silver" by varying amounts which have recently averaged some 30 to 35 million ounces. Working with the larger total allows Table 5 to provide a more coherent picture of the separate influences on the Treasury silver stock.

The three memorandum columns at the extreme right give the amounts of silver certificates outside of the Treasury converted to a

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bullion equivalent at 0.7734375 ounces per dollar. It will be noted that by the end of 1964 retirement of silver certificates had reduced the bullion equivalent of those in circulation almost 300 million ounces below the total Treasury silver stock. As long as retirement of silver certificates proceeds at a rate in excess of the decline in the Treasury's silver stock—as it has thus far in 1965—the Treasury's margin of "uncommitted" silver will be widening. No doubt the rate of retirement of silver certificates will fall over time, particularly since a relatively large amount of silver certificates are probably lost or destroyed and will never be presented for redemption or retirement. There would be no point in immobilizing any substantial fraction of Treasury silver as backing for these notes and it might conceivably interfere with an orderly resolution of the coinage problem.

On the basis of the information in Table 5, it appears possible that Treasury stocks of silver might be depleted in 2 to 3 years if present trends continued. The projected rate of use of silver in coinage would probably fall back as the present crash coinage program achieved its aims. On the other hand, it is quite possible that the Treasury would have to supply larger amounts of silver in holding the market price of silver—an absolute essential to protect the existing coinage—as its own stocks neared depletion.

The latter possibility counsels against any delay in beginning the transition to a new coinage system. It is encouraging that redemptions of silver certificates in the early months of this year have been relatively modest in amount, well below the peak levels last year when a dock strike and other factors led to a sharp but temporary increase. This decline in the rate of redemptions has been more or less roughly paralleled by a decline in the futures price of silver which may well signify that market expectations of any increase in the spot price of silver are considerably dampened. However, it is clear that any failure to proceed promptly with the creation of a new subsidiary coinage system reducing the need for silver would encourage speculation and might lead to a rapid depletion of Treasury stocks of silver.

If the Mint were to switch over to the production of nonsilver coinage by the beginning of 1966, Treasury stocks would surely be adequate to stabilize the silver market through sales and/or redemptions during the time that would be needed to produce large amounts of new, nonsilver coins.

If the Mint were to switch over to the production of reduced content silver coinage during 1965, it is not self-evident that Treasury stocks would be large enough to hold world silver prices below, say, $1.29+ during the transition period, let alone for any extended period thereafter. Stocks might conceivably be adequate to negotiate the transition, but a favorable outcome depends upon a number of factors about which little assurance can be felt. Net coinage requirements would

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TABLE 5.—*Analysis of Changes in U.S. Treasury Silver Stocks Since 1958*

[In millions of fine troy ounces]

	Silver used in coinage	Bullion exchanged for silver certificates	Old silver dollars paid out	Other [1] causes of change	Total change in silver stocks	Silver stock at end of period [2]	Memorandum: Bullion equivalent of silver certificates [3] at end of period		
							In circulation	Held by Federal Reserve banks and agents	Total
1958	−38.2		−12.7	+142.8	+91.9	2,106.2	1,683.5	188.3	1,871.8
1959	−41.4		−15.7	+10.8	−46.3	2,059.9	1,651.1	209.3	1,860.4
1960	−46.0		−16.2	−5.5	−67.7	1,992.2	1,632.0	215.9	1,847.9
1961	−55.9		−23.8	−49.8	−129.5	1,862.7	1,616.3	191.2	1,807.5
1962	−77.4		−27.4	+10.4	−94.4	1,768.3	1,536.0	177.5	1,713.5
1963	−111.5	−19.0	−51.5	−2.0	−184.0	1,584.3	1,440.4	105.4	1,545.8
1964:									
January	−9.8	−3.5	−1.0	+3.1	−11.2	1,573.1	1,331.8	192.4	1,524.2
February	−11.3	−2.2	−2.3	+1.2	−14.6	1,558.5	1,317.4	175.0	1,492.4
March	−15.3	−3.9	−16.5	+1.9	−33.8	1,524.7	1,326.4	153.1	1,479.5
April	−16.4	−8.0		−.8	−25.2	1,499.5	1,314.1	112.5	1,426.6
May	−16.2	−3.4		+1.4	−18.2	1,481.3	1,317.6	100.2	1,417.8
June	−11.5	−8.2		−11.8	−31.5	1,449.8	1,321.1	80.3	1,401.4
July	−11.4	−3.4		+3.0	−11.8	1,438.0	1,271.4	92.7	1,364.1
August	−18.9	−5.1		+.1	−23.9	1,414.1	1,245.3	100.0	1,345.3
September	−20.3	−21.4		+3.7	−38.0	1,376.1	1,205.4	96.4	1,301.8
October	−22.3	−44.1		−2.5	−68.9	1,307.2	1,117.5	88.3	1,205.8
November	−23.7	−20.5		−1.9	−46.1	1,261.1	1,049.6	66.5	1,116.1
December	−26.0	−17.6		+.5	−43.1	1,218.0	952.3	82.1	1,034.4
1964	−203.0	−141.4	−19.8	−2.1	−366.3	1,218.0	952.3	82.1	1,034.4

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1965:									
January	−26.1	−11.2	----------	+.2	−37.1	1,180.9	866.6	103.3	969.8
February	−22.5	−8.7	----------	+2.6	−28.6	1,152.3	817.0	88.7	905.7
March	−25.3	−7.3	----------	−3.0	−35.6	1,116.7	763.9	68.5	832.4
April	−27.3	−12.4	----------	−.4	−40.1	1,076.6	----------	----------	----------

[1] Includes purchases, lend-lease returns, net sales and transfers to Government agencies, sales to industry during 1959–61, variation in the amount of subsidiary coin and bullion held in the Treasurer's General Account, and a residual discrepancy arising from the fact that coinage and bullion exchanges are shown here on a Mint accounting basis while the total change in silver stocks is shown on the more widely available *Daily Statement* basis.

[2] As shown in the *Daily Statement*. The total includes approximately 64.8 million ounces held by certain agencies of the Federal Government.

[3] Issued after June 30, 1929.

Source: Treasury *Daily Statements*, *Circulation Statements*, and unpublished material.

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probably be smaller (private hoarding could outweigh Treasury net recoveries of silver from the existing stock of coinage), but speculative demands for silver would surely be much larger. The market would not expect that the Treasury would, or could, hold silver prices at $1.29+ beyond a fairly short period of transition, and the volume of Treasury redemptions, or sales to the market, at $1.29+ could expand rapidly as the market anticipated the imminent appearance of much higher silver prices. Indeed, this psychology could even develop with a transition to base alloy subsidiary coinage if at the same time the silver content of the dollar were reduced since this would raise the monetary value of silver and encourage the belief that the market price would also rise.

The problem of the transition to silver coinage of reduced content is examined more fully in Section V of this study.

The Influence of Price on Silver Production and Consumption

The remainder of this section of the discussion will examine the extent to which an increase in the market price of silver would be likely to bring production and consumption into an early balance. In principle, there should be some increase in the relative price of silver that would help to bring about market equilibrium. Higher prices can be expected to encourage net substitutions and economies in use on the consumption side and also to encourage some increase in silver production beyond that which would otherwise occur. In the context of the present study, the pertinent issues are the size of the increase in price that would be required, and the nature of the adjustments that would take place during a transition to the new equilibrium. Only the first of these issues—the eventual price at which the market might balance—will be discussed at this stage. It must be emphasized that at this stage no attention is to be paid to the feasibility of achieving a successful transition to a new system of reduced content silver coinage.

Actually, the question of how the transition would be achieved is fully as important, indeed much more important from the standpoint of the Treasury and the provision of an adequate supply of coinage, than the eventual price at which the market might settle. Any proposal to reduce the silver content of U.S. coinage would have to allow for the fact that a quicker supply response to rising silver prices would come from existing stocks of silver—including silver coinage in circulation—than from an expansion in new production, which would only occur after some lapse of time. Because an increase of market price much above $1.38 an ounce would imperil the existing subsidiary coinage, the transitional problems take on unique significance. How, or whether, the transition to silver coinage of reduced silver content could be effected is a complicated issue, better explored separately

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from the probable longer-run effects of higher price on the consumption and production of silver.

Consideration of the prices that might eventually be reached in silver markets, after the transitional period during which price would have been stabilized, can, however, throw a good deal of light on the practicability of replacing our present coinage system with one of reduced silver content. Reduction of the silver content of our existing coinage system would increase the ceiling, or ceilings, to which the market price of silver could rise before Treasury sales of silver to the market would again be required. If it appears that the market price of silver might again reach the monetary value of our coinage within a reasonably short period of time, reduction of silver content could not be regarded as an eligible long-run solution, irrespective of whether or not the immediate transition could be safely negotiated.

A limiting consideration is the fact that straight silver-copper alloys with less than 50 percent silver content are not acceptable because of their poor physical characteristics. It will be assumed, pending Section IV's examination of the technical and metallurgical characteristics of alternative coinage alloys, that silver-copper coins of 800, 700, 600, and 500 fineness do meet at least minimum standards of acceptability and are relatively easy to produce. However, lower silver contents can also be achieved by cladding silver on an inner core of copper or lower content silver and by adding some nickel and zinc to otherwise unacceptable silver-copper alloys. These possibilities will be discussed subsequently. For the present, with attention confined to straight silver-copper alloys, the question is whether, after the transition to a coinage system with reduced silver content, silver prices would be at all likely to reach the ceilings listed in Table 6. If analysis of supply and demand factors suggests very strongly that the ceiling associated with a certain silver content could be reached in the foreseeable future, that particular coinage alternative would have to be ruled out as a long-run solution.

TABLE 6.—*Monetary Value of U.S. Coinage of Existing Thickness and Diameter for Various Silver Contents*

Silver content	Monetary value	
	Silver dollar	Subsidiary coins
90 percent	$1.29+	$1.38+
80 percent	1.48+	1.58+
70 percent	1.71+	1.83+
60 percent	2.03+	2.17+
50 percent	2.48+	2.66+

Source: Bureau of the Mint.

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The Influence of Silver Price Upon Production

An increase in the price of silver which led to an increase in the expected profitability of silver mining would normally be expected to lead to some subsequent increase in production. Higher prices would tend to encourage more exploration, higher production from mines already in operation, reopening of submarginal properties, and the reworking of old mine tailings. The strongest influence of higher silver prices, as such, would be upon the segment of the industry engaged in silver mining proper. In that case, the immediate effect is to increase total revenue per ton of ore in direct proportion to the increase in silver price. Where silver is found in association with other metals, the importance of a silver price increase is modified by the proportion of total revenue attributable to silver. Where only traces of silver are found with other metals, the increase in revenue will obviously not be of much consequence. Between this extreme and that of pure silver mining there is a range of situations in which an increase in silver price will have a greater or lesser effect upon company receipts.

Against the nominal stimulus to production from a higher price must be set the fact that silver mining is not a manufacturing operation. A higher price for silver may be required simply to maintain production at a given level. As marginal mines and deposits are worked out, continuing exploration activity is required even to maintain known reserves at a constant level. This exploration activity can be increasingly expensive in relationship to the market value of the new silver reserves that are discovered. Technological progress in exploration and mining techniques can arrest or even reverse a tendency for the level of reserves and the amount of current production to decline at any given level of silver prices. But, a fairly rapid rate of technological progress may be essential not only to overcome diminishing returns to exploration effort, but also to offset the effects of steady increase in money wages and other costs over time.

Shallow deposits of silver have presumably been well worked over and deep mining is very expensive. Private efforts here and abroad, and the Bureau of Mines shallow drilling program in this country, may discover sizable additional silver deposits near to the surface. The recent find of Texas Gulf Sulphur in the Timmins region of Ontario is impressive. Published reports at the time estimated that 55 million tons of copper, zinc, and silver ore, with an average grade of 4.85 ounces of silver per ton, had been found under an overburden of 20 feet. It would seem unwise to count on finds of this sort occurring frequently, but it does suggest that sizable new finds may occur.

Rising silver prices would exert some effect on the overall profitability of mining operations in which silver occurs in byproduct as-

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sociation with other metals. Data are not available to estimate the extent of any stimulus to base-metal mining that would result from a higher price of silver. However, it is well to recognize that the very concept of a byproduct is to some extent a convenient accounting fiction and while higher silver prices may not make "by-products" into "co-products" in very many cases, some overall stimulus to the profitability of base-metal mining and some consequent increase in silver production could be expected to occur. There is no evidence, however, that this stimulus would be very strong.

The main line of causation is not likely to run from higher silver prices to base-metal mining. Instead, a major influence upon levels of silver production in the future, as in the past, will be the amounts of copper, lead, and zinc that are produced, and the proportion of silver in total tonnage. Therefore, estimation of the direct effect of higher silver price upon its production must be supplemented by estimation of the amounts of silver that will be forthcoming as a more or less natural consequence of expansion in base-metal mining.

World Silver Production

Some major characteristics of world silver production since 1900 are summarized in Chart 1. It will be noticed that there has been a substantial degree of correspondence between short-run fluctuations in the output of copper, lead, and zinc, and the output of silver. Longer-run trends in the production series were similar until the period following World War II. Since 1945 aggregate world output of copper, lead, and zinc has grown rapidly; the output of silver has also increased, but more slowly.

Some of the appearance of synchronous fluctuation in the upper and lower panels of Chart 1 is due to the three interruptions to production caused by World War I, the Great Depression, and World War II. However, there is little doubt that the byproduct relationship also accounts for much of the parallelism in the production movements. Unfortunately, there are no comprehensive historical data available at the world level on the amounts of silver mined as byproduct and mined as pure silver. This obstructs any conclusive statistical evaluation of the separate influence of base-metal production and silver price upon the production of silver. Such evidence as there is suggests that the byproduct relationship has generally been the more important.[1]

[1] The price and byproduct influences were tested by a multiple correlation of world silver production with silver price and the aggregate output of copper, lead, and zinc during the 1900–1963 period. Erratic influences upon silver production were so strong during the period that the overall correlation is a very poor one, with only about 35 percent of the overall variation in silver production explained by silver prices and base-metals production taken together. Silver prices and production were actually negatively correlated, although base-metal production was, as expected, positively related with silver

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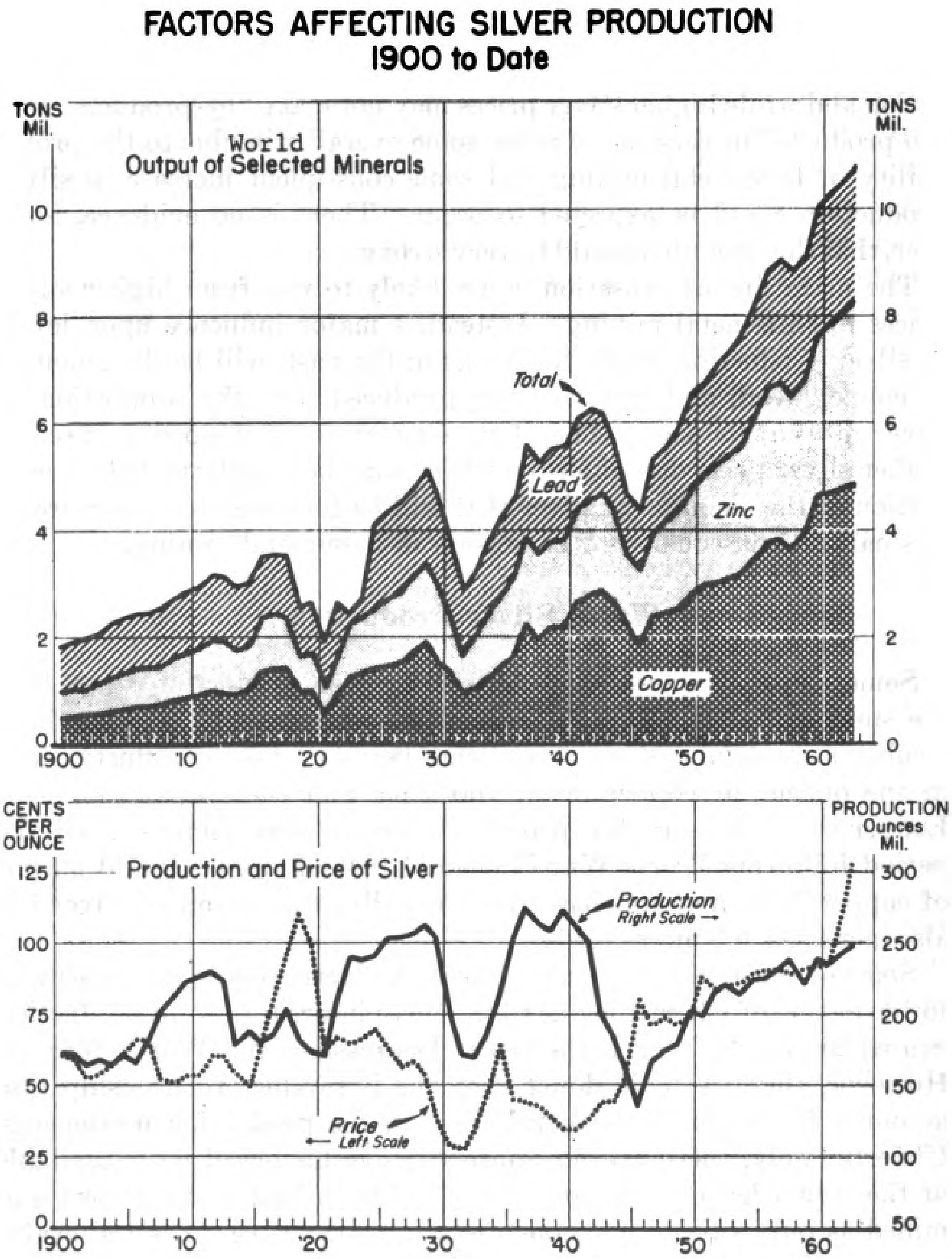
Chart 1



Indeed, the statistical association of silver production and silver price does not appear to have been particularly close or consistent. Until the depression of the 1930's, there is indication of an inverse relationship with production falling when price was rising, and the

production. The relationships are much closer in the postwar period, particularly between silver production and the production of base metals. However, the period of time is short and the correlation between silver prices and base-metals production is relatively high. Under these conditions, the multiple correlation technique does not yield dependable estimates of the independent influence of the explanatory variables, in this case silver price and base-metals production.

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reverse. Price and production did fall sharply together during the early depression years and then rose together under the stimulus of the U.S. Silver Purchase Program, and a general revival in base-metal mining. Aside from this cyclical rise and fall, silver price and production seem to have been most closely related in the period following World War II. But, this has also been a period of very rapid growth in base-metal production which would account for the observed increase in silver production. In all likelihood the sustained postwar expansion in copper, lead, and zinc output has, in fact, been the dominant influence on world silver production. The postwar increases in the price of silver may have played some limited part in encouraging the expansion of output, especially in regions where pure silver mining is important. However, it is only recently that the price increases have been sizable and more time is needed to see just how much new production will be forthcoming as a result.

Increases in copper and zinc production in the postwar period have far exceeded the expectations generally held in the early 1950's. It is interesting in this connection to compare the actual increases that have occurred with the projections for 1975 made by the Paley Commission in 1952. Table 7 shows that by 1962 copper production already exceeded the Paley Commission estimate for 1975 by a wide margin. World copper reserves are very large and the Paley estimate for 1975 is quite unlikely to prove to be accurate. Zinc production also gives every indication of rising well above the Paley estimate; the estimate for lead production may be closer to the mark. The apparent failure of these projections, made little more than a decade ago, to anticipate trends in base-metal mining is a sobering reminder of the difficulties involved in any long-range forecast.

There are some general features of the experience since 1900 that do offer guidance as to probable future levels of silver production. Dur-

TABLE 7.—*Comparison of Paley Commission 1975 Estimates of Free World Copper, Lead, and Zinc Production with Actual Production, 1950 and 1962*

[Production in thousands of short tons]

	1950 actual	1962 actual	1975 Paley estimate	Percentage increase	
				1962 over 1950	1975 estimate over 1950
Copper	2, 515	4, 145	3, 850	65	53
Lead	1, 644	2, 060	2, 700	25	64
Zinc	1, 931	3, 010	3, 200	56	68

Source: Report of the President's Materials Policy Commission and Bureau of Mines.

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ing the entire period since 1900 the overall trend in silver production has been positive, but not very large. On the basis of the production experience since 1900, the annual average increase in world silver production has been only about 325,000 ounces. Silver production has known extreme variations in the past, and this cautions against the acceptance of any mechanical projection of past production levels as a guide to what could happen in the future.

Conditions in the postwar years are more relevant as an indication of the degree of future expansion in silver output that may be expected. The 325,000 ounce annual production increment, based upon the entire experience since 1900, is far too low as an estimate of future production increases. The aggregate production of copper, lead, and zinc has grown rapidly in the postwar period, and recent increases in the price of silver have offered additional encouragement for the expansion of silver mining. While base-metal production will not necessarily continue to grow so rapidly, increases in silver prices might compensate for some slackening in copper, lead, and zinc production. On the basis of the relatively favorable production experience in the postwar period, an annual average increase in world silver production of about 3½ million ounces might be expected in the future. In general, this average increase of 3½ million ounces seems a much better guide to what may be expected in the future than the much lower 325,000 ounce average increase over the entire period, 1900–63.

Even this higher estimate of future production increases may very well be too low. Table 8, dated October 27, 1964, gives estimates of new Free World silver production supplied to the Treasury by Mr. Simon D. Strauss, Vice President, American Smelting and Refining Company, and member of the Silver Committee of the American Mining Congress. These estimates of the new production of silver that may take place in the next 4 years were described as conservative and based upon projects for which financing was already committed. Table 8–A presents estimates made on the same basis but at a somewhat later time by Robert O. Hardy, President, Sunshine Mining Company, and Chairman of the Silver Committee of the American Mining Congress. These estimates of the new production of silver try sources should be more accurate, over the timespan to which they refer, than any mechanical projection of past experience. Furthermore, the Strauss and Hardy estimates receive support from the fact of a 7 million ounce increase in Free World silver production during 1963. Preliminary data suggest that a much smaller increase of only some 2 million ounces may have occurred during 1964. The Strauss and Hardy estimates, if they were realized, would mark a fairly significant departure from postwar production experience, but would do very little to close the large gap between Free World consumption and production.

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TABLE 8.—*Estimate of New Free World Silver Production Expected in the Next 4 Years*

Location	Ounces of silver
United States:	
Mineral Park	168,000
Battle Mountain	432,000
East Tintic	2,500,000
Bingham Canyon	750,000
Flat Head	1,000,000
Wah Chang	300,000
Blue Hill	117,000
Missouri Lead Belt	500,000
Twin Buttes	1,500,000
Total	7,267,000
Mexico	1,000,000
Central and South America	1,000,000
Europe:	
Consolidated Mogul	550,000
Northgate	1,100,000
Total	1,650 000
Australia and Southeast Asia:	
Cobar	500,000
Mount Isa	5,800,000
Marinduque	1,500,000
Te Aroha	70,000
Total	7,870,000
Canada:	
Texas Gulf Sulphur	7,750,000
Granduc	750,000
Brunswick	2,500,000
Western Copper	570,000
Lake Dufault	1,500,000
Total	13,070,000

SUMMARY

United States	7,267,000
Mexico	1,000,000
Central and South America	1,000,000
Europe	1,650,000
Australia and Southeast Asia	7,870,000
Africa	[1]
Canada	13,070,000
Total	31,857,000

[1] No change.

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New foreign silver production in the next 4 years would amount to about 25 million ounces according to Table 8, and to about 30 million ounces according to Table 8–A. A net addition of this size to current production would be greater than the gains that have been made in recent years, although not drastically out of line with foreign production increases in the mid-1950's. Between 1949 and the present time, the 4-year moving total of increases in foreign production has been as high as 29 million ounces in 1949–53, and as low as 1.6 million ounces in 1959–62.

TABLE 8–A.—*Estimate of New Free World Silver Production Expected in the Next 4 Years*

Location	*Ounces of silver*
United States:	
Mineral Park	168,000
Battle Mountain	432,000
East Tintic	2,500,000
Bingham Canyon	750,000
Flat Head	1,000,000
Wah Chang	300,000
Blue Hill	117,000
Missouri Lead Belt	500,000
Twin Buttes	1,500,000
Silver Summitt	1,000,000
	8,267,000
Mexico	2,000,000
Other America: E. Mochito	1,000,000
Peru:	
Cerro	1,500,000
Machicala	500,000
Kiowa	200,000
Arcata	350,000
Quiruvilca	250,000
	2,800,000
Europe:	
Consolidated Mogul	550,000
Northgate	1,100,000
Largentiere	1,500,000
	3,150,000
Australia:	
Cobar	500,000
Mount Isa	5,800,000
	6,300,000

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TABLE 8-A.—*Estimate of New Free World Silver Production Expected in the Next 4 Years*—Continued

Location	Ounces of silver
Southeast Asia:	
Marinduque	1,500,000
Te Aroha	70,000
	1,570,000
Canada:	
Texas Gulf Sulphur	7,750,000
Granduc	2,500,000
Brunswick	750,000
Western Copper	570,000
Lake Dufault	1,500,000
Mount Washington	200,000
	13,270,000
Grand total (approximate)	38,000,000

The projected 7- to 8-million-ounce increase in U.S. production during the next 4 years may be slightly more difficult to achieve. No sustained increase of this magnitude has occurred in U.S. production during the postwar period. However, there is reason to believe that some increase in U.S. silver production will occur within the near future, possibly on the scale envisaged in the Strauss-Hardy projections. A study of the silver situation prepared last year in the Department of the Interior projected an increase in U.S. silver production of about 1 million ounces per year, reaching a level of 41 million ounces by 1970. While somewhat below the increases suggested by Strauss and Hardy, the Interior estimate is essentially consistent with them in anticipating some increase above the plateau upon which U.S. silver production has remained for more than a decade. On the other hand, the Interior study projects only an 18-million-ounce increase in world production by 1968, about half the amount anticipated by the American Mining Congress.[1]

U.S. Silver Production

Needed increases in silver production will undoubtedly have to come very largely from outside of the United States. Table 9 summarizes the world distribution of silver production in the postwar period. U.S. production of about 60 million ounces in the period immediately following World War I was some 30 percent of world production. The U.S. proportion of world output had fallen below 25 percent after World War II and it has fallen further to less than 20 percent at the present time. Separate discussion of the U.S. industry could hardly

[1] It is understood that the Interior study will be published as Information Circular 8257.

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be justified on the basis of its importance in the world supply picture. However, there are much fuller and more dependable statistics available on U.S. production than there are on most foreign sources of production. These statistics throw some light on the respective importance of the price of silver and the output of the metals with which silver is found.

TABLE 9.—*Free World Production of Silver by Countries, 1948–52, 1953–57, and 1962*

Country	Average production, 1948–52		Average production, 1953–57		Production, 1962	
	In thousands of fine troy ounces	Percent of Free World total	In thousands of fine troy ounces	Percent of Free World total	In thousands of fine troy ounces	Percent of Free World total
Australia	10, 560	6. 4	14, 222	7. 6	17, 250	8. 5
Bolivia [1]	6, 996	4. 2	5, 987	3. 2	3, 760	1. 8
Canada	21, 064	12. 7	28, 931	15. 4	30, 669	15. 1
Mexico	50, 053	30. 2	45, 191	24. 0	41, 249	20. 3
Peru	13, 322	8. 0	22, 164	11. 8	36, 017	17. 7
United States	39, 246	23. 6	37, 450	19. 9	36, 345	17. 9
All other	24, 715	14. 9	34, 223	18. 2	37, 815	18. 6
Total, Free World	165, 956	100. 0	188, 168	100. 0	203, 105	100. 0

[1] Exports.

Source: *Annual Reports of the Director of the Mint.*

The basic data are presented in Table 10. The variations in pure silver production of column 2 do not seem to bear any simple relationship with the silver prices of column 4. Practically all of U.S. pure silver production is located in the Coeur d'Alene region of Idaho and most of it in one mine—the Sunshine. Changes in production sometimes have been due to special reasons not directly connected with the price of silver. For example, there were fairly lengthy interruptions of production at the Sunshine Mine because of labor disputes in 1962 and 1963. These could have prevented the appearance of production increases encouraged by higher silver prices. An even more basic limitation of the price and output data of Table 10, as guides to the price-sensitivity of silver production, is the fact that silver prices had been approximately constant for a decade, until they began their sharp increase late in 1961. Some time may have to elapse before the effect of rising prices is fully registered in production increases.

Average gross hourly earnings in metal mining rose by about 100 percent between 1947 and 1961, while the price of silver rose by only 30 percent. Productivity in silver mining can hardly have risen rapidly enough to prevent a continuing squeeze on profit margins.

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TABLE 10.—*United States Silver Production by Type of Ore and the Price of Refined Silver in New York, 1947–63*

Year	Total silver production (million fine troy ounces)	Silver ore and placers (million fine troy ounces)	Silver found in association with base metals (million fine troy ounces)	Silver price (cents per ounce)
1947	38.6	10.0	28.6	71.82
1948	39.2	10.5	28.7	74.36
1949	34.9	8.3	26.6	71.93
1950	42.3	14.0	28.3	74.17
1951	39.9	12.8	27.1	89.37
1952	39.8	12.5	27.3	84.94
1953	37.7	11.1	26.6	85.19
1954	35.6	14.1	21.5	85.25
1955	36.5	11.1	25.4	89.10
1956	38.7	11.3	27.4	90.83
1957	38.7	12.5	26.2	90.82
1958	36.8	15.1	21.7	89.04
1959	23.0	10.3	13.0	91.20
1960	36.8	13.8	23.0	91.37
1961	34.9	13.7	21.2	92.45
1962	36.3	11.9	24.4	108.37
1963	35.2	11.7	23.5	127.91

Whether or not a widening of profit margins could achieve much of an expansion in pure silver production is uncertain, but the possibility cannot be entirely disregarded. Higher silver prices in the mid-1930's were followed by sharp expansion in U.S. silver production from precious metal ores, although the paralleling increase in the price of gold at that time was also an important influence. In any case, the absolute magnitude of any future U.S. production increases from pure silver mining could not be very great relative to total requirements.

While the data of Table 10 do not reveal much evidence of the influence of price upon silver production, there is clear evidence of the importance of the byproduct character of most silver production. An index of the silver found in association with other metals, computed from column 3 of Table 10, is plotted in Chart 2 along with an index of the aggregate U.S. output of copper, lead, and zinc. These series fluctuate together very closely because of the conditions of joint supply under which about two-thirds of U.S. silver output is produced. In addition to the close fluctuation of the two indexes, it is interesting to note the overall decline in silver ouput relative to copper, lead, and zinc ouput. A falling ratio of silver per ton of base-metal production means that increases in silver price may be necessary simply to keep silver's contribution to $1 of total revenue at a constant level. Under such circumstances it does not seem at all likely that moderate in-

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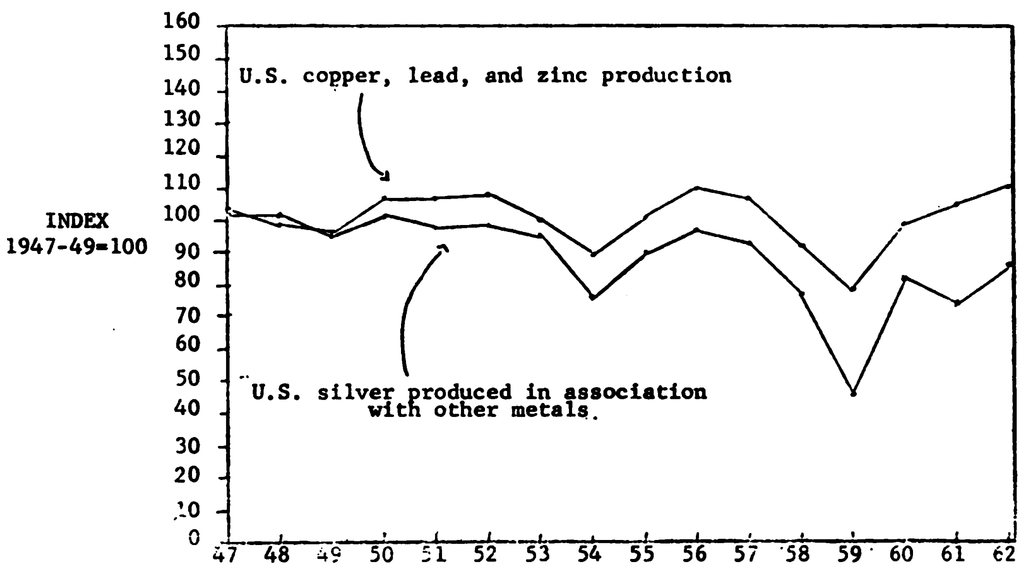
creases in silver price would give any net stimulus to base-metal mining.

If this observed decline in the amount of silver found with base metals should continue, the effect on overall silver output could be sizable. It is quite conceivable that silver production could fall in absolute terms even though silver prices were rising, if the yield of silver per ton of base ores were to decline at all rapidly. Statistics for silver mining outside of the United States are inadequate to determine whether or not there is a worldwide trend toward lower silver yield in byproduct situations. Scattered evidence and geological considerations suggest to some observers that there may be such a trend. If there is, and if it should become pronounced, the outlook for any continued expansion of world silver production would be much less certain. Major dependence would then have to be placed upon the effect that higher prices could exert on pure silver mining, an effect for which there really is not much direct evidence at all.

Chart 2 Indexes of Copper, Lead and Zinc Production and Silver Produced in Association With Other Metals, 1947-1962



The Influence of Silver Price Upon Consumption

Discussion of the probable influence of silver prices upon noncoinage demand can be quite brief. Statistical information that bears directly upon the issue is very limited in its range and coverage. The available statistics can be supplemented to some extent by descriptive material on new uses for silver, the extent to which rising silver prices are said to encourage economy in the use of silver, etc. While of some value, this descriptive material is not overly enlightening as to the actual effect that rising prices would exert upon consumption.

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The chief influences upon silver consumption in the postwar period appear to have been (a) growth in the use of silver as a consequence of rising consumer income, (b) changes in the industrial consumption of silver as a consequence of new uses, and (c) the dampening effect upon the growth of demand exerted by increases in the relative price of silver. U.S. silver consumption, aside from coinage demand, has really shown only very moderate overall growth during the postwar period, although a very large increase in consumption did apparently take place during 1964.

The statistics on U.S. silver consumption presented earlier in this section pointed to considerable expansion in relatively newer uses, such as batteries and electronic and electrical components, but this expansion has been just about matched by decreasing uses in silverware and jewelry, while photographic uses have been relatively constant. The consumption statistics suggest that the declines in the more traditional uses of silver began before the increase in silver prices during 1961, but price increases undoubtedly intensified these reductions in consumption. In the 3 years, 1961–63, overall consumption of silver in this country for noncoinage purposes remained relatively constant, before increasing by about 12 percent in 1964.

Foreign consumption of silver experienced a very rapid growth phase in the postwar period until 1961. Between 1953 and 1961, the industrial use of silver outside of the United States approximately doubled. Most of this increase in consumption is undoubtedly attributable to rapid increases in income in Western Europe and Japan. Foreign consumption of silver showed a tendency to level off in 1961, just as it did in this country. Subsequent upward revisions in the data on foreign consumption now credit 1962 and 1963 with small increases, but much below the earlier rate of growth and the increase that took place during 1964. It seems reasonable to believe that rising prices for silver have exerted some influence in dampening foreign demand. From 1953 to 1961, the increase in average monthly silver prices in London was a little less than 8 percent over all. Practically all of this increase occurred in 1955, and from 1955 through most of 1961, the London price of silver was almost constant. Therefore, the marked postwar expansion in foreign consumption occurred at approximately constant prices. In 1964, when silver prices leveled off, foreign industrial consumption of silver rose by about 15 percent.

The relative constancy in consumption of silver in 1962 and 1963 very probably was the resultant of opposing forces: the continued growth in income and output that would encourage more use of silver, and the higher price of silver that would encourage less. It is uncertain whether or not further price increases, similar in magnitude to those since 1961, would continue to offset the rapid growth in consumption that would otherwise occur because of rising incomes and

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new uses. However, the assumption of slow growth in consumption of silver in physical terms as a consequence of trend growth in income and rising relative prices of silver does find some support in recent experience.

Prospective Levels of Silver Price in a Free Market

This concluding section considers the danger that within a few decades the market price of silver might reach the higher monetary values associated with various hypothetical reductions in the silver content of the existing coinage. Major reliance is placed upon an examination of the degree to which a given level of higher prices for silver would be successful in removing the excess demand that prevails at the current price of $1.29+, and in keeping silver markets in balance thereafter. This examination of silver supply and demand draws upon the earlier analysis of the factors that influence silver production and consumption. It does not lead to absolutely definite conclusions and there may also be some value in a more direct approach. Therefore, initial consideration will be given to what a direct extension of the postwar trend in the price of silver would imply for coinage alternatives.

Monthly average New York silver prices are plotted in Chart 3 from 1915 through 1964. The monetary values of U.S. coinage of the existing thickness and diameter for 800, 700, 600, and 500 fineness, taken from Table 6, have also been drawn on the chart. It appears from inspection that if silver prices were to continue something like their postwar increase, which really can be said to date from the depression low of 25¢ silver, a level of $2 an ounce could very easily be reached within the next two decades.

The general level of world costs and prices has moved upwards during much of the postwar period, and it could be argued that continuation of an upward movement of similar proportions is less likely in the future. If so, one factor that has contributed to postwar increases in the price of silver will be lessened in influence. On the other hand, there may be reason to believe that future supplies of silver will be available at increasing real cost because of the steady depletion of known resources and the accompanying need to intensify expensive exploration effort. In such a case, silver prices would be expected to rise relative to a general index of commodity prices. A judgment on this latter score is difficult enough; the byproduct nature of two-thirds of silver production complicates it further.

Extension of past price trends is obviously a very crude forecasting technique. For that matter, the accurate forecasting of a commodity price two decades in the future by any technique whatsoever is not within the realm of possibility. In the present case, however, the question is not so much the single most probable value for the price of

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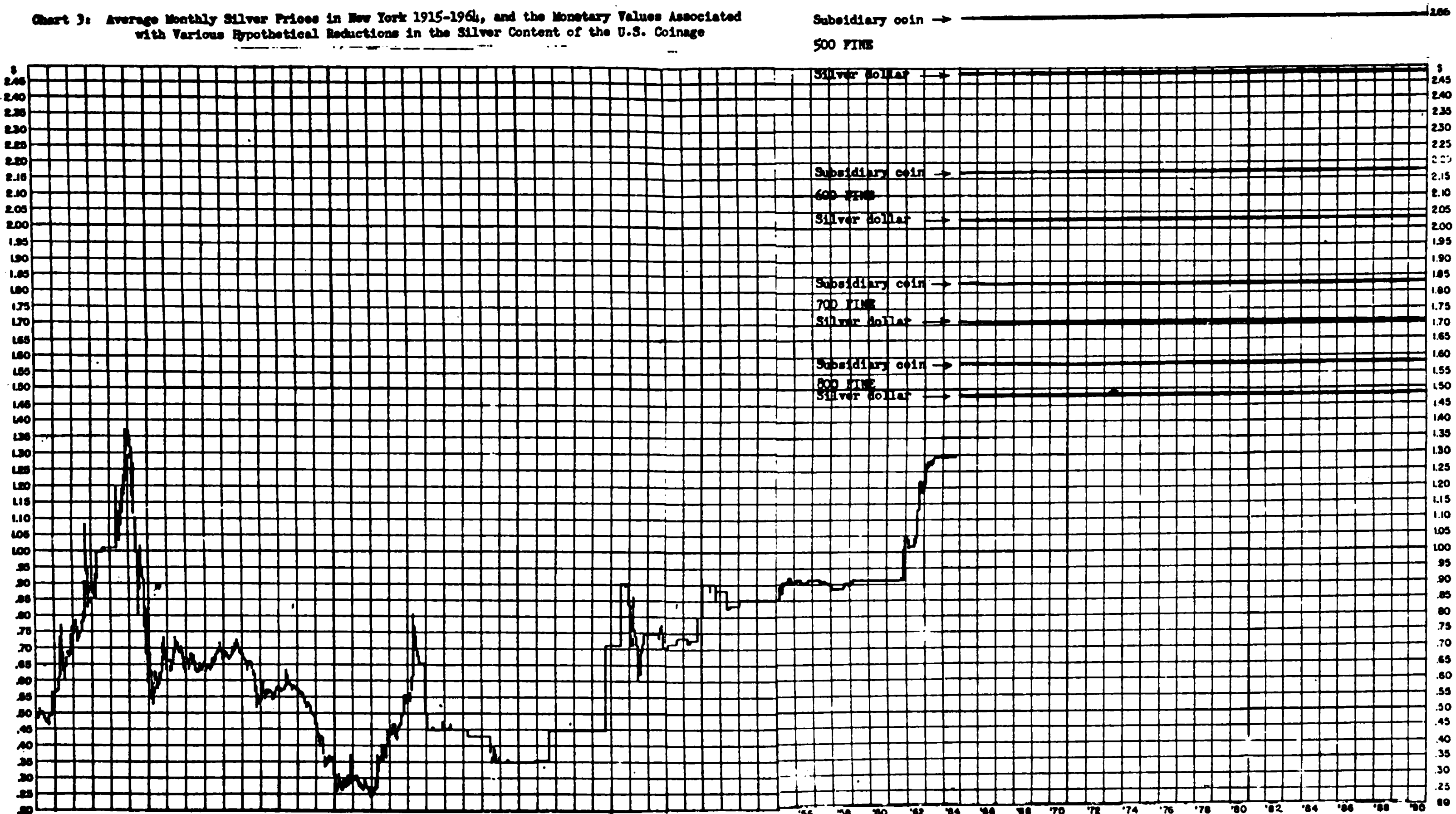
Chart 3: Average Monthly Silver Prices in New York 1915-1964, and the Monetary Values Associated with Various Hypothetical Reductions in the Silver Content of the U.S. Coinage



Source: Silver price from Handy and Harman; Monetary Values computed by the Bureau of the Mint.

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silver in, say, 1985, as whether there is reason to believe that by that time the price of silver could have reached the various monetary values drawn in on Chart 3. The postwar trend of the price of silver does suggest that an increase to $2 an ounce, within the next two decades or so, is far from impossible. Unless the analysis of supply and demand can point decisively to factors that promise to hold the price of silver well below its postwar trend rate of increase, it would seem that 800, 700, and even 600 silver content should definitely be ruled out as longrun solutions to the coinage problem.

The alternative to direct projection of the apparent trend in the price of silver is a consideration of the factors bearing upon the supply and demand for silver. The more important of these factors have already been discussed and it is only necessary now to pull together earlier conclusions and apply them to the question at hand. There would, in general, seem to be three major determinants of the extent to which silver prices would rise in a free market. The first is the initial size of the excess demand that will exist at the market price of $1.29+ when prices are permitted to rise. Excess demand will continue to exert upward pressure on price until it is eliminated by adjustments in consumption and production. The second determinant of the price rise that would be required to bring silver markets into balance is the net effect over time upon silver production of rising silver prices and trend growth in the production of metals with which silver is found. The third determinant is the net effect over time upon silver consumption of higher silver prices and trend growth in consumer income and the industrial output in which silver is used. An omitted factor of some consequence on the supply side is the supplement to current production that would be forthcoming at various price levels from existing stocks of silver. This omission is probably less serious where longrun trends in prices are at issue, than it would be if the intent were to forecast prices a few years ahead.

In holding the free market price of silver at $1.29+ an ounce the Treasury acts as residual supplier to the world silver market. Consequently, the amounts that the Treasury is obliged to supply to the market are one measure of the excess demand—speculative and nonspeculative—in the market at $1.29+. Since the Treasury has only been holding the line at $1.29+ for a relatively short time and because of the presence of transitory speculative demands, it is questionable how accurate an indication of the behavior of excess demand over time one can gain from this source.

An alternative approach is to subtract U.S. coinage demand from the Free World production deficits presented earlier in this section. The results are shown in Table 11. They suggest a "normal" annual deficit from 1949 to 1958 of about 25 to 35 million ounces, met from a range of sources other than current production. The price of silver

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was approximately constant during this period. During 1959 and 1960 the residual world deficit increased about 40 million ounces above the earlier level. In 1961 there was a further increase of about 40 million ounces, some of which may have represented speculative demand in anticipation of the halting of Treasury sales of free silver. While deficits decreased somewhat in 1962 and 1963 as the price of silver rose to $1.29+, they remained well above pre-1959 levels. In 1964, the deficit increased by about 40 million ounces. As in 1961, this probably reflected some inventory accumulation in anticipation of an increase in the price of silver. This suggests that aside from speculative demands, which could be expected to carry Treasury redemptions to much higher levels, there may now be excess demand of a "permanent" sort amounting to perhaps 75 million ounces at the current price of silver.

TABLE 11.—*Free World Silver Production Deficit, U.S. Coinage Demand, and the Residual Deficit, 1949–64*

[In millions of fine troy ounces]

	Indicated production deficit	U.S. coinage demand	Residual deficit
1949–53 average	−63.9	36.5	−27.4
1953–57 average	−72.6	37.5	−35.1
1958	−64.2	38.2	−26.0
1959	−110.9	41.4	−69.5
1960	−121.6	46.0	−75.6
1961	−173.6	55.9	−117.7
1962	−168.5	77.4	−91.1
1963	−205.4	111.5	−93.9
1964	−334.9	203.0	−131.9

Source: Table 1.

What size this underlying deficit would be after a transition to coinage of reduced silver content is conjectural. Resumption of anything like earlier rates of growth in foreign consumption of silver—and the apparent increase in 1964 was very large—could easily cause annual excess demand to increase to 100 million ounces or more in a few years. However, the more conservative course may be simply to estimate the market gap at 75 million ounces.

How readily could this 75 million ounce gap be closed from the production side? The postwar trend increase in silver production is only 3½ million ounces a year; its continuation would do practically nothing to close the gap and dampen the upward movement of price. The Strauss-Hardy estimate of an 8 to 10 million ounce annual net increment to world silver production includes whatever may have been the stimulating effect of the increase of more than 40 percent in silver

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prices between late 1961 and 1963 and the generally improved outlook for primary metal output at the present time. That production estimate may prove to be an accurate one, but it is far from clear to what extent a higher price of silver accounts for the increase, or how long one could count on sustained increases in silver production of this size.

It is even less clear to what extent, if any, excess demand could also be closed from the consumption side. The statistical information is meager and firm conclusions are very difficult to reach. There is no doubt that, other things being equal, steadily rising silver prices would reduce the volume of silver consumed. But world incomes will be rising and the potential for new uses of silver is said to be considerable. If the consumption of silver were to remain approximately constant because of rapidly rising silver prices while production grew at something like 8 million ounces annually, excess demand would be narrowed in time, but the potential rise in the price of silver would be very great. Indeed, so long as *any* excess demand were chronic, silver prices would be likely to rise, although not necessarily at a steady pace because of the intermittent appearance in the market of silver drawn from existing stocks.

The price of silver rose more than 40 percent in 2 years between late 1961 and 1963 and was only stopped by the U.S. Treasury redemption ceiling. Excess demand seems to have been about 70 million ounces, and this gap was only slightly reduced, if at all, by the increase in price. There are now some signs of a lagged response of production. Consumption growth was slowed a little, but only temporarily. It is extremely doubtful whether recent experience offers any assurance whatsoever that silver prices would remain below $2 in the next two decades. Indeed, it is not at all difficult to contemplate price rising much farther. It is very hard to rule out the possibility of a doubling or even a tripling in the price of silver unless it can be shown that a higher price of silver would cut back the consumption of silver appreciably from present levels. A basic difficulty is that the silver supply-demand situation has been changing very rapidly in the last half dozen years, so rapidly that little basis exists upon which to estimate with much assurance the independent effect of silver prices upon consumption.

In the last analysis, it is the uncertainty as to how high silver prices might rise within two decades that argues most strongly against reducing the silver content of the coinage as a longrun solution to the coinage problem. That uncertainty could certainly be held to rule out 500 fineness as well as the higher silver contents. This is a question of judgment. No one can be sure that the price of silver would not double in the next two decades and reach the melting point of 500 fine silver coinage. This does seem somewhat less likely than the possi-

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bility that price would reach or exceed $2. Longrun supply and demand factors are not the only reason why silver coinage of 500 or lesser fineness may be unsuitable as a longrun solution. On the basis of longrun market factors alone, silver coinage of 500 fineness is not absolutely ruled out, although the case for it is seriously weakened even without reference to the difficulties of the transition period. Its advantages and disadvantages from a technical and a metallurgical point of view will be considered subsequently along with those of a range of other possible alloys.

All of the discussion to this point has assumed that U.S. coinage demand could be met in the foreseeable future from official stocks of silver remaining at the end of a transition period, possibly supplemented by recovery of old coin. The validity of such an assumption is highly questionable. In the course of its investigation, Battelle made detailed projections of the rates at which Treasury silver would be exhausted on various assumptions as to silver content and coinage requirements. With 50 percent silver content, Battelle predicted that Treasury silver would be entirely exhausted somewhere between 1969 and 1975, if not before. If it were to prove necessary for the Treasury to add its own demand to that of the market, there can be little doubt that the price of silver would rise well above $2 during the next two decades. Indeed, once Treasury stocks were exhausted, the prospect of keeping any silver coinage in circulation would not be at all bright.

Conclusion

1. Recent years have seen the development of an enormous gap between Free World production and consumption of silver. The overall deficit, inclusive of coinage demands, was over 200 million ounces in 1963 and almost 340 million ounces in 1964. Even if all coinage demands, U.S. and foreign, are subtracted, a deficit remains although relatively modest in size.

2. U.S. Treasury stocks of silver declined to 1,218 million ounces by the end of 1964 and will decline further to 1,000 million ounces or less by mid-1965. Legislative action on a new coinage system is essential while Treasury stocks of silver are still large.

3. On the basis of past experience, higher silver prices and increases in base-metal production promise to increase world silver production. The independent influence of higher silver prices cannot be estimated with any precision, but there is no reason to doubt that substantially higher prices would lead to some expansion in silver output. Unfortunately, the current production deficit is so large that it cannot be closed from the production side.

4. During the last 15 years, most of the growth in the industrial consumption of silver has occurred in foreign countries; U.S. consumption has grown more slowly. There were some signs that the recent

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increase in silver prices had checked the overall growth in world industrial use of silver, but only temporarily, and 1964 found silver consumption increasing sharply both here and abroad.

5. A simple extension of the postwar trend of silver prices suggests that $2 an ounce might easily be reached by 1980 or 1985. Analysis of supply and demand factors does not yield any precise estimate of the level that silver prices might reach in a free market. The analysis does suggest that there is a very appreciable risk that price could reach $2 an ounce then, or even much sooner. Battelle's detailed quantitative projections of the rate of exhaustion of Treasury stocks lead to an even more pessimistic appraisal since with 50 percent silver content they can foresee the complete exhaustion of Treasury silver as early as 1969.

6. In view of these considerations, it does not appear that reduction of silver content to 800, 700, or 600 fineness would constitute a longrun (20- to 25-year) solution to the coinage problem. On the basis of longrun supply and demand factors, silver coinage of 500 fineness is, perhaps, not definitely ruled out, although there certainly is substantial risk that a rising market price of silver would soon imperil coinage of 500 fineness. That risk would be overwhelming even for lower silver contents if future U.S. coinage demand could not be met exclusively from Treasury silver holdings.

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IV. Metallurgical and Technical Characteristics of Alternative Coinage Alloys

This section of the discussion is concerned with the metallurgical and technical characteristics of the various coinage alloys that might replace silver of 900 fineness in a new coinage system. The objective is to narrow the field of possible coinage alloys to those which are acceptable from a metallurgical and technical standpoint. It will then be possible to deal more effectively with problems of the transition to a new coinage system.

The analysis of the preceding section has led to the elimination of silver alloys of more than 500 fineness because of the prohibitive risk that the market price of silver would reach, or exceed, $2 an ounce within the next 20 years or so. The metallurgical and technical characteristics of silver alloys of 500 fineness remain to be considered along with those of a fairly wide range of base alloys. In addition, there are possibilities in the form of composite coinage materials with silver or base alloy outer layers clad on an inner core. These will be discussed in the course of the present section. Intensive analysis of the technical and metallurgical characteristics of these clad materials will be found in the Battelle study, and the Mint has, itself, been conducting an exhaustive investigation of the feasibility of the use of clad material in U.S. coins.

The alternative alloys are taken up in alphabetical order and any material that has been seriously proposed to, or by, the Treasury receives at least brief consideration in the course of the discussion. In the interest of brevity, attention is chiefly concentrated upon those alloys that seem to show promise. Except in the case of few materials which are readily eliminated because of some glaring deficiency, each coinage alloy is considered under five general headings. These are: Public acceptability, operation in vending machines, counterfeiting potential (including the use of blanks and foreign coins in vending machines), ease and certainty of production, and cost and availability of raw materials. Results of the discussion under these headings are summarized in Tables 1 and 2, at the end of this section, which show acceptable and rejected coinage alloys separately.

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Aluminum

Public Acceptability

Aluminum coins are unlikely to be acceptable to the public. Pure aluminum is very light in weight with a density of 2.7 grams per cubic centimeter, in contrast to a density of 10.3 for 900 fine silver. Aluminum is also very soft. It could be hardened by the addition of manganese but its wearing qualities would still be relatively poor. Aluminum can be processed so as to produce different colored coins but this seems unlikely to increase its chances for public acceptance. Foreign coinage use of aluminum is chiefly limited to low denominations. There are some examples of use by developed industrial countries; namely, Austria, Italy, and Japan. On balance, it would seem that aluminum would be rated very low in acceptability by the public if proposed as the basic alloy in a new coinage system. It is conceivable that an aluminum 1-cent piece would be acceptable to the public, but its use in high denominations lacks precedent elsewhere and probably would encounter strong public opposition.

Operation in Vending Machines

Pure aluminum has an electrical resistivity of about 2.7 microhms-cm. This is close to the 2.1 resistivity of 900 fine silver and the 3.1 of the present 1-cent piece. However, current vending machines depend not only upon coins being nonmagnetic, of proper size, and of appropriate electrical resistivity; they also depend upon coins being of a certain minimum weight in order to roll properly and they use a bounce test for hardness.[1] Aluminum coins fall below minimum weight requirements and existing vending machine rejectors cannot easily be redesignated to handle lightweight coins. Furthermore, if manganese were added in order to harden aluminum coins, their electrical resistivity would be raised well above that of the present 1-, 10-, 25-, and 50-cent pieces. Undoubtedly, some rejection apparatus could eventually be designed to take aluminum coins and reject other alloys. No such apparatus is available now and no one is known to be working on the problem.

Counterfeiting Potential

Unless aluminum coins were to receive some special processing, the potential for counterfeiting would seem to be very great. Sheet aluminum is readily available and the manufacture of coin blanks would not be difficult at all. The metal is soft and would take impressions readily from counterfeit dies. If the dies were of high quality, the minting of aluminum counterfeits might become a problem of some proportions.

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[1] The best single parameter in this connection is probably the product of an alloy's electrical resistivity and its density. Throughout most of the ensuing discussion that deals with vending machine operation, attention is confined to electrical resistivity because the densities of eligible coinage alloys do not vary widely.

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Aside from the threat of direct counterfeiting, aluminum blanks would probably pose a real problem for the vending machine industry. Rejectors might eventually have to be equipped with some sensing device by which blanks could be told from coins. This would undoubtedly prove to be difficult and expensive.

Ease and Certainty of Production

Aluminum is a very easy material to work and over the long run it probably would not present any difficult minting problems. The Mint has had no production experience working with aluminum, but experimentally it has been established that present techniques could be adapted readily to the fabrication of any material as soft as aluminum.

Cost and Availability of Raw Materials

Aluminum is cheap with a domestic market price of 24½ cents per pound for unalloyed primary aluminum ingot. Mint requirements would be tiny in proportion to U.S. annual consumption of aluminum of some 3 million short tons.

Conclusion: Rejected as possible coinage alloy.

Reasons: Lack of public acceptability, vending machine, and counterfeiting problems.

Columbium

Public Acceptability

Columbium has been proposed as a coinage material in the 50-cent piece and as a cladding material. The density of columbium is 8.57, just a little less than copper (8.96) and nickel (8.90). The color is gray, the ring is about the same as with silver, and the material is tarnish resistant. Wearing qualities should be appreciably better than those of silver coins. Public acceptability, as with any "exotic" material, is somewhat uncertain.

Operation in Vending Machines

Very little work has been done on the adaptation of vending machine rejectors that would be required with a pure columbium coin, or a columbium alloy. In theory, there would not appear to be any insuperable difficulties but practical experience is lacking. Columbium is fairly heavy and it is nonmagnetic. Its electrical resistivity is in the range of 12.5 to 16.0 microhms-cm, depending upon temperature. This compares with an average resistivity of 2.1 for 900 fine silver and 32.0 for cupronickel (the alloy in the 5-cent piece).

There have been experiments with powder metallurgy techniques in an effort to develop a columbium alloy which would work in existing vending machine rejectors without any alteration being required. However, at the time of writing, these efforts had not progressed much

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beyond the experimental stage and had not achieved the required degree of success under operating conditions.

Counterfeiting Potential

Columbium coins would be very difficult to imitate with any material of relatively low value.

Ease and Certainty of Production

The melting point of columbium is exceptionally high—4,474° F. to silver's 1,760° F. Columbium strip would have to be purchased from suppliers, or the Mint would have to acquire new equipment. It is said to be a very ductile material which does not work-harden when cold fabricated. The Mint should be able to make coins from purchased strip of columbium, although costs of fabrication would be somewhat greater.

Cost and Availability of Raw Materials

While fairly acceptable from other points of view, the cost of columbium is prohibitive. A price of $20 to $35 an avoirdupois pound was initially mentioned to the Treasury but a price range of $36 to $50 is quoted in the *American Metal Market*. Even the $20 to $35 price is well above a current price of $18.81 for silver. It is conceivable that on a large guaranteed coinage demand unit costs might be reduced to, or below, $10 a pond. This would still be a very expensive coinage material.

There has been no U.S. mine production of columbium ore in recent years. About 60 percent of U.S. imports of columbium concentrate are from Canada; the rest are rather widely dispersed. Domestic stocks of concentrate and ingot are fairly sizable relative to demand for the metal but it is estimated by Battelle that it would take 2 to 3 years to expand production appreciably. Furthermore, coinage requirements would apparently be very large relative to current consumption of the metal and large relative to the national (strategic) stockpile.

Conclusion: Rejected as possible coinage alloy.

Reasons: High cost and uncertain supply outlook. Not accepted in present vending machines. Mint cannot fabricate with existing equipment.

75 Copper-25 Nickel (Cupronickel)

Public Acceptability

Cupronickel is the alloy presently used in the U.S. 5-cent piece and the most widely used coinage material in the world. The weight is good with a density of about 8.6 in contrast to a density of 10.3 for 900 fine silver, and about 9.6 for 500 fine silver. A cupronickel 25-cent piece would weigh 5.37 grams in contrast to 5.83 grams for 500 fine

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silver, and 6.25 grams for the present 900 fine 25-cent piece. The color is very good. Cupronickel does lack the luster of coin silver when the silver is untarnished. Also, its ring is not quite so impressive as that of the existing silver coins. However, a cupronickel coin ages well and its physical wear characteristics are very good—appreciably better than those of silver.

Cupronickel coinage has been used for relatively high denomination coins in the United Kingdom and has circulated side by side with silver coinage. Some objection to the use of cupronickel here would be lodged by individuals and groups who, for one reason or another, favor coinage with high intrinsic value. However, this sort of objection would be encountered if any base alloy were proposed for use in the 10-, 25-, and 50-cent pieces. It should be countered by insistence that under modern conditions high intrinsic value in subsidiary coinage tends to interfere with, rather than facilitate, performance of the essential medium of exchange function.

A question arises as to the role of the present 5-cent piece in a cupronickel system. Continuation of the 5- and 10-cent pieces in their present size and diameter, which probably is desirable, would lead to the anomaly of a 5-cent piece larger than the 10-cent piece, but made from exactly the same material. Opinions will differ as to whether this is important, but it is possible that some other material should be used for the 5-cent piece if cupronickel were to be used in the subsidiary denominations.

Operation in Vending Machines

Cupronickel has a resistivity of 32.0 microhms-cm., which is well above the 2.1 resistivity of 900 fine silver. Because existing rejectors are constructed to accept cupronickel 5-cent pieces, no unusually difficult problems are encountered in making a rejector that will accept cupronickel subsidiary coinage along with silver subsidiary coinage. The National Rejector Company has built a prototype which accepts cupronickel and silver 10-, 25-, and 50-cent pieces—NRCO 8000 Series Model X. The estimated factory cost of this new rejector, not currently in production, is $20. There are now about 4.5 million NRCO rejectors in service of three different series—4900, 5800, and 8000 regular. Many of these could be modified, at the factory or at a branch service facility, to accept existing silver coins and a new cupronickel system at an estimated cost of perhaps $10 each.

It has been estimated by the rejector industry representative that the required changeover could be accomplished within 2 years. Possibly it could be made even more rapidly at some increase in expense.

The rejector industry has concentrated upon designing a mechanism that would accept cupronickel 5-, 10-, and 25-cent pieces. A rejector such as NRCO's Model X would also accept the existing 5-cent piece, but, as mentioned previously, it may seem desirable to use a different

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alloy for the 5-cent piece if cupronickel is used for subsidiary coinage. No work has been done on the additional modification that would be required if the rejector were to accept a new 5-cent piece and cupronickel 10-, 25-, and 50-cent pieces, along with existing coins. One possible way in which that additional rejector modification could be avoided would be to make the 5-cent piece in a cupronickel system from nickel-silver (discussed below). The resistivities and other properties of nickel-silver and cupronickel are close enough so that both old and new 5-cent pieces would be acceptable in rejectors. On most rejectors no modification would be required on the 5-cent channels.

A much more promising resolution of vending machine difficulties would be to use outer layers of cupronickel clad on a copper core for all of the subsidiary denominations. Such coins would work in unaltered vending machine rejectors. They are discussed subsequently under the heading of "Other Clad Coins."

Counterfeiting Potential

The direct counterfeiting potential with cupronickel coinage should be quite low. Despite its comparative cheapness, cupronickel is not readily available from commercial suppliers. There are vending machine problems with a proposed subsidiary cupronickel coinage, but they relate to the use of foreign coins, or expanded U.S. 5-cent coins. The problem, in the instance of vending machines, is not so much the potential use of blanks, for they would be relatively difficult to obtain.

The rejector industry representatives do anticipate that a problem would arise if the U.S. were to switch to cupronickel subsidiary coinage, because of the use in vending machines of low-value foreign coins made from cupronickel. They have furnished a lengthy list of these coins which are sufficiently close in size to the U.S. 25-cent piece to operate a rejector mechanism set for a U.S. cupronickel 25-cent piece.

In addition, there is a potential problem with a cupronickel system in that the 5-cent piece could be flattened in a hydraulic press or by some other means and used as a 25-cent piece. Whether or not this would occur on any significant scale is questionable, but it is a further minor difficulty with a cupronickel system. This particular difficulty would not be overcome by substituting a 5-cent piece made of nickel silver in the cupronickel series since the two alloys have similar electrical resistivity.

Ease and Certainty of Production

The Mint has had long experience with the fabrication and minting of cupronickel. This is an important consideration where large numbers of coins may have to be produced in a very short period of time. Cupronickel is a tougher material than silver and is not quite so easy to mint. However, no unusual problems would be encountered

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and cupronickel must be rated very high in terms of ease and certainty of production.

Cost and Availability of Raw Materials

Cupronickel is also very attractive from the standpoint of the cost and availability of raw materials. Copper at 33 cents a pound and nickel at 79 cents a pound—alloy cost 45 cents—would be used in place of silver at $18.81 a pound. Coinage at the projected fiscal 1965 rate would use approximately 5,355 short tons of copper and 1,785 short tons of nickel annually. Copper presents no serious supply problem on a long-run basis, although intermittent shortages and sharp price movements can be expected to occur at times. Coinage needs would be a very small fraction of total consumption. The annual amounts of nickel used would be very small relative to U.S. consumption of 124,500 short tons in 1963.

Conclusion: Acceptable as coinage alloy.

Copper-Zinc Alloy (98 Copper-2 Zinc)

This alloy is red in color and its use for higher denomination coins does not merit any extended discussion. Along with similar alloys such as 96 copper-4 nickel, it does have an electrical resistivity similar to that of silver and could be used in existing rejectors. Some rejectors, which have been set specifically to reject copper slugs and cut-down pennies, would require minor adjustment. Copper-zinc coins could be easily fabricated on existing and planned Mint equipment. Because of their red color, they would merit consideration chiefly as an emergency measure, if silver were not available for coinage, and necessary vending machine adjustments were not yet complete. It is also conceivable that such an alloy might be used for the 5-cent piece if cupronickel were used for subsidiary coinage.

Nickel (Pure)

Public Acceptability

Pure nickel has a density of 8.90 approximately the same as cupronickel. It is whitish-gray in color and in mint condition is generally considered to be slightly more attractive than a cupronickel coin. Wearing qualities are excellent. Nickel is being more and more widely used as a coinage material although often a silver coin of higher denomination is retained in the series. This has been the case in Switzerland, Canada, France, the Netherlands, and Japan. South Africa has recently announced plans to replace its existing subsidiary coinage of 500 fine silver (reduced from 800 fine in 1951) with pure nickel coins, while retaining one high-denomination silver coin. Pure nickel coins would probably be readily accepted by the American public. The coins are very attractive and more closely

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resemble silver coinage than is the case with any of the base alloys, except nickel silver when it is in mint condition.

Operation in Vending Machines

Pure nickel is magnetic and existing rejector mechanisms are designed so as not to accept coins which are magnetic. It would be necessary entirely to redesign rejector mechanisms so as to be able to pass magnetic nickel coins but to reject magnetic iron slugs. While this probably could be done, it would be very difficult and could not be done quickly, particularly since practically all coin-operated mechanisms now depend upon the magnetic principle to some extent, and many less sophisticated mechanisms depend upon it entirely. The extent of the problem may be inferred from the fact that the International Nickel Company has directed its efforts to the development of a nonmagnetic alloy (discussed below) rather than to the modification of vending machine rejectors in order to make them capable of accepting pure nickel coins.

Counterfeiting Potential

Pure nickel coins would be extremely difficult to counterfeit because of the metal's relatively high melting point (2651° F.) and its hardness. There is little basis upon which to assess the potential for the use of nickel blanks, or blanks with comparable electrical resistivity, in vending machines since it is not clear what sort of rejector could be designed to accept pure nickel coins. The electrical resistivity of pure nickel is 9.5 microhms-cm. No other commonly used coinage alloy has a resistivity very close to that value although many brasses and bronzes, available commercially, do have similar resistivities.

Ease and Certainty of Production

Production of pure nickel coins would pose a very difficult problem for the Mint. Existing brass mill equipment could not be used because of the high melting point of nickel. The new Mint would have to be specially designed and/or nickel strip would have to be purchased for use in existing Mint facilities. The minting of nickel coins would still be very difficult with existing equipment even if strip were purchased, but it could be accomplished.

Cost and Availability of Raw Materials

Nickel costs 79 cents per pound. The International Nickel Company has estimated that at fiscal year 1965's projected rate of production of 10, 25, and 50-cent pieces about 15.7 million pounds of nickel would be required. These requirements would have to be met by imports from Canada or from the domestic stockpile. U.S. mine output comes exclusively from the Hanna Mining Company's properties in Oregon. In 1963, the nickel content of Hanna's production of ferro-

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nickel was about 21.4 million pounds but this ferronickel would not be suitable for mint requirements.

Conclusion: Rejected as possible coinage alloy.

Reasons: Vending machine problem associated with use of a magnetic alloy. Otherwise acceptable, although difficult to make with existing Mint equipment.

Nickel (Inco Alloy 95 Nickel-5 Silicon)

The International Nickel Company has developed an alloy of 95 nickel and 5 silicon which is nonmagnetic, thus removing, at least potentially, the major barrier to the use of nickel in slug rejectors of the present type. A further effort has been made to modify the alloy so that it will simulate the properties of 900 fine silver coinage and work in unaltered coin rejectors.

As one of their tests, existing rejectors roll the coin through a magnetic field. A coinage metal such as silver with very low electrical resistivity is slowed more in its travel, by eddy currents induced as it passes through the magnetic field, than is a material of higher electrical resistivity. Silver is a relatively "slow" coin, while cupronickel, for example, is a relatively "fast" coin. Having removed the magnetism of pure nickel coinage through the addition of 5 percent silicon, Inco technicians have sought to restore just such a sufficient degree of weak magnetism to the coin as to make it as "slow" as silver. In their most successful effort, the weak magnetism pulls the coin into contact with a piece of aluminum oxide tape which retards the rolling coin through physical friction. Without this retardation the 95 nickel-5 silicon coin would be too fast, since its electrical resistivity is higher than that of silver coins. The required magnetism has been sought at various times by adding a thin core of pure nickel, or a core of 80 percent nickel and 20 percent iron, to the coin. The 80 percent nickel and 20 percent iron core is now preferred since its magnetism does not vary within the ranges of temperature that would be encountered.

Despite this, early test results were not entirely satisfactory, and the feasibility of the Inco approach has never been demonstrated conclusively. According to the rejector industry, on its initial tests the Inco coin was only successful in fooling rejectors about 70 percent of the time; 95 to 97 percent success was required in their view. Inco subsequently demonstrated that slight modification of existing rejectors—application of the small strip of special tape referred to above—is capable of achieving a higher success ratio, at least under controlled test conditions for a limited number of trials. However, in the judgment of the vending machine and coin rejector industries, even with the application of the special tape the Inco coin cannot achieve a satisfactory success ratio under actual operating conditions. Wearing of the tape and variability in the strength of the magnets in the rejector

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mechanisms could be expected to create difficult problems in actual practice. There was a comparable negative finding by Battelle on the ability of the Inco coin to work in existing vending machines.

Aside from the technical issue of use in vending machines, comment on the modified nickel coin can be relatively brief since many general comments applicable to pure nickel coinage are also applicable here.

Public Acceptability

The public would seem likely to accept the modified coin about as readily as a pure nickel coin.

Operation in Vending Machines

Discussed above.

Counterfeiting Potential

This would be a very difficult coin to counterfeit, at least as difficult as a pure nickel coin, and probably more difficult. The use of blanks in vending machines would present about the same problem as with existing silver coins since the modified coin simulates silver's electrical resistivity. Some additional difficulty might arise if it were not possible to simulate the narrowed resistivity range of 2.0 to 2.5 microhms-cm. that some rejectors are using in order to reject copper blanks and foreign coins.

Ease and Certainty of Production

It is very doubtful whether the Mint could make the modified nickel alloy; certainly it would be an expensive undertaking requiring different equipment. The necessary facilities could probably be included in the new Philadelphia Mint. If the modified alloy were to be used it apparently would be necessary to buy annealed blanks from Inco, at least until the new Mint is on stream. It is possible that current and planned rates of subsidiary coin production could be achieved using the purchased blanks. Even when annealed the alloy would be harder than cupronickel, and this makes minting a more difficult task, but not an insurmountable one. The material is being patented; exclusive rights to the patent would be turned over to the U.S. Government, for use by the Mint or designated suppliers, in the event that the Mint were to decide to use the material for coinage.

Cost and Availability

Inco has estimated that the coiled strip would cost $1.50 per pound; this includes a metal cost of about 80 cents per pound. The coinage requirements for nickel have been discussed above. At the fiscal 1965 rate, about 15.7 million pounds would be needed, roughly 6 percent of U.S. annual nickel consumption. The overall supply situation is probably adequate. It is true that nickel was regarded as scarce in the early 1950's, and it still is not in such assured supply as copper, for example.

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The Bureau of Mines estimates known Canadian nickel reserves at 6 million tons and describes this as a very conservative appraisal. Canada is the principal Free World supplier of nickel and has accounted for about 80 percent of Free World production in recent years, and has supplied almost all of U.S. import requirements. Free World production of nickel was some 270,000 tons in 1963; almost half of this was consumed in the United States. If Free World consumption continued at the 1963 rate, known Canadian reserves would be depleted in about 25 years. Very large nickel reserves exist in New Caledonia and Cuba; but these should be excluded in determining the adequacy of nickel supply.

Nickel prices have almost tripled during the postwar period. Market shortages do not now exist but it cannot be said with complete assurance that they could not arise within, say, 20 to 25 years. The possibility that nickel prices could rise during that period so far as to imperil the subsidiary coinage, as has been the case with silver, is extremely remote. In this sense, nickel coinage can properly be regarded as a "permanent" solution; it would offer much less seigniorage than cupronickel.

> Conclusion: Acceptable coinage alloy if consistent operation in vending machines could be demonstrated under operating conditions. Could not be fabricated on existing Mint equipment but coins could be struck at the Mint from annealed blanks.

Nickel Silver (65 Copper-18 Nickel-17 Zinc)

Public Acceptability

Also termed German silver, this alloy differs from cupronickel by the substitution of zinc for some nickel and copper. Proportions can vary but the 65 copper, 18 nickel, and 17 zinc alloy is probably best suited for coinage use. Because the alloy is fairly close in metallurgical composition and other characteristics to cupronickel, its advantages and disadvantages are perhaps best established by direct comparison with cupronickel, where that is possible. Nickel silver is slightly lower in weight than cupronickel because some zinc with a density of 7.1 is substituted for nickel and copper with densities of 8.9. When newly minted, the coin is very attractive and has a silverlike appearance, but it develops a yellowish cast as it tarnishes with age, while cupronickel keeps its grayish-white color indefinitely. Wearing qualities of nickel silver are also somewhat inferior to those of cupronickel; the ring of the two coins is similar. Nickel silver is not very widely used for coinage. Some current examples are Portugal, Philippines, and Taiwan.

In general, nickel silver must be rated a little below cupronickel in most of the characteristics that would be likely to influence public acceptability. The margin of superiority for cupronickel is not ex-

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tremely wide but it is consistent. Public acceptability of nickel silver might conceivably be affected adversely by the fact that it is a rather cheap silver substitute with extensive household uses, *e.g.*, it is the common base for silver-plated flatware.

Operation in Vending Machines

Very little work has been done on the use of nickel silver in vending machines. However, the electrical resistivities of nickel silver (29.0) and cupronickel (32.0) are close, both are nonmagnetic, and would have similar roll properties. Nickel silver coins of the right size will work in existing rejector apparatus set for the cupronickel 5-cent piece. As noted previously, this opens the possibility of making the 5-cent piece in a new system from nickel silver and making 10-, 25-, and 50-cent pieces from cupronickel. From the standpoint of minimizing the vending machine adjustment problem another possibility would be to leave the current 5-cent piece unchanged and to introduce nickel silver 10-, 25-, and 50-cent pieces. Either system would work in the prototype NRCO Model X rejector along with existing coinage. Either system, or ones exclusively of cupronickel or nickel silver, would have a 5-cent piece that could be flattened to work as a quarter in vending machines.

Counterfeiting Potential

Nickel silver would offer slightly more potential for counterfeiting than would cupronickel. Both are relatively cheap materials but nickel silver is much more readily available from a wide range of commercial suppliers. The same consideration suggests that the use of nickel silver blanks in vending machines would be more likely than cupronickel. Although the use of nickel silver blanks in the 5-cent slots of existing rejectors has not been brought to the Treasury's attention, it is possible that a problem might develop if a new system were to use nickel silver in the higher denominations.

Ease and Certainty of Production

The Mint has made nickel silver coins for foreign countries and the experience was satisfactory. The melting of the alloy materials produces zinc fumes which could be a problem where Mint facilities are located in downtown regions. The fumes can be removed by the installation and operation of electrostatic precipitators, or the copper and zinc can be prealloyed in a separate melting operation. The resulting increase in cost can be estimated at roughly 10 percent. Despite this complication, nickel silver undoubtedly could be fabricated and minted in large volume on existing Mint equipment.

Cost and Availability of Raw Materials

Manufacturing costs would be somewhat higher on this alloy than on cupronickel although materials cost would be silghtly lower since

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some zinc is substituted for copper and nickel. Zinc is only about one-sixth as expensive as nickel, and ordinarily about one-third to one-half as expensive as copper. The overall difference in cost between cupronickel and nickel silver alloys would not be large enough to influence the choice between them.

Conclusion: Acceptable as possible coinage alloy.

Plastic Coinage

Several exploratory letters have been written to the Treasury by firms engaged in the manufacture of plastics. One firm sent a sample plastic medallion to the Treasury, but the overall appearance of the medallion did not inspire confidence as to the degree of public acceptability plastic coinage would find. It is possible that in time some combination of powdered metal and plastics technology could be used to produce satisfactory coins. However, the Treasury has no reason to believe that such developments are imminent. The case for the introduction of plastic coins was argued by the Comptroller of the Royal Mint several years ago. At the time this aroused some interest in plastic as a coinage material. This interest seems now to have ebbed. There are no known instances of the use of plastic as a coinage material, and it must be rejected from consideration on the basis of the present technology. Much the same verdict must be given on glass coins.

Conclusion: Rejected—poor quality and probable public aversion to nonmetallic coins.

Stainless Steel

Public Acceptability

Stainless steel is lighter than most of the conventional coinage materials with a density of about 7.8 to 8.0 depending upon its composition. Coins made of stainless steel are white in color and their wearing qualities are superior to those of any other coinage material, except possibly pure nickel coins. Because stainless steel is very hard, coins have to be made with less relief, *i.e.*, the design and lettering are not raised as far from the coin background as in the case of coins made from softer alloys. The overall appearance of stainless steel coins suffers as a consequence. The foreign use of stainless steel coins is limited to Italy (100 and 50 lire) and Turkey. Public acceptability of stainless steel coins in this country is conjectural.

Plain carbon steel can be clad with a relatively thin layer of another material, usually about 15 percent of the thickness on each side. Cladding materials currently being used in this way are nickel and cupronickel in Argentina, brass and copper in West Germany. The edges of these coins are unattractive and susceptible to rust. The coins do not merit serious consideration for use in this country.

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Operation in Vending Machines

Vending machine test results on stainless steel have not been encouraging to date. Stainless steels containing 10 percent and more of nickel are nonmagnetic in their unworked state. But, a major difficulty is that so-called nonmagnetic stainless steels become magnetic when cold-worked, and the coins would then be rejected in vending machines. Three types of stainless steel, presumably nonmagnetic, were supplied for rejector tests. Blanks made from each of the three types of steel were refused by the rejectors. These blanks had been upset at the Mint before testing and even this small amount of fabrication was apparently sufficient to induce some magnetism. The actual stamping process might well have an even stronger effect upon stainless steel blanks. It may be that some stainless steel, suitable for coinage, can be found that will remain nonmagnetic.

Assuming that a stainless steel can be found that will remain nonmagnetic under deformation, the nature of the required adaptation of rejectors will then depend upon the electrical resistivity of the stainless steel. The National Rejector Company has done some work on the problem of building a rejector that would accept silver coins and stainless steel coins of relatively high resistivity (*e.g.*, 75 microhms-cm.). It should be noted that a rejector such as the one NRCO is working on would continue to accept the cupronickel 5-cent piece. No work has been done, so far as is known, on the presumably more difficult problem of designing a rejector that would accept existing coinage, a stainless steel 5-cent piece, and cupronickel 10, 25, and 50-cent pieces.

Counterfeiting Potential

Actual duplication of a stainless steel coin would be a very difficult task because of the hardness of stainless steel. Although direct counterfeiting would probably not constitute a serious problem because coins would be so difficult to mint, the use of stainless steel blanks in vending machines would seem to pose a threat of some consequence. Material from which blanks could be made would be readily available. It might be possible to find a stainless steel for coinage purposes which had electrical resistivity unlike that of the more readily available types but this is by no means certain.

Ease and Certainty of Production

Stainless steel presents serious problems for the Mint. It would be necessary, pending the construction of necessary facilities, to purchase the stainless steel from outside suppliers in the form of strip. Even so, the methods of coin fabrication would be entirely different from those used in the past, or those that are presently contemplated for the new Mint. It is true that the Mint made some magnetic stainless steel coins for Costa Rica but only with great difficulty. Mint experience on that production established that entirely new fab-

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rication techniques would be required for coins larger than the U.S. 25-cent piece.

Conclusion: Rejected as possible coinage alloy.

Reasons: Some question as to public acceptability, replacement of existing vending machine rejectors, and difficult production problems.

Silver (500 Silver-500 Copper)

Public Acceptability

Silver coins of 500 fineness would be slightly lighter than existing coins because the density of copper is less than that of silver. The present 50-cent piece weighs 12.50 grams; a silver 50-cent piece of 500 silver and 500 copper would weigh 11.66 grams. It would be possible to tell 500 fine coins from 900 fine coins simply by weighing the coins in question.

Newly minted 500 fine silver coins could be made to resemble existing silver coins by being given an acid bath at a final production stage. This bath etches away the copper from the surface of the coin, leaving a thin film of silver. With wear, now intensified by the use of coins in vending machines which test for size, the external film of silver is rubbed off. This exposes reddish and yellowish areas on the coin and gives it an unattractive mottled appearance.

Largely because of these poor wearing qualities, 500 silver-500 copper is not generally considered to be an acceptable coinage alloy. The last country using 500 silver-500 copper is South Africa which has recently announced its decision to replace the 500 alloy with pure nickel coins.

Public acceptability of a 500 silver-500 copper coin is highly questionable.

Operation in Vending Machines

A strong point with 500 silver-500 copper coinage is the very minor adjustment of vending machine rejectors that would be required. The slight change in weight and electrical resistivity from existing silver coinage would not affect the majority of vending machines at all. Some vending machine rejectors whose selectivity range has been made very narrow would probably require some adjustment. For all practical purposes, it can be said that the 500 silver-500 copper coinage would work in existing rejectors.

Counterfeiting Potential

There probably would be no serious increase in counterfeiting potential with the 500 silver-500 copper coinage, at first. As worn 500 fine coins began to make up the bulk of coins in circulation, some wider latitude for counterfeit coins would begin to emerge to the extent that the worn 500 fine coins would be less readily distinguished than the present coinage from cheap imitations made from base metals.

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The use of blanks in vending machines should be only slightly more serious with 500 fine silver than it is at present.

Ease and Certainty of Production

It is estimated that the use of an acid bath treatment to improve the initial appearance of the coins would increase current Mint operating costs by about 10 percent. In addition, new equipment and additional space would be required which the Mint does not have at present.

Cost and Availability of Raw Materials

The reduction of silver content from 900 to 500 fineness would reduce the direct cost of coinage metal by more than 40 percent for a given level of silver prices. Questions of the availability of raw materials are complex and center upon the adequacy of Treasury silver stocks to meet future coinage demand, without recourse to market purchases. These questions are discussed subsequently.

Conclusion: Rejected.

Reasons: Very poor appearance when worn. A quaternary silver, discussed next, is preferred on the basis of wear characteristics. A clad silver coin, subsequently discussed, would have the desirable vending machine properties of 500 silver-500 copper.

Silver Alloy—United Kingdom (500 Silver-400 Copper-50 Nickel-50 Zinc)

Public Acceptability

The United Kingdom and a large number of other countries have in the past used an alloy consisting of 500 silver, 400 copper, 50 nickel, and 50 zinc. Sweden coins an alloy of 400 silver, 500 copper, 50 nickel, and 50 zinc; Finland, one of 350 silver, 570 copper, and 80 zinc; and Mexico, one of 100 silver, 700 copper, 100 nickel, and 100 zinc. The addition of nickel and zinc to low silver content alloys reduces the rate of deterioration in appearance. When newly minted the coins, and even those of lower fineness than 500, are relatively attractive. However, the appearance of circulated coins would still leave much to be desired, despite the addition of nickel and zinc that helps to delay the appearance of the mottled surface that is characteristic of coins of low silver content. On technical and metallurgical grounds, the 500 quaternary alloy is not acceptable if coins are required to wear well and retain their appearance for 20 to 25 years. Consequently, it is clear that the alloy merits consideration only if a very high premium is placed upon the retention of some silver in the coinage. Even then, in the judgment of the Mint technical staff, the quaternary alloys would be a poor way to accomplish this end. Silver clad coins with high content silver as the outside layers would be preferable on the grounds of appearance and wear characteristics.

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Operation in Vending Machines and Counterfeiting Potential

The addition of nickel and zinc in the quaternary alloy raises the electrical resistivity of the hardened coin to about 6.8 microhms-cm. This means that the coins would not work in vending machines with the eddy-current rejector. The resistivity range of rejectors could probably be widened to accept the existing coinage and the quaternary alloy but this would be a major undertaking, involving major revamping or replacement. Furthermore, if this were done, vending machines would be much more vulnerable to a variety of foreign coins and blanks than they are at the present time. The potential for direct counterfeiting of this alloy would not differ greatly from that for 500 silver-500 copper.

Ease and Certainty of Production

A quaternary alloy is a much more difficult problem for the Mint but it could be made without drastic change in existing procedures and equipment. The most significant modification of current practice would be the double melting process required so that zinc could be added in alloy form. Approximately a 30-percent increase in melting equipment would be required.

Cost and Availability of Raw Materials

As in the case of 500 silver-500 copper, the major uncertainty is the price and availability of silver in the event that Treasury stocks did not prove adequate to meet coinage and other requirements.

Conclusion: Barely acceptable as a coinage alloy.

Silver Clad Coins

Battelle has examined a wide range of multilayered coinage materials, including some with high-content silver alloys as the outside layers. The inner core on these coins could either be pure copper or a low-content silver-copper alloy with the overall fineness of the alloy varying according to the exact specifications of the outside layers and the inner core. If the present 900 fineness alloy were to be clad on a pure copper core, the resulting material would be approximately 400 in fineness. Much the same overall fineness could be achieved by using 800 fineness silver as the outside cladding and substituting a low-content silver-copper alloy as the inner core. For example, the Mint has made experimental strikes from 800 fineness silver clad on a 215 fineness silver-copper core which gives an overall fineness of 400.

The requirement of a minimum thickness of cladding to insure reasonable wear characteristics precludes any marked reduction in overall silver content and for practical purposes an average fineness of 400 can be taken as broadly representative of the minimum silver content, acceptable from a technical and metallurgical standpoint, where high fineness silver is clad on a pure copper or a low-content silver core.

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Any fineness much lower than 800 in the outside cladding would not make an acceptable coin.[1]

Public Acceptability

Silver-clad coins would be quite attractive in appearance if the outside cladding were at least 800 fineness. In such a case, the color would be the same as that of the present silver coinage except on the edges of the coins. When the core is composed of silver-copper alloy the edges of newly minted coins differ very slightly from the present coinage. Wear characteristics of silver-clad coins would be satisfactory if minimum thickness requirements were observed on the outside cladding.

Operation in Vending Machines

The high silver-copper clad on low silver-copper alloys would work in all vending machines without adjustment. If a pure copper core were used, most machines would need adjustment and pure copper slugs would then be accepted.

Counterfeiting Potential

Clad coins would be more difficult to counterfeit than the existing silver coinage.

Ease and Certainty of Production

The Mint has a substantial but limited capacity for the melting and rolling of silver-copper alloy strips but would probably have to purchase strip from outside suppliers. As a general proposition, it appears that the cladding of silver would present some difficulties where dependence had to be placed upon outside suppliers for a large volume of material. In any event, all bonding (cladding) operations would have to be performed in private plants.

Cost and Availability of Raw Materials

As with coinage of 500 fineness, the crucial question is whether Treasury stocks of silver would be adequate to meet longrun coinage requirements, and, if not, what effect Treasury purchases of silver in the market would have upon price.

Conclusion: Acceptable coinage alloy from a technical and metallurgical point of view.

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[1] On the basis of their analysis of the overall silver situation, Battelle determined that it would probably be necessary to reduce the silver content of the coinage to about 15 percent, and even so the need might arise to abandon silver altogether as a coinage material sometime in the 1970's. Consequently, their primary recommendations were for base alloy coinage, but they also suggested that if any silver were to be retained in the subsidiary coinage, it should either be limited to a high-content half-dollar or spread very thinly through the subsidiary coinage. In the latter case, they suggested that a 400 fineness silver quaternary alloy used as outside cladding on a copper-alloy core "might possibly meet minimum standards of acceptable appearance." In the judgment of the Mint technical staff, the quaternary silver alloys are undesirable on technical and metallurgical grounds and the exterior silver cladding on any composite coin should not be reduced below 800.

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Other Clad Coins: Cupronickel (or Nickel-Silver) Clad on a Copper Core

The multilayer principle recommended by Battelle can be applied to base alloy coinage. Coins with outer layers of cupronickel clad on a copper core will operate in existing vending machine rejectors along with the present silver coinage (probably nickel-silver would also work as outside cladding but tests have not been made). This resolution of the vending machine problem would allow the rapid introduction of new coins without the difficulty, expense, and inconvenience of modifying existing coin rejectors. On the other hand, the clad coins would be more expensive to produce than the straight cupronickel alloy and strip will have to be purchased from outside suppliers.

Public Acceptability

These cupronickel clad coins would be only slightly lighter in weight than the existing coinage. The color of the coins with cupronickel cladding is very good. Because of the copper core, a reddened edge is exposed in the blanking process. Milling of the coins improves their appearance. Wear tests conducted by Battelle and by the Mint technical staff point to an expected average life of 20 to 30 years. The coins are expected to retain an attractive appearance throughout their life in circulation.

Operation in Vending Machines

As recommended by Battelle, the Mint and the rejector industry have conducted extensive testing of the operation of cupronickel clad coins in existing vending machines. This testing has demonstrated that when produced according to specifications (which are not intolerably narrow) these coins work in unaltered vending machine rejectors.

Counterfeiting Potential

The reddened edge of these coins and the difficult production process for the clad material from which they are made should insure against counterfeiting on any substantial scale. Vending machines set for silver coins will accept these clad coins and in time, the sensitivity of rejectors could even be narrowed slightly from their present settings if desired.

Ease and Certainty of Production

The Mint has made sizable production runs using the cupronickel clad material and has not encountered any difficulties of consequence. Given adequate supplies of the clad strip, high levels of production on the new coins could be reached quickly.

Cost and Availability of Raw Materials

The availability of the cupronickel clad strip from outside suppliers has been under intensive investigation by the Mint. This investigation

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is continuing but enough is known at this time to insure that adequate supplies of the strip will be available to support the full-scale production effort on the new coins that will be necessary during any transition to a new coinage system. Cost estimates are not yet entirely firm but it appears that the processing cost on the strip material will be in the neighborhood of $1 per pound, perhaps less as experience is gained with large-scale production.

Conclusion: Acceptable coinage material.

Titanium

Titanium has been suggested to the Treasury as a coinage material but does not appear to be suitable. A major shortcoming is the alloy's light weight. No work is known to have been done on the rejector problem, nor is there any experience with mint fabrication of the metal. The melting point of titanium is too high to permit the use of ordinary brass mill equipment.

Conclusion: Rejected.

Zirconium-Hafnium

Zirconium-hafnium has been suggested to the Treasury as a possible alloy from which 50-cent pieces might be made. However, the cost of the alloy would appear to be prohibitive, wholly aside from other considerations. Zirconium strip was quoted to the Treasury at about $8 per pound—the 1963 *Minerals Yearbook* quotes $10 to $14 per pound. However, the addition of hafnium, recommended to enable the detection of counterfeit coins, would raise the price sharply. Hafnium is quoted at $138 a pound. One company thought that a zirconium 88-hafnium 12 alloy could be provided at a cost about equal to silver with some chance that the resulting volume of production might lower the cost to 50 percent of silver. Under the circumstances, neither zirconium nor zirconium-hafnium appear to be eligible coin alloys.

Conclusion: Rejected.

Summary

For summary of the material in Section IV, see the tables in the Summary at the beginning of the document.

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V. Problems With a Changeover to Reduced Content Silver Coinage

The discussion of technical and metallurgical considerations has reduced the potentially acceptable coinage materials to six. These are: cupronickel (75 copper-25 nickel), nickel silver (65 copper-18 nickel-17 zinc, or slightly different proportions), cupronickel or nickel silver clad on a copper core, the INCO alloy (95 nickel, 5 silicon with a magnetic core), the United Kingdom silver alloy (500 silver, 400 copper, 50 nickel and 50 zinc), and silver clad alloys (overall fineness about 400). The present section discusses the feasibility of a changeover to silver coinage of reduced content; a section to follow will discuss similar problems for the base alloys.

Special Problems With the Silver Alloys

The major questions not yet discussed with respect to the two reduced content silver alloys—the United Kingdom quaternary and silver clad—are whether Treasury silver stocks would be large enough to achieve two objectives: (*a*) Hold the spot market price of silver below \$1.29+ [1] by means of redemptions and/or sales of silver to the market during a period of transition, and (*b*) meet Treasury coinage requirements after the period of transition and thereby minimize the danger that the longrun market price of silver would again imperil the subsidiary coinage.

The first objective of holding the market price during the transition period is absolutely essential to protect the existing coinage. If the market price were to break loose, much of the existing coinage would quickly go out of circulation and there would be a risk of serious disruption to commerce. The second objective of retaining large Treas-

[1] It is occasionally suggested that the line be held at \$1.38+, instead of \$1.29+ since silver dollars are not likely to stay in circulation anyway. It is also suggested that some such rise in price might be induced by making those who want silver collect their own silver certificates; otherwise it is clear that the law would have to be altered so that the redemption right did not continue to place an effective ceiling at \$1.29+. In any event, the slight narrowing of excess market demand that the 9-cent price increase might conceivably encourage would surely be outweighed by the immediate stimulus that would be given to large private speculative purchases of silver, spot and forward. The judgment of anyone who had earlier gone long on silver at \$1.29+ would be vindicated. Although some profit taking might result, the net effect would undoubtedly be to encourage much larger speculative positions in anticipation of the next price increase. If the Treasury could assure the market that the \$1.38+ line would be held indefinitely, a move to \$1.38+ might be regarded as advantageous. It is very hard to see how the market could be sure that the new ceiling would be held after the earlier one had been abandoned.

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ury stocks of silver after the transition is perhaps not quite so vital, but it would be difficult to recommend reduced content coinage if it were uncertain that Treasury stocks of silver would meet coinage needs for a good many years after the transition period.

The approach employed here will be to work through arithmetic examples of the possible effect upon Treasury silver stocks of two alternative ways in which the transition to reduced content silver coinage might be attempted. These examples are not intended as definite forecasts of what would necessarily happen.

Forecasting the future behavior of silver markets is extremely hazardous. This, itself, cannot fail to be a major factor in determining the eventual decision on coinage alloys. However, despite the wide margins of uncertainty, it is believed that the examples presented here provide some insight into the feasibility of a transition to silver coinage of reduced content. While every effort has been made to choose assumptions that seemed inherently plausible and consistent with the available data, inevitably the choices may be subject to question. Therefore, the assumptions that have been made will be discussed in some detail, and the components of the projected changes in silver stocks will be separated as clearly as possible.

The Mint Coinage Estimates

The basic coinage estimates in Table 1 were supplied by the Mint. The columns for 500 fineness coinage reflect an assumption that, because of the time required to obtain necessary legislation for a change in coinage alloys, the change to 500 fineness coinage would not occur until January 1, 1966. The estimates of total coinage requirements are based upon an assumption that the crash coinage program will have been concluded by the end of fiscal 1966, after which time the Arthur D. Little trend estimates of coinage requirements will be valid. Fiscal 1964 coinage is actual, while the estimates for fiscal 1965 and 1966 are based upon the latest budget estimates.

Other tables in this section use the Mint coinage estimates, adjusted to a calendar year basis, and the figures for calendar 1964 will differ slightly from the actual amounts of silver that were used. Additional assumptions regarding redemptions, transitional and replacement coinage requirements, and recovery of old coinage have been made in the course of the present study and underlie the arithmetic of some of its tables.

Treasury Recovery and Replacement of the Existing Coinage

It will be useful to begin with a brief description of the way in which the Treasury might attempt a transition to reduce content silver coinage. The Treasury would have to plan to recover as much as it

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could of the 900 fineness coinage, meanwhile producing new lower content coins at a rate sufficient to insure an adequate supply of total coinage at all times. Throughout this process, the price of silver would have to be held below the melting point of the 900 fineness coinage in order to assist the recovery of old coin. It would not be sufficient merely to prohibit the melting and export of coins since hoarding could also prevent the Treasury from making substantial recoveries. Indeed, controls over the melting of coins are redundant so long as the market price of silver can be held and they are likely to be ineffective if the market price cannot be held. As discussed later, it may nevertheless be desirable for the Treasury to obtain standby authority for controls over the melting, hoarding, and export of coin and bullion.

TABLE 1.—*Estimated Use of Silver Bullion for Coinage at 900 and 500 Fineness*

[In millions of fine troy ounces]

Fiscal year	Estimated silver needed for coinage during year	
	900 fine coinage	500 fine coinage
1964	144.0	144.0
1965	272.2	272.2
1966	330.0	256.4
1967	119.9	66.0
1968	111.9	61.6
1969	116.3	64.0
1970	120.2	66.2
1971	125.3	69.0
1972	130.0	71.6
1973	135.4	74.6

Source: Bureau of the Mint.

Attempting to call in the old coinage and have it exchanged for the new coinage does not appear to be practical or desirable. It would be too difficult, indeed impossible with present Mint facilities, to produce and accumulate a substitute set of coins while also meeting current coinage requirements.

Table 2 summarizes a hypothetical situation in which the Treasury attempts recovery of the existing coinage through ordinary channels in a transition to 500 fineness silver coinage—the United Kingdom alloy with 400 copper, 50 nickel, and 50 zinc. Column (1) of Table 2 presents an adaptation of the Mint coinage projections of Table 1. In Table 2, coinage estimates have been placed on a calendar year basis by successive averaging of Table 1's fiscal year figures, and it is as-

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sumed that 500 fineness coinage would not begin until January 1, 1967, because of the need to modify existing rejector mechanisms.

It will be recalled that the addition of nickel and zinc to the alloy raises its electrical resistivity out of the resistivity range of the present silver coins. It is possible that the vending machine adaptation could be accomplished more rapidly than is assumed in Table 2. In such a case, the introduction of the new coins might even be brought forward to January 1, 1966. The essential conclusions to which Table 2 points would not be greatly modified as a result.

TABLE 2.—*Projected Behavior of Treasury Silver Stock Through Calendar Year 1972 Where Coinage of 500 Fineness Begins Jan. 1, 1967, 900 Fine Coinage Is Partially Recovered and the Market Price of Silver Is Held at $1.29+ During a 4-Year Transition Period*

[Millions of fine troy ounces]

Calendar years	Potential amounts of silver used in coinage				Potential amounts of silver used in redeeming silver certificates or in making outright sales to the market	Treasury recoveries of 900 fineness coinage	Treasury silver stock at end of period
	Mint projection of ordinary requirements	Increments required to replace Treasury recoveries of 900 fineness coinage	Increments required to replace portion of coinage not recovered	Total coinage required			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1964	−208.1			−208.1	−150.0		1,200.0
1965	−290.9			−290.9	−100.0		809.1
1966	−225.0			−225.0	−75.0		509.1
1967	−64.4	−222.2	−83.3	−369.9	−75.0	+400.0	464.2
1968	−63.4	−166.7	−83.3	−313.4	−75.0	+300.0	375.8
1969	−65.7	−111.1	−83.3	−260.1	−100.0	+200.0	215.7
1970	−68.2	−55.5	−83.3	−207.0	−150.0	+100.0	(−)
1971	−70.9			−70.9			(−)
1972	−73.7			−73.7			(−)

NOTE.—Column (2) equals 5/9 of column (6); column (3) equals 5/9 of total nonrecoveries of 600, divided equally among the 4 years.

It is possible to conceive of even earlier introduction of the new coins. This would cause some disruption because the new coins would not work in all vending machines. As long as the new coins were a fairly small part of all coins in active circulation, the situation might be tolerable. However, the new coins would require a slightly different production process, and it does not appear that it would be possible to start production much before early 1966 under the best of circumstances.

The treatment of silver dollars in Table 2 and all of the subsequent tables in this section is the same and should be explained at this point. The 45 million authorized for this fiscal year have not been produced, and it is possible that they will not be. However, this will not reduce the overall amount of silver used by the Mint. The chief limitation on current production of subsidiary coinage is the amount of slab anneal-

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ing capacity in the Mint. It is understood that silver not used in coining silver dollars would be used in subsidiary coinage, up to the limit imposed by annealing capacity, during the remainder of the crash coinage program. Therefore, the amount of silver originally included for silver dollars is appropriately left in the tables during the crash coinage program.

Columns (2), (3), and (6) of Table 2 all relate to the recovery and replacement of the existing coinage. Estimates of the silver content of subsidiary coinage that would be in circulation at the time of the transition are necessarily approximate; but the Mint estimates that something like 1,600 million ounces of silver is probably outstanding in the form of subsidiary coinage. In a recent press release, the American Mining Congress has mentioned a figure, apparently based upon *Circulation Statement* estimates, of 1,400 million ounces in subsidiary coinage, and 400 million in silver dollars, for a total of 1,800 million ounces, of which they feel foreign experience suggests that some two-thirds, or 1,200 million ounces, could eventually be recovered by the Treasury.[1] It would seem unwise to count on recovering any 900-fineness silver dollars, and the Mint figure of 1,600 million ounces of subsidiary coinage will be taken as representative of the size of the pool from which recoveries might be made.

How much of the old coinage really could be recovered by the Treasury is very uncertain. It has been suggested that, on the basis of foreign experience, eventually as much as two-thirds of the old coinage could be recovered. However, the attempt to recover our existing coinage would come at a time when severe coin shortages have just been overcome and would have to proceed with the market price of silver at its monetary ceiling. Hence, the foreign experience of substantial recoveries may well be irrelevant.

A question also exists as to the probable time profile of the recovery of the old coinage since it obviously would not "pay" to hold the price of silver indefinitely while only a trickle of recoveries was being made. Current figures on the flow of coin to and from the Reserve banks are not of much aid in this connection because they are distorted by the coin shortage and consequent changes in the circuit flow of coin. This changing pattern is reflected in Chart I which shows coin payments and inventories of the Federal Reserve banks and their receipts of coin from the Mint and the member banks since 1961. The success of

[1] On the basis of a statistical sampling of the age distribution of coins in circulation, Arthur D. Little Inc., estimated the value of silver subsidiary coinage in circulation on January 1, 1963, at $1,117 million, a silver content of about 900 million fine ounces. (See *Hearings on S. 874* before the Subcommittee on Financial Institutions of the Senate Committee on Banking and Currency, March 26, 1963, pp. 117–120.) On January 1, 1963, the *Circulation Statement* showed a value of $1,739 million, a silver content of about 1,400 million ounces. The Mint estimates used in this section imply a loss rate falling between that in the A. D. Little study and that used in the *Circulation Statement*.

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the Mint crash coinage program in rebuilding coin inventories during early 1965 is clearly apparent. However, in the present context, it is the reflow of silver subsidiary coinage that is pertinent. This is shown separately in Chart II. The statistics for fiscal 1961 and 1962 do indicate relatively large annual gross flows of subsidiary silver coin back to the Federal Reserve banks in normal periods. However, these data are seriously defective for the purpose at hand, not only because of the constricted flows now occurring, but also because there is no way of knowing to what extent the larger flows in earlier years simply reflected a continual recycling between the Reserve banks, the member banks, and some coin users of a relatively small fraction of the total outstanding coinage.

Column (6) of Table 2 shows total Treasury recoveries of 1,000 million ounces over a 4-year period, with recoveries declining steadily. Total recoveries are placed at five-eighths, rather than two-thirds, of the amount assumed to be in circulation because only 4 years are allowed for the recovery period, instead of the longer period to which the estimate of two-thirds recovery must be taken to refer. Even so, the estimate of recoveries is very generous, and to recover this amount of coin in 4 years it is doubtful whether the Treasury could depend solely upon routine recovery through the Federal Reserve banks even if there were no coin shortage. The cooperation of commercial banks and coin-collecting agencies probably would have to be sought. It should be emphasized very strongly that unless the coin shortage had been entirely broken by the time recovery of the old coinage was attempted, nothing like this amount of coinage could possibly be recovered. The estimated scale of recovery is included in Table 2 and later tables not because it is inherently plausible, but simply to work out the implications of attempting a transition to reduced content silver coinage under favorable circumstances.

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Chart I

Federal Reserve Bank Subsidiary and Minor Coin Payments, Inventories, Receipts from the Mint, and Member Banks, 1961-1965
(in millions of pieces)

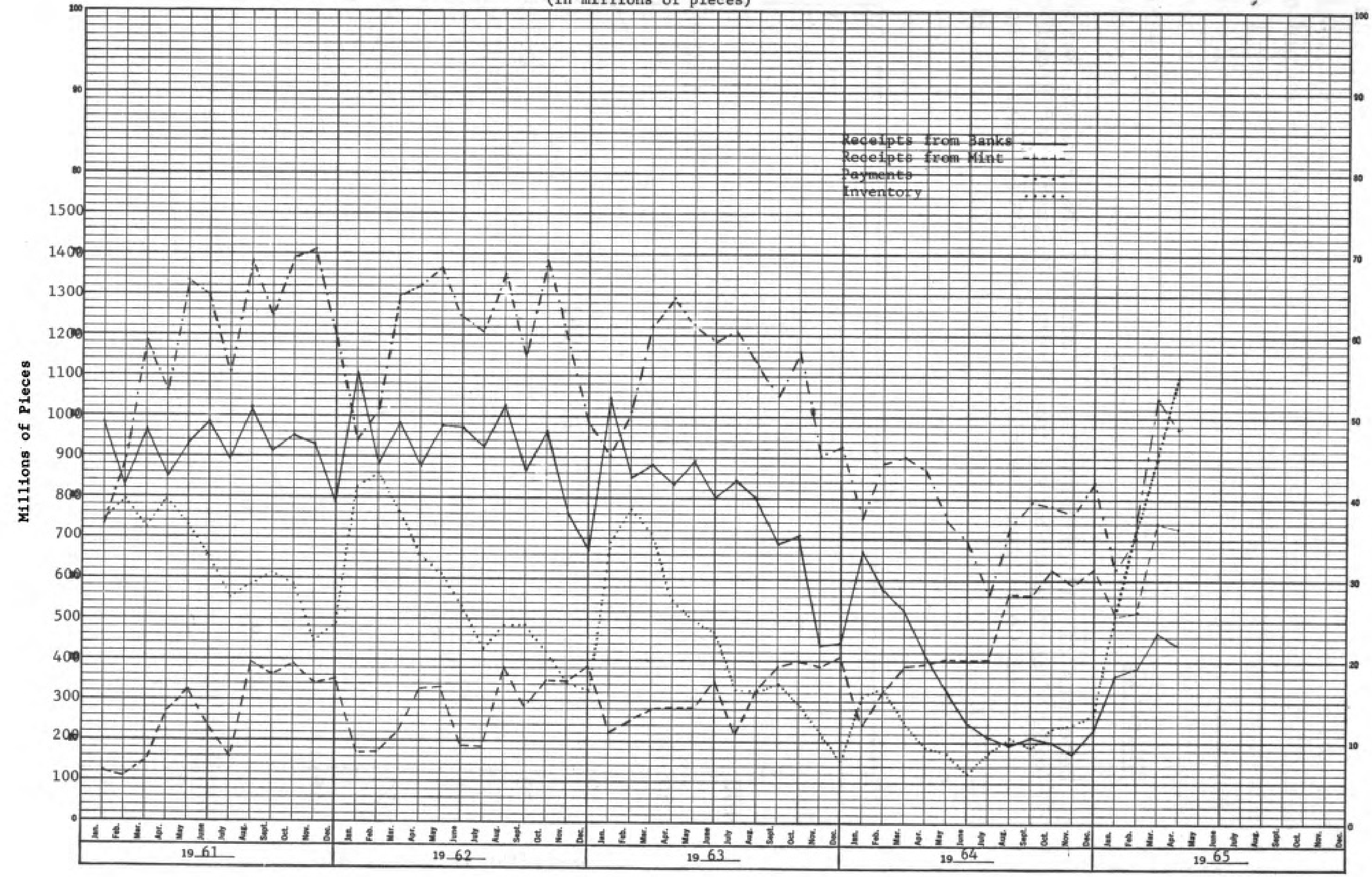

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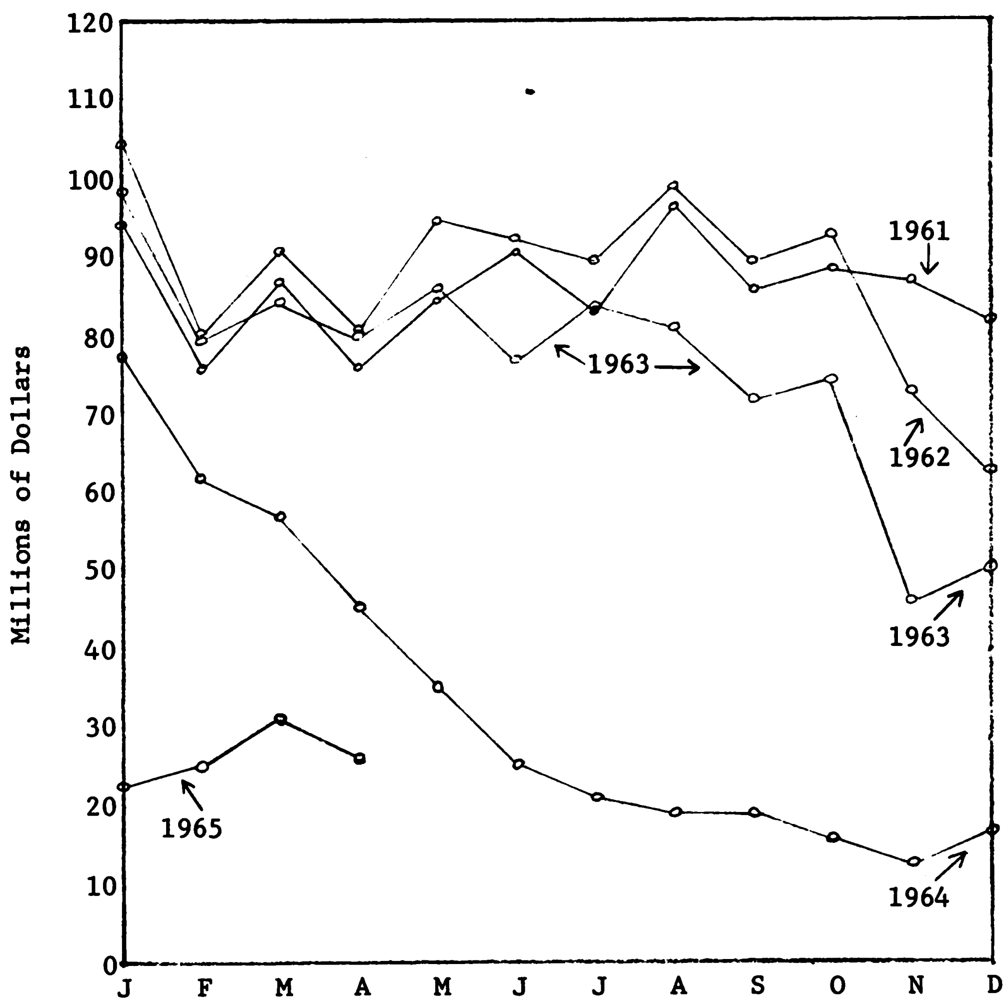
Chart II

Receipts of Silver Subsidiary Coins by the Federal Reserve Banks from Member Banks and Others, Exclusive of Receipts of Coin from the Mint, Monthly, 1961-1965



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The gross recovery of the existing coinage by the Treasury is not a net addition to Treasury silver stocks because of the need to replace the higher content coin withdrawn from circulation. Additionally, the Treasury probably should plan to replace the higher content coinage which is not recovered, since it would have to be assumed that much of it had been hoarded and would no longer be available for transaction purposes. The estimates of coin in circulation possibly include a certain amount of coin that has been lost. Although the Mint estimates do attempt to correct for this, the correction may not be entirely adequate. Hence, complete replacement of the coinage recorded as being in circulation would not necessarily be essential. The table is constructed on the assumption that complete replacement is attempted. The effect of relaxing this assumption will be noted subsequently.

Column (2) shows the amounts of 500 fineness coinage required to match recoveries of 900 fineness coinage, and column (3) shows the estimated amounts required to offset nonrecoveries. On the assumption of total recoveries of 1,000 million ounces from a stock of 1,600 million ounces, there are 600 million ounces of the old coinage to be replaced at five-ninths of the original fineness. The amount is allocated in column (3) evenly among the 4 years. The sum of columns (1), (2), and (3) gives the total coinage requirements which the Treasury should plan to meet.

In addition, some silver would have to be used to hold the market price of silver during the transition period. Column (5) shows the amounts of redemptions or outright sales to the market that might be required. It should be noted in this connection that to revoke the redemption right would not free the Treasury from the need to sell silver to the market. Protection of the existing coinage requires that the market price of silver be stabilized; this requires sales of silver to the market equal to excess demand at the stabilized price; whether or not certificates are retired is a separate, although important, question.

The amounts shown in column (5) for market stabilization are necessarily fairly approximate, although they do not seem unreasonably high in the light of recent experience. Bullion exchanges against silver certificates in 1964 were close to 150 million ounces. It is assumed that excess demand would decline to 100 million ounces in 1965, reach a "normal" level of about 75 million ounces by 1966, and remain there through 1968. As the transition period neared completion, the market would come to expect an increase in the price of silver and some speculative demand would be added to ordinary requirements. Therefore, sales to the market are increased to 100 million ounces in 1969 and to 150 million ounces in 1970.

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Such a pattern of Treasury sales does not make allowance for any strong feedback from the sharply falling silver stocks in column (7) to the redemptions in column (5). Yet, as the stock of silver fell, there could be an acceleration of redemption demands. Very heavy speculative pressure could develop in the case of any transition to silver coinage of reduced content. The rate of redemptions in late 1964, during a mild speculative flurry, should remain as a sobering reminder of the potential scale that speculation in silver can quickly take.

The decline in Treasury silver stocks on the assumptions embodied in table 2 would be rapid. Despite the recovery of a large amount of 900 fineness coinage, stocks would be entirely exhausted before 1970. The overall result is not very sensitive to moderate changes in the assumptions that underlie it, although the exact point at which Treasury stocks would run out is shifted in time by most changes in assumptions.

On the assumptions of Table 2, about 300 million ounces of silver are used in replacing the coinage that is not recovered. It could be argued that this need not be done because some unrecovered coin will have been recorded in circulation when it actually was lost. This may well be true and implies that not all of the unrecovered coin need be replaced. However, to argue that none of it need be replaced is to assume that the coinage stock just prior to the transition would be in excess of public requirements so that some increase in hoarding could be tolerated. Certainly there is no present evidence that the stock of silver coinage is excessive relative to the demand for it. It is very difficult to know how much, if at all, the more than 300 million ounces of silver scheduled to be used in replacing unrecovered coinage could safely be reduced. Therefore, the table carries the full amount.

It could also be argued that the time pattern of recovery of old coin might be more rapid than has been assumed here. This would permit a shorter transition period and possibly reduce the overall amounts of silver used in stabilizing the market price. The problem here is in knowing just what degree of shortening of the time pattern of recovery would be a practical possibility. This is explored subsequently with the aid of an example based upon slightly different assumptions.

In summary, if it were decided to try to replace the existing coinage, the likelihood of successfully negotiating a transition to subsidiary silver coinage of 500 fineness does not appear to be very great at all. On the assumptions used here, the Treasury would be back in the market before the transition was even complete, but the Treasury would now be buying silver to meet its coinage requirements,

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rather than selling to protect the existing coinage. The total exhaustion of Treasury silver stocks before the transition was even completed would not necessarily occur on all assumptions. With a shorter period of transition, instituted somewhat sooner, the savings in the sales or redemptions required to peg the market price of silver could be sufficient to leave the Treasury with some silver after the transition. On any reasonable set of assumptions, however, it does not appear that the Treasury would be likely to have very much silver left.

The general conclusion remains, therefore, that it would appear to be impractical and extremely hazardous to attempt to replace the existing subsidiary coinage with 500 fineness silver.

Recovery and Replacement With 400 Fineness Coinage

Table 2–A presents the comparable situation where a transition is attempted to subsidiary silver coinage of 400 fineness; for example, 800 fineness silver clad on a low-content silver-copper core. The picture is somewhat improved relative to 500 fineness coinage, although the decline in Treasury silver stocks is still very rapid. The decline in Treasury silver is not quite so precipitous for two reasons. First, new coinage at the 400 fineness rather than 500 takes only four-fifths as much silver. Second, coins made from silver clad on a copper core would work in existing vending machines. Hence, it is assumed that the production of new coins, and recovery of old coins, could begin on January 1, 1966. This shortens the transition period and reduces the amount of silver that must be used to stabilize the market price of silver at the melting point of the old coinage. The transition could not begin much sooner than January 1, 1966, because of the probable leadtime required for the production of required amounts of the clad strip. Other assumptions are the same as those discussed for the transition to 500 fineness and do not require additional comment now, other than to reiterate the earlier warning that recovery of any substantial part of the existing coinage in present circumstances seems extremely doubtful.

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TABLE 2–A.—*Projected Behavior of Treasury Silver Stock Through Calendar Year 1972 Where Coinage of 400 Fineness Begins Jan. 1, 1966, 900 Fine Coinage Is Partially Recovered and the Market Price of Silver Is Held at $1.29+ During a 4-Year Transition Period*

[Millions of fine troy ounces]

Calendar years	Potential amounts of silver used in coinage: Mint projection of ordinary requirements (1)	Increments required to replace Treasury recoveries of 900 fineness coinage (2)	Increments required to replace portion of coinage not recovered (3)	Total coinage required (4)	Potential amounts of silver used in redeeming silver certificates or in making outright sales to the market (5)	Treasury recoveries of 900 fineness coinage (6)	Treasury silver stock at end of period (7)
1964	−208.1			−208.1	−150.0		1,200.0
1965	−290.9			−290.9	−100.0		809.1
1966	−102.5	−177.8	−66.7	−347.0	−75.0	+400.0	787.1
1967	−52.8	−133.3	−66.7	−252.8	−75.0	+300.0	759.3
1968	−52.0	−88.9	−66.7	−207.6	−100.0	+200.0	651.7
1969	−53.9	−44.4	−66.7	−165.0	−150.0	+100.0	436.7
1970	−55.9			−55.9			380.8
1971	−58.1			−58.1			322.7
1972	−60.4			−60.4			262.3

NOTE.—Column (2) equals 4/9 of column (6); column (3) equals 4/9 of total nonrecoveries of 600, divided equally among the 4 years.

However, accepting the hypothesis of substantial recoveries upon which Table 2–A is based, there is some room for difference of opinion whether or not it would be possible to negotiate the transition and replace the existing coinage with 400 fineness coinage. The arithmetic of Table 2–A implies that the transition might be made. Certainly, no very large margin of safety would exist, particularly since the steady decline in Treasury silver quite possibly would give rise to the need for even larger sales to the market than are allowed for in column (5) of Table 2–A. In any event, the amounts of silver available to the Treasury for use in coinage after the transition would be small, particularly if any allowance for strategic needs were included. On the basis of the projections of Table 2–A, Treasury silver would be gone by 1976 or 1977. After that time, the Treasury would have to buy silver in the market. This would greatly increase the chance that the market price of silver would again eventually be driven to the melting point of subsidiary coinage. It is true that the new melting point in excess of $3 would provide more leeway for price-induced adjustments in market supply and demand.

A Different Approach

Tables 2 and 2–A are necessarily based upon fairly rigid assumptions and these affect the pattern of decline in Treasury stocks. It would be possible to vary some of these assumptions and note the effect

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that this would have on the result. There may also be some value in a slightly different approach. Instead of assuming a certain pattern of recoveries of the old coinage and observing the net effect upon the Treasury silver stock, the example can be turned around in order to show what pattern of recoveries would actually be required to hold the silver stock at any given amount. This is not only convenient in that it allows one to see more clearly what rate of recovery of the old coinage would be required for a successful transition; it also involves a minimum of assumptions, since recoveries of coinage can be treated as a residual.

It will be assumed that replacement of the entire subsidiary coinage is attempted within a 2-year period to minimize the drain on Treasury stocks from holding down the market price of silver, and to reduce the likelihood of coin shortages in the transition period. The rates of coin production required for this rapid replacement would not be possible with existing Mint facilities even if silver strip were purchased. This limitation is ignored in the examples that follow although, in practice, it would be a matter of overriding significance.

The rate at which old coins could be recovered is extremely uncertain and in Tables 3 and 3–A no attempt is made to allocate the recoveries among particular years. This means that the extreme right-hand column of these tables no longer purports to give the actual Treasury silver stock but simply registers what the stock would be without allowance for recoveries of old coin.

Table 3 shows the situation for a 2-year replacement of the existing subsidiary coinage with coinage of 500 fineness, beginning January 1, 1966. Table 3 suggests that fully 500 million ounces of silver would have to be recovered by the end of 1967 to prevent Treasury stocks from falling to zero. If it were somehow possible in the space of the 2-year transition period to recover the entire 1,000 million ounces used in the earlier examples, Treasury stocks would still be reduced to less than 600 million ounces at the end of the transition.

The parallel situation with respect to 400 fineness coinage is presented in the accompanying Table 3–A. This example is based upon the same assumptions as those of Table 3 except for the lower fineness of the new coins. In this case, it would be necessary to recover about 250 million ounces by the end of 1967 to prevent Treasury stocks from falling to zero. The recovery of 1,000 million ounces of silver during the transition period would leave the Treasury with a stock of about 750 million ounces at the end of the transition. However, it is not at all clear how recoveries on this scale could actually be accomplished within a 2-year period.

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TABLE 3.—*Example of the Replacement of the Existing Coinage With Coinage to 500 Fineness During a 2-Year Period; No Allowance Made for Recovery of the Old Coinage*

[In millions of fine troy ounces]

Calendar years	Potential amounts of silver used in coinage			Potential amounts of silver used in redeeming silver certificates or in making outright sales to the market	Treasury silver stock at end of period without any allowance for recovery of old coin
	Mint projection of ordinary requirements	To replace 900 fineness coin	Total coinage required		
	(1)	(2)	(3)	(4)	(5)
1964	−208.1		−208.1	−150.0	1,200.0
1965	−290.9		−290.9	−100.0	809.1
1966	−125.0	−444.4	−569.4	−75.0	164.7
1967	−64.4	−444.4	−508.8	−100.0	−444.1
1968	−63.4		−63.4		
1969	−65.7		−65.7		
1970	−68.2		−68.2		
1971	−70.9		−70.9		
1972	−73.7		−73.7		

NOTE.—Column (2) is 5/9 of the 1,600 million ounces of subsidiary coin assumed in circulation, divided equally between the 2 years.

TABLE 3–A.—*Example of the Replacement of the Existing Coinage With Coinage of 400 Fineness During a2-Year Period, No Allowance Made for Recovery of the Old Coinage*

[In millions of fine troy ounces]

Calendar years	Potential amounts of silver used in coinage			Potential amounts of silver used in redeeming silver certificates or in making outright sales to the market	Treasury silver stock at end of period without any allowance for recovery of old coin
	Mint projection of ordinary requirements	To replace 900 fineness coin	Total coinage required		
	(1)	(2)	(3)	(4)	(5)
1964	−208.1		−208.1	−150.0	1,200.0
1965	−290.9		−290.9	−100.0	809.1
1966	−102.5	−355.6	−458.1	−75.0	276.0
1967	−52.8	−355.6	−408.4	−100.0	−232.4
1968	−52.0		−52.0		
1969	−53.9		−53.9		
1970	−55.9		−55.9		
1971	−58.1		−58.1		
1972	−60.4		−60.4		

NOTE.—Column (2) is 4/9 of the 1,600 million ounces of subsidiary coin assumed in circulation, divided equally between the 2 years.

The example does show that a successful transition to reduced content silver coinage, if possible at all, would require a very short transition coupled with a high rate of recovery of the old coin. In interpreting these examples, it should be kept in mind that the production of

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the new coins has been set arbitrarily at required rates, without reference to the fact that such production would exceed Mint capacity. Furthermore, no attention has been paid to the very real possibility of an accelerating speculative demand for silver as Treasury stocks declined. It is one thing to construct an example in which Treasury silver stocks fall and are then reconstituted by recoveries of old coin, and quite another thing to estimate just how destructive of confidence a sizable fall in Treasury silver could be during an admittedly hazardous transition to silver coinage of lower content.

Conclusions

1. The examples that have been presented do not exhaust all the possible ways in which a transition to reduced content silver coinage might be attempted. It is believed that they do cover the more promising alternatives open to the Treasury. The general conclusion must be unmistakable. The transition to silver coinage of reduced content would be an extremely risky undertaking, and Treasury silver stocks would probably be depleted within a relatively short period of time. If there is a partial and limited exception to this overall conclusion, it arises with 400 fineness where a high proportion of the existing coinage is recovered at a rapid rate.

2. Even there the risks would have to be judged intolerably great unless there were clear evidence, at the time a decision was reached, that the coin shortage had ended and subsidiary silver coinage was temporarily redundant.[1] No one could be sure in any case that the price of silver would not be driven again to the melting point of subsidiary coinage; this might not occur within the immediate future. In general, analysis of the special problem of the transition to reduced content silver coinage suggests that attention can appropriately be concentrated from this point in the study upon the base alloy alternatives.

3. However, there may be special reasons for continuing to produce a single silver coin which would circulate alongside the new base alloy coins. This issue is discussed briefly in an appendix to this section.

Appendix: Notes on the Retention of a Silver 50-Cent Piece

There may be advantages in retaining a single circulating silver coin. It seems reasonably certain that a clad silver 50-cent piece of 400 fineness could be continued in our coinage system for a good number of years, perhaps indefinitely. Furthermore, if for some reason it did become impossible to continue silver in this limited role, a shift to a

[1] This is clearly not the case at the present time.

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base-alloy 50-cent piece could be effected without serious difficulty or disruptive effect.

The amounts of silver which might be used in a clad silver 50-cent piece can be estimated approximately. Between 1957 and 1961, production of 50-cent pieces ranged between 25 and 30 million pieces annually. Since then production has increased sharply, rising to 92 million pieces in 1963 and to 206 million pieces in 1964, when hoarding of Kennedy 50-cent pieces was severe. The more recent levels are, of course, abnormally high. A more reasonable figure might be an annual production of 100 million pieces. This would still be about twice the number of pieces projected by Arthur D. Little for 1968, and it might even be preferable to start with a lower amount initially.

The important consideration, in the present context, is that the production of 100 million 50-cent pieces from the 400 fineness silver alloy would use only some 15 million ounces of silver, about 5 percent of the current rate. This amount would clearly fall within permissible limits of silver usage, particularly since with a transition to base alloy coinage this amount of silver might very possibly be recovered by the Treasury from the existing coinage.

The advantage in retaining a silver 50-cent piece is the extension of a continuous tradition of circulating silver coinage. Of course, sentiment and tradition must not be allowed to obstruct the transition to a secure coinage system, adequate to the needs of the present. However, by eliminating silver from the dime and quarter, a major drain on Treasury silver stocks would have been removed, and the retention of a silver 50-cent piece should be possible.

The retention of one or two silver coins is common practice internationally. Some examples are Japan, France, Italy, the Federal Republic of Germany, the Netherlands, Belgium, and Greece. In continuing with the silver dollar at its existing fineness and a clad silver 50-cent piece of 400 fineness, our own coinage system would come more nearly into corresponding with present practice abroad. As it stands, our own consumption of silver in coinage dwarfs that of the rest of the world and threatens to dislocate silver markets and lead to severe shortages for industrial use.

In suggesting the possible retention of a silver 50-cent piece, it must be stressed that the uncertainties of the future silver situation preclude any definite commitment as to the amounts of 50-cent pieces that would be produced. Also, during early stages of any transition to a new coinage system, the Mint should be concentrating heavily upon the production of the new base-alloy coins. Production of the 400 fine 50-cent pieces should only be phased in gradually as capacity became available and silver supplies were clearly adequate for the purpose. Finally, at the risk of some repetition, it should be emphasized that

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the use of any silver whatsoever in the 10- and 25-cent pieces (which are crucial to the needs of commerce in a way that the 50-cent piece is not) is ruled out for the reasons developed earlier.

The feasibility of retaining a 400 fineness silver half dollar should be examined exhaustively by the Treasury before making its legislative recommendations. These notes are only intended to raise the possibility of keeping a silver 50-cent piece, not to provide the full justification that such a course of action would require.

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VI. Further Consideration of the Base Metal Alloys[1]

The previous section has concluded that the transition to a reduced content silver alloy used throughout the subsidiary coinage would be extremely risky and that Treasury stocks of silver would probably be depleted during or soon after the transition period. This negative conclusion applies without reservation in the case of the 500 alloy, and it does not appear that the outlook is much more promising in the case of the 400 alloy. None of the silver alloys of lower fineness than 400 meet minimum standards of acceptability. As noted previously, in the judgment of the Mint technical staff, the exterior silver cladding on any composite coin should not be reduced below 800, and this precludes reducing the overall fineness much below 400. Therefore, the silver alloys are eliminated as the basic subsidiary coinage material. The possibility remains of using very limited amounts of silver in a clad 50-cent piece, but the bulk of future subsidiary coinage production must be nonsilver. The present section will consider the advantages and disadvantages of the base alloys that remain and discuss the ways in which the transition from the present silver coinage to a new system largely of base alloy coinage could best be attempted.

Relative Merits of the Remaining Alloys

There are four remaining alloys: Cupronickel, nickel silver, cupronickel or nickel silver clad on a copper core, and the Inco coin. No final choice will be made from among them at this stage, but their respective advantages and disadvantages will be summarized and a tentative judgment established. At an early stage of this study, criteria were developed against which it was suggested that a future coin program might be judged. It will be helpful now to compare the extent to which the remaining alloys do successfully meet the different criteria.

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[1] This chapter was written before the Mint had completed its intensive investigation of the clad coinage materials with respect to production feasibility and an assured supply of the bonded strip. Consequently, it does not fully reflect information available to the Mint and Treasury at the time the eventual coinage decision was made. This fact should be borne in mind in reading the present chapter and in interpreting the study's final conclusions and recommendations.

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Medium of Exchange Function and Permanence of the Solution

Any of these base alloys would appear to meet the essential requirement of no interruption to the essential medium of exchange function, although specific changeover problems with the alloys remain to be discussed. Any of the alloys would also appear to meet the requirement that there be a minimal chance of any serious disruption to the new coinage system within the next 20 to 25 years.

Assured Access to Raw Materials

On the question of assured access to raw materials, the Inco coin does present potential problems. As noted earlier, nickel does not seem likely to present a really critical overall supply situation. But the fact remains that U.S. production of ferronickel is unsuitable for coinage, and U.S. coinage requirements would have to be met from the existing stockpile of nickel and/or Canadian production. In addition to the overall nickel supply picture, the special nature of the production process with the Inco coin means that for a considerable period of time the Mint would be largely dependent upon a single commercial source of supply for the alloy itself. In order to achieve a rapid transition to high level of production, it would apparently also be necessary to have annealing and blanking operations carried on by Inco at its Huntington, West Virginia, plant.

Provision could possibly be made subsequently to carry on all or some of these operations in the new Philadelphia Mint or perhaps to look to a later transition to a pure nickel coin and plan the new Philadelphia Mint facilities accordingly. All of this adds uncertainties and complications at a time when planning for future Mint operations is difficult enough. These considerations and those of raw material supply should not entirely rule out the Inco coin, but they do suggest that it must offer some clear advantages over the other alloys to compensate for its less than ideal position from the point of view of supply.

Public Acceptability

Public acceptability of a new coinage system was viewed as resting upon a number of factors among which were demonstrated necessity of the need for a change to the new system, physical characteristics of the new coins, minimum of inconvenience to the public, and absence of extreme hardship to a particular group or industry. The first of these factors, the need for the change, applies equally with all of the alloys. The physical characteristics of different coinage materials were discussed in some detail in Section IV when these four base alloys were selected from a larger number of potential alloys.

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Physical Characteristics of the Coins

Aside from questions of operation in vending machines, it can be argued that on the basis of their physical characteristics the coins should be ranked: Inco, cupronickel or nickel silver, and the clad coins. Such a ranking would be based upon the belief that nickel is a slightly more desirable coinage metal than cupronickel or nickel silver and that clad coins are generally not quite so desirable as conventional alloys. However, extensive Mint testing of the clad materials has revealed that their wear properties and other physical characteristics are in no way inferior to homogeneous alloys made from the outside cladding material. The reddened edge of the clad coins is a matter of appearance on which opinions might possibly differ. So long as the coins are durable, attractive, and perform the medium of exchange function, the reddened edge would not appear to be a matter of very great importance.

Operation in Vending Machines

Public acceptability will also depend upon the new coins working in vending machines. The strong point claimed for the Inco coin is its ability to work in existing vending machine rejectors. In some machines, the application of a small piece of tape has improved performance. As noted previously, the claims made for the Inco coin have never been demonstrated convincingly, despite repeated tests. There is reason to believe that all of the problems have not yet been overcome, and may never be. The case for the Inco coin does rest primarily upon its consistently successful operation in vending machines under actual operating conditions. Consequently, the failure of the Inco coin to demonstrate its compatibility with the existing silver coinage in vending machines is very nearly a decisive objection to its use. Inco claims that an entirely new type of rejector mechanism, based upon electronic principles, might be designed around their coin. No such equipment exists, and even if it did, it would not meet the immediate problem.

The cupronickel clad coins have, on the other hand, conclusively demonstrated their ability to work alongside the existing silver coins in the 10-, 25-, and 50-cent channels of existing vending machines. Similarly, the silver-copper alloy clad on a low-content silver core, which has been suggested for use in the 50-cent piece, would work in vending machines with no alterations required. Nickel silver clad on a copper core has not been tested in vending machines, but on the basis of its physical characteristics it would work. A possibility, in the case of the base-alloy-clad materials, would be to use one or the other of them as a transitional coin while vending machine rejectors

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were being modified or replaced to accept ordinary cupronickel or nickel silver coins.

The relative importance of compatibility of the new coinage and the present coinage in vending machines will be discussed further in the context of changeover problems. To this point, major emphasis has been placed upon the inconvenience to the public if new coins will not work in vending machines and the possibly disruptive effects upon the vending machine and coin rejector industries. In addition, large companies whose products are nationally distributed through vending machines would understandably be concerned in such a case. These are very important considerations that should be weighed carefully before reaching any final decision—particularly the inconvenience to the public and possible disruption of commerce. It should also be pointed out that under conceivable circumstances the effort to insure that new coins would work immediately in every vending machine could come into conflict with the more important objective of insuring an adequate supply of coins at all times. This could be the case if the compatible coinage material were not available quickly in needed volume. Since this is a matter which the Mint is investigating intensively, it need not be considered further here.

Absence of Hardship

The absence of serious hardship to any single group or industry is a reasonable objective, whichever one of the base alloys is selected for the subsidiary coinage material. As noted above, this suggests the desirability, if not the absolute necessity, of finding a coin which will work in existing vending machines, or possibly offering some assistance to the vending machine industry if such a coin is not used. The needs of the silver users will be met if silver is removed from the coinage—except for the relatively small overall requirements if silver clad is used in the 50-cent piece—and the price of silver is held at the present level during a fairly lengthy transition period. Silver producers might reasonably be protected by a proposal that the Treasury would stand ready to buy newly mined domestic silver—say at $1.25+—for a period of time. In the absence of such a purchase program, producers might fear the market-depressing impact of the liquidation of speculative stocks of silver, accumulated in the mistakened belief that the price of silver was sure to rise above $1.29+.

Ease and Certainty of Production

Ease and certainty of high levels of coin production are extremely important; they could become a vital consideration in the case of a quick changeover. It is clear that cupronickel has many advantages

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here because of long Mint experience with the material and dependable commercial sources of cupronickel strip. Nickel silver is also a relatively easy material for the Mint to work with; as noted earlier the addition of zinc does complicate melting procedures to some extent. But, nickel silver strip should be readily available from commercial suppliers.

Both the Inco coin and the clad coins offer potential difficulties, although in the case of clad coins the difficulties quite possibly can be resolved. The Inco coin will be hard on dies and may require heavier presses. This assumes that annealed blanks would be supplied by Inco, but certainty of supply cannot be absolutely assured in such an event. Unless the Mint could build up very large inventories of the blanks, which would hardly be possible at first, there would be the threat that a strike at Inco, a failure in quality control, or some other temporary interruption to the steady flow of acceptable blanks could disrupt Mint production schedules. With the clad coins, there is little question of the Mint's ability to work the material. But, assurance of an adequate supply of the clad strip is uncertain on the basis of what was known at the time this report was written. This uncertainty will be resolved by intensive Mint investigations currently underway.

Minimization of Cost of Coinage

The minimization of the cost of coinage is a sensible objective only at an acceptable level of coinage quality. Cupronickel would probably offer the most seigniorage. Nickel silver should run a close second with some increase in cost because of the need for special procedures where zinc is alloyed with copper and nickel. The exact cost per pound of clad strip has not yet been determined. Approximate information is available, and suggests that the cost of clad cupronickel strip would initially be in the range of $1 to $1.50 per pound.

Cupronickel alloy costs about 45 cents a pound and only a further 5 cents, or so, need be added in the case of the homogeneous alloy for melting and rolling operations performed in the Mint. Where the strip is purchased from outside suppliers, the comparable cost would be about 65 cents per pound. The cost of cupronickel clad on a copper core would fall in the range of $1 to $1.50 per pound, assuming the same 45-cent cost of alloy. The Inco strip would probably cost about $1.50 per pound. In view of the relatively large amount of seigniorage with any of these materials and the general importance of the coinage, it could be argued that alloy cost should not be given very much weight in the final decision. It probably should receive some consideration.

One type of cost calculation which may be relevant is the extra cost of clad strip, or the Inco coin, over straight cupronickel or nickel

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silver. Since the clad coins are chiefly attractive because they will work in existing vending machines, their extra cost, if they are used permanently, should be contrasted with the once-and-for-all cost of altering vending machine rejectors. Where clad coins were used only during a transition period, the extra cost could be viewed as necessary to achieve speedy introduction of the new coins. But, if clad coins are used permanently, cost more than conventional alloys, and are superior in no respect other than use in vending machines, a question arises whether eventual modification of rejectors to accept conventional alloys might not prove desirable.

With the clad coins, the increment paid (in the first instance by the Mint and ultimately by the public) in lieu of altering vending machines is probably on the order of 50 cents to $1 per pound of coinage material, and about $1 in the case of the Inco coin. The extra cost in the case of cupronickel-clad coins might be $10 to $15 million annually at high rates of coin production, and reduced proportionately at lower rates of production. This extra continuing cost contrasts with a one-time vending machine conversion cost that might range from $50 to $100 million if a straight cupronickel or nickel silver coin were to be used. The use of either of these coinage materials would also, in the opinion of the vending machine industry, involve intolerable continuing costs because the selectivity of their rejectors would be so greatly impaired that they would accept a wide variety of slugs and foreign coins. In addition, there would be losses because of "downtime" while rejectors were being modified. These losses are difficult to quantify, but could be considerable.

Cost comparisons of the sort described here while of some relevance could not be a decisive factor, even if plausible magnitudes could be assigned to them. They cannot measure the inconvenience to the public and the attendant disruption to commerce that might follow a decision to introduce large amounts of coin into circulation which would not be compatible with the present coinage in vending machines.

Balance of Payments Cost

Alternative base alloy programs would not have an appreciably different effect upon the balance of payments, except for the Inco coin. There, unless nickel were used from the stockpile, imports of nickel from Canada would increase, possibly by $10 to $20 million annually.

Other possible effects upon the U.S. international position are less tangible and very difficult to estimate. Advocates of silver in the coinage will stress the importance of its retention and cite the return to some silver in coinage by Western European countries. The retention of the present silver dollar and the use of the 400 fineness clad alloy in the 50-cent piece would seem to meet the requirements of prestige.

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Summary: The Relative Merits of the Base Alloys

The choice between cupronickel and nickel silver on the one hand and between the Inco coin and clad coins on the other is best considered separately. Cupronickel and nickel silver are "permanent" coinage alloys; they will not work as subsidiary coinage in existing vending machines. The Inco and clad coins can be regarded as "transitional" coins which will work in vending machines while rejectors are being altered for a permanent coinage of pure nickel, cupronickel, or nickel silver; or equally well, they may be regarded as permanent coins if it is determined that modification of vending machine rejectors is not desirable. It will be assumed, simply for the purpose of discussion, that eventual modification of rejector mechanisms may be contemplated.

Assuming that vending machine rejectors were to be modified eventually, the choice of permanent coinage materials lies primarily between cupronickel and nickel silver. The transition to pure nickel coinage appears to be impractically difficult since, as indicated in Section IV, it would mean the replacement of practically every coin testing device currently in use. As between cupronickel and nickel silver, the differences are not great, although in most respects cupronickel is a slightly superior coinage material. Some people feel that silver makes a slightly better looking coin, *i.e.*, more like silver, when newly minted. But, this is probably more than offset by its tendency to yellow with age and its general inferiority to cupronickel from the Mint standpoint. The upgrading of the 5-cent coin material that would occur with cupronickel would, perhaps, not be an ideal solution, nor is it an altogether attractive prospect to have 5- and 10-cent pieces of present size made from the same material. However, all things considered, the preference here would be slightly in favor of subsidiary coinage made from cupronickel, with the present 5-cent piece unchanged. The alternative of leaving the present 5-cent piece unchanged and using nickel silver for the subsidiary coinage would also be acceptable.

The cupronickel or nickel silver clad on a copper core has the great advantage of avoiding the need for modification of vending machines. The Inco coin does not work acceptably and even if it did it would be superior to the clads only on the basis of appearance. The clad coin is to be preferred since it would lead logically and easily to a permanent coinage of cupronickel, or nickel silver, or, as seems equally desirable, could be retained as the permanent coinage material.

Changeover Problems with the Base Alloys

While the announcement of a plan to switch to a base alloy for subsidiary coinage is not likely to cause intensified hoarding of silver

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coins by the public, the Mint must be prepared to offset any conceivable scale of withdrawals. Similar considerations would apply in the case of reduced content silver coinage, and it will be recalled that some of the arithmetic examples in Section V allowed for complete replacement of the coinage in circulation at the time of the changeover, whether or not the old coins could be recovered. Most of those not recovered were assumed to have been hoarded. A crucial difference is that the prospect of a sharp increase in silver prices would disappear, and the major threat to a smooth transition would be removed.

However, the public may want to hold relatively large amounts of silver coins; new ones because they are the last of their kind, old ones because of enhanced numismatic value, real or imagined. This could mean that a large part of the production of 1964 silver coins might fairly rapidly, if temporarily, be withdrawn from circulation along with an appreciable amount of older coins. The effective countermeasure is a very high rate of production of the new coins and their introduction in large volume. If a silver 50-cent piece is continued in production, the withdrawal of silver coins may well be minimized.

Possible Need To Replace Existing Coinage

The net effect of these considerations is that, while side-by-side circulation of the new and old coins is altogether likely, there are residual uncertainties and the prudent course is to be prepared to replace the coinage fairly rapidly, if required. The "replacement problem" with a base alloy is very difficult from the case of a transition to silver coinage of reduced content. In that case, the situation was complicated by the need to recover as much as possible of the existing coinage and turn it out again in the form of lower content coins. With the changeover to base alloy coinage, the problem is inherently a much simpler one of rapidly achieving a rate of production sufficient to offset withdrawals from circulation. Because the rate of withdrawal of the old silver coins is difficult to estimate in advance with accuracy, the Treasury must plan to replace much of the existing coinage and have the capability to do it within a relatively short period of time. If the coin shortage should ease by early next year, the changeover problem should be a relatively simple one. At the present time, planning should go forward on the less favorable assumption that there will still be a coin shortage at the period of peak demand in the second half of 1965.

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Possible Interim Expansion of 5-Cent Production

Assuming for the sake of discussion that legislation providing for a new base alloy coinage were passed by late spring or early summer, only a limited amount of the new coins could be produced by the end of the calendar year, and their introduction should probably be delayed until 1966. At the same time, the public might possibly be making some net withdrawals of silver coin from circulation. This could contribute to a tight coinage situation next year at about this time (December). One step that can be taken even before the legislative consideration of the Treasury proposals is to plan for extra production of 5-cent pieces beyond the amounts scheduled under the current crash coinage program. The logic of such a procedure would be that whatever the eventual decision on the subsidiary coinage material, extra 5-cent pieces would be a valuable addition to the circulating coinage during the difficult initial stages to the changeover.[1]

If it were considered certain that silver would not be continued in the coinage, there might even be something to be said for a reduction in the rate of silver coinage after the beginning of the year. To the extent that this allowed increases in the rate of coinage of 5-cent pieces, coins which would stay in circulation would be increased at the expense of coins which possibly might not to the same degree. There are, however, difficulties with such an approach. A much larger number of 1- and 5-cent pieces must be produced to carry on a given dollar amount of commercial transactions. Furthermore, such a shift might cause some disruption in Mint production schedules. For these reasons, it probably is better to plan to continue to produce silver coins at fairly high levels up to the time that a switchover is made to a new subsidiary coinage alloy.

This would not, however, preclude some intensification of the production effort next year on 5-cent pieces, at the expense of 1-cent pieces. It is understood that the Mint will have considerable flexibility in this respect as new presses already on order are delivered. A further but more far-reaching effort along these lines would be the establishment of additional temporary facilities which could be used to produce cupronickel 5-cent pieces from purchased strip and rapidly shifted to the production of subsidiary coinage at a later time in the year.

Possibilities of this sort have been canvassed thoroughly on earlier occasions when planning the current crash coinage program. Great progress has been made along these lines. Approximately 50 coin stamping presses and additional blank annealing and cleaning lines

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[1] As is now amply clear (May 1965), the Mint's crash coinage program has been eminently successful in overcoming the shortage of 1-cent and 5-cent pieces and has built up the sort of backlog referred to in the text.

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are on order, and it is understood that further 10-coin stamping presses are about to be contracted for. However, the changeover to a new coinage alloy may mean that even higher levels of coin producing capacity will be required until the new Philadelphia Mint comes on stream. If so, there probably is a need to reexamine the possibility of seeking authorization to obtain additional space where supplementary minting of coins from purchased strip could take place. This might involve the installation of coin-stamping presses in the present San Francisco building, or in temporary facilities elsewhere, or both. In any event, "outside" operations should remain under Mint control and jurisdiction.[1]

Dimensions of the Changeover Problem

Some rough idea of the production effort that might be required to insure an efficient changeover to base alloy coinage can be gained by reference to the volume of subsidiary coin estimated to be in circulation at the time of the changeover. Table 1 presents approximate estimates of the number of pieces of subsidiary coin that will be in circulation at the end of calendar year 1965 and their face value. These estimates supplied by the Mint are lower than those that would be carried in the *Circulation Statement*, but higher than those implied by the A. D. Little estimates for January 1963 based upon the age distribution of a selective sampling of coins by the Federal Reserve banks. Further internal studies of the amount of coin in circulation should probably be made by the Treasury, but the present estimates are adequate for the purpose at hand.

One dimension of the changeover problem is simply the total amount of base alloy coins that would have to be produced in order to replace silver coins now in circulation. There is every reason to believe that there will be extensive side-by-side circulation of silver and base alloy coins. However, to be entirely secure, plans should be made for the full replacement of the existing coinage. Another dimension of the changeover problem is the peakload production that will be required in early stages of the changeover when withdrawals of old coin would possibly present a problem. Complete replacement of the more than 12 billion pieces of outstanding subsidiary coinage with base-alloy coinage would probably take about 3 years. This assumes that 1- and 5-cent production would be continued at roughly the rates now scheduled for fiscal 1966 and that the remainder of Mint facilities would be shifted as rapidly as possible to the production of base-alloy coins with the maximum feasible reliance upon the purchase of strip. Replacement could be accomplished even more rapidly, if existing and planned capacity were to be expanded.

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[1] The Treasury's proposed legislation includes authorization to resume the minting of coins at the San Francisco Mint.

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TABLE 1.—*Estimated Subsidiary Coin in Circulation at End of Calendar 1956*

	Pieces (in millions)	Value (in millions of dollars)
50-cent	1, 233	$616
25-cent	3, 317	829
10-cent	7, 844	784
	12, 394	2, 229

Source: Bureau of the Mint.

Full replacement of the existing coinage is hardly likely to be obligatory within 3 years, but this does set an approximate upper limit on the overall production task. What does seem likely to be required is the ability to reach peak rates of production very quickly in order to offset any net withdrawals of old coin in initial stages of the transition. This does tend somewhat to increase the attractiveness of cupronickel as the subsidiary coinage material since the Mint is thoroughly familiar with its processing, no period of experimentation would be required, and dependence upon outside suppliers would be minimal.

Purely for the sake of illustration it may be useful to consider the timing of a shift to cupronickel subsidiary coinage. At the time of writing, it is not possible to evaluate a similar changeover to cupronickel clad coin, but the Mint is examining the problem in depth and detail. In the case of straight cupronickel, if the Mint were able to commence full-scale production of subsidiary coins by July 1 of next year, it might be possible to produce as many as 1.9 billion pieces by the end of the calendar year. The maximum annual production rate would be 3.8 billion pieces of cupronickel subsidiary coin with existing production facilities and approximately the existing distribution among 1-cent, 5-cent, and subsidiary coin production. If this maximum rate could be quickly achieved, a little more than 15 percent of the outstanding amount of subsidiary coinage could be replaced in the first 6 months. If the coin shortage eases early next year, this rate of replacement of subsidiary coin should be entirely adequate. Still, there is much to be said for an immediate effort to provide an even larger temporary productive capacity, and if there is continuing evidence next year of a coin shortage, some action will be obligatory. The leadtimes for expansion in coin-producing capacity are long, and deliveries of needed equipment and materials are sometimes uncertain. However, the Mint's efforts under the crash coinage program have been prodigious, and, if required, they undoubtedly can expand their capacity even further.

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Vending Machines and the Changeover

The possible need for very intensive production of the new coins is complicated by the vending machine problem. Where the new coinage material did not work in present rejectors, there would be two extreme alternative courses of action. In one the vending machine constraint would be accepted and coin production would be adapted accordingly. Production of silver coins would be continued at high rates while vending machines were being modified and parallel production of the new coins was begun, but the introduction of new coins would be delayed until vending machines were fixed. The objections to such a program are obvious. Even if vending machines could be altered in less than 2 years, the drain on silver stocks during that time could be very great. Furthermore, it would be extremely difficult to arrange for the parallel production efforts on old and new coins without running the risks of a divided effort and inadequate production of both.

The other alternative would be to commence production of the new coins as soon and as rapidly as possible and place them in circulation without awaiting the modification of vending machines. This would have the advantage of not continuing the production of silver coins at a time when many of them would go out of circulation as soon as they were issued. The obvious disadvantage would be the fact that new coins would not work in unaltered vending machines. While this should, in fact, tend to keep some additional amounts of old coin in use, it could hardly fail to disrupt machine merchandising and greatly inconvenience the public. In early stages of the transition, new coins would still be a small fraction of the total amount of coin outstanding. If vending machines could be altered rapidly, and their operators would have some incentive to do so, the changeover might be achieved without dire results. Whether such a program could gain legislative approval, or should be recommended, is another question entirely which will not be examined here.

The Transitional Coins

The obvious attractiveness of the clad and Inco coins, is the potential they offer for avoiding the vending machine problem. Introduction of the new coins into circulation could proceed as rapidly as they could be produced. The critical factor then tends to become the leadtime required to obtain adequate amounts of the Mint input—clad strip or annealed Inco blanks. While successful resolution of vending machine difficulties is highly desirable, it will be necessary to guard against attaching too much importance to that single objective. The supply of the material for the transitional coin must be completely assured. Otherwise, there is a danger that a high rate

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of production could not be sustained. This could potentially even be more serious in its overall effects than the difficulty with vending machines that would result if ordinary cupronickel coins were used.

Inco apparently has the capacity to make the required amounts of strip but the Mint would need annealed blanks at least initially. Even if the Inco coin were satisfactory in other respects, assurance would be needed that adequate amounts of blanks would be forthcoming, and that they could be struck on existing Mint equipment. Similar considerations apply in the case of clad strip upon which the details of assured sources of supply were not available at the time of writing. Battelle has recommended that the Mint initiate an exhaustive investigation on this crucial point and just such an investigation is underway.

Melting, Hoarding, and Export Controls

Brief comment will be made on the role that melting, hoarding, and export controls might play during the changeover to a base alloy, although full examination and analysis of the problem will not be attempted here. It may be desirable to obtain standby authority for the Secretary of the Treasury to institute controls over the hoarding, melting, and exporting of silver in the event he determines certain conditions occur. But, with the possible exception of export controls, the usefulness of such controls as part of an orderly changeover appears questionable; rather, their function would appear to be that of emergency maneuvers to be taken only if the possibility of holding the silver price through sales from our own stock during the critical changeover period is seriously threatened. If the changeover is started soon to a base alloy, this threat will undoubtedly be avoided.

The purpose to be served by controls over the melting of coin if the Treasury is able and willing to hold down the price of silver is questionable, since there would then be no incentive to melt coins. Furthermore, the prohibition of melting at the same time as the price of silver is being held could foster the misconception that the price was shortly going to be allowed to rise, and stimulate speculation in bullion.

Melting controls might be obligatory in a "last ditch" effort to maintain coin in circulation where the Treasury had tried to hold the price of silver, but then ran out of silver which could be sold in the market. In general, this would not even seem to be a remote possibility where the transition is to a base alloy, rather than to a reduced content silver alloy. Moreover, while melting controls could be required under some circumstances, too much should not be expected from their application, since a prohibition on melting could not effectively prevent hoarding under those circumstances.

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Controls over the hoarding of coin, while perhaps conceivable in theory, would be extremely difficult to enforce effectively. It is hard to see just how controls could be designed which would discriminate successfully between prohibited hoarding and the accumulation of coin in the ordinary course of business, and in coin collections. Possibly, penalties for coin hoarding could be devised that would limit large accumulations by professional speculators, and such controls might play some part in effecting the recovery of old silver coin in the transition to silver coinage of reduced content. Even this seems doubtful, however, since a legal apparatus effective in dissipating large hoards would seem almost certain to encourage even more widespread "family" accumulations. While the question deserves fuller discussion and analysis than it will be given here, there does not seem to be much value in controls on the hoarding of coin. Controls on the hoarding of bullion might conceivably be more effective.

There is a stronger case for export controls during a changeover period. Certainly, they would be an essential backstop to any controls over the melting or hoarding of coin. But if these controls are not used because the Treasury is holding the market price of silver, the case for export controls on silver is much less clear.

The only situation in which we would want to prohibit the export of silver bullion would be during a period when there was heavy foreign speculative demand, which added to the drains on Treasury stock—as was the case temporarily in the latter months of 1964. However, one result of applying export controls would be a partial separation of the U.S. market from the world market, and there would be some increase in world prices above the pegged U.S. price. As a consequence, some U.S. domestic demand for silver, previously met from imports, would now be met from Treasury stocks, a cheaper source of supply. By frustrating the foreign demand for Treasury silver, it could be argued that some net saving would arise. It should be recognized that silver users would probably regard the separation of U.S. and world markets as a threat to their assured sources of supply. If so, export controls might stimulate silver users to make precautionary purchases of Treasury silver in advance of their current requirements. The fact that, aside from speculative demands, the United States is a natural importer greatly increases the possibility of this response to a higher world price.

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VII. Conclusions and Recommendations

1. Cupronickel is the best permanent material for a new subsidiary coinage, ignoring the vending machine problem. A close second choice would be nickel silver for 10-, 25-, and 50-cent pieces.

2. Either cupronickel or nickel silver coins would require "factory" adjustment of sophisticated vending machine rejectors, entailing significant costs and transitional inconvenience. This may not be adjudged intolerable, in view of their advantages in other respects. However, since extensive experiments confirm that cupronickel (and probably nickel silver) clad on a copper core operates successfully in unaltered vending machine rejectors, preferable options are available. A clad coin can be used during a transition period, or permanently.

3. Information on the wear properties of clad coins is altogether encouraging, and they undoubtedly meet all the requirements for permanent use in the coinage. If desired, they could, with equal facility, serve as a transitional coin while further study and research on the adaptation of vending machines was being conducted. An overriding requirement with clad coins is the production feasibility of the strip and the assurance of an adequate supply for processing in the Mint.

4. Because of a number of unresolved questions, the Inco coin comes into the picture only if an assured supply of clad strip cannot be obtained. In any event, the Inco coin would have to have demonstrated conclusively that it would work in vending machines with minimal adjustments, that it could be struck successfully in large volume on existing Mint equipment, and that adequate supplies of strip or annealed blanks would be available.

5. Subsidiary silver coinage of reduced content, such as silver-copper alloys clad on a low-content silver-copper core, suffers both from difficult transitional problems and incomplete assurance that the subsidiary coinage would not be imperiled again within a fairly short period of time. The danger of a complete breakdown during the transition period cannot be ruled out, and the use of silver throughout the subsidiary coinage should not be viewed as an eligible option. If any silver is to be retained in the subsidiary coinage system, it should be limited to the silver dollar and to a clad 50-cent piece of 400 fineness. In any event, the retention of the monetary value of the silver dollar at its present fineness is absolutely essential to a successful transition.

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6. During the transition to a new coinage system, it will be obligatory to hold the market price of silver at its current level in order to protect the existing coinage. Since this will remove the incentive to melt the existing coinage, controls over melting would probably not serve any useful purpose. Effective controls on the hoarding of coin appear impractical. Controls on the export of silver coin and bullion may serve a useful purpose during the transition period. There is something to be said for having standby authority to invoke controls. A prompt transition to base-alloy coinage would make the actual use of controls unnecessary.

7. New coins should be placed in circulation through normal channels. Every effort should be made as soon as possible to prepare for extremely high rates of production of the new coins. This should include an interim expansion in the production of 5-cent pieces (which would provide substitutes for silver coin and subsequently release Mint capacity for the new coins) and arrangements for additional temporary production space. If this were to be outside of existing Mint facilities, it should remain under Mint control.

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