The Paper Column

The Changeover from 12- to 18-Subject Plates

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The Bureau of Engraving and Printing announced on April 28, 1952 that they were converting currency production from 12- to 18-subject sheets (Hall, 1952, p. 1). The conversion for all classes and denominations was accomplished by September 9, 1953 when the last production from 12-subject plates was delivered (Hall, 1953, p. 65).

The changeover to 18-subject plates resulted directly from the development of non-offset inks. Once printed, these inks set rapidly enough that when the sheets came off the press and landed on the pile, the ink did not transfer to adjacent sheets. The story of the inks is highly technical so without going into the chemistry of inks we will focus on processing and how non-offset inks allowed for larger plate size.

The conversion program began with $1 silver certificates. $1s always led the charge when innovations came along because they comprised the highest volume product so BEP management traditionally attempted to maximize their technological gains by bringing the $1s along first.

Furthermore, when innovations did occur generally the first plates to be affected were the backs because backs were printed first. This almost was true for the 18-subject changeover. One of the 18-subject $1 face plates beat the first back plates to certification by a day; otherwise the tradition of backs-first prevailed.

The changeover from $1 12- to 18-subject plates involved a brief experimental phase followed by a gradual switch from 12- to 18-subject production during which both types of plates were in use. Consequently, the changeover story for the $1s is the most complex and most interesting.

The biggest hurdle faced by the Bureau was that there were no 18-subject bicolor rotary overprinting presses to apply the series, Treasury signatures, seals and serials. This did not deter Director Hall's aggressive push to use the larger plates. As an interim measure, they purchased flatbed typographic presses to do the overprinting until they could design and have built rotary presses.

They utilized two types of flatbed overprinting presses. The first acquired were mono-color presses that were used in tandem where one applied the black overprint and the other the blue. Next came bicolor presses that applied both colors simultaneously.

Both types of flatbed overprinting presses were used through April 1954. The mono-color tandem pairs appear to have been used exclusively for overprinting $1 silver certificates, whereas the bi-color presses appear to have been employed for all the other classes and denominations (Martin and others, 2015).

Newly designed and built 18-subject rotary overprinting presses came on line in March 1954. By then all production was in 18-subject form so within a period of about 10 days all of it was being processed by the new machines.

Processing

Printing from intaglio plates is a challenging undertaking because the image to be printed is from grooves cut into the surface of the plate rather than ridges standing in relief on the plate. Thus the ink is held in the recessed grooves and the paper must be pressed under great pressure so that it deforms downward

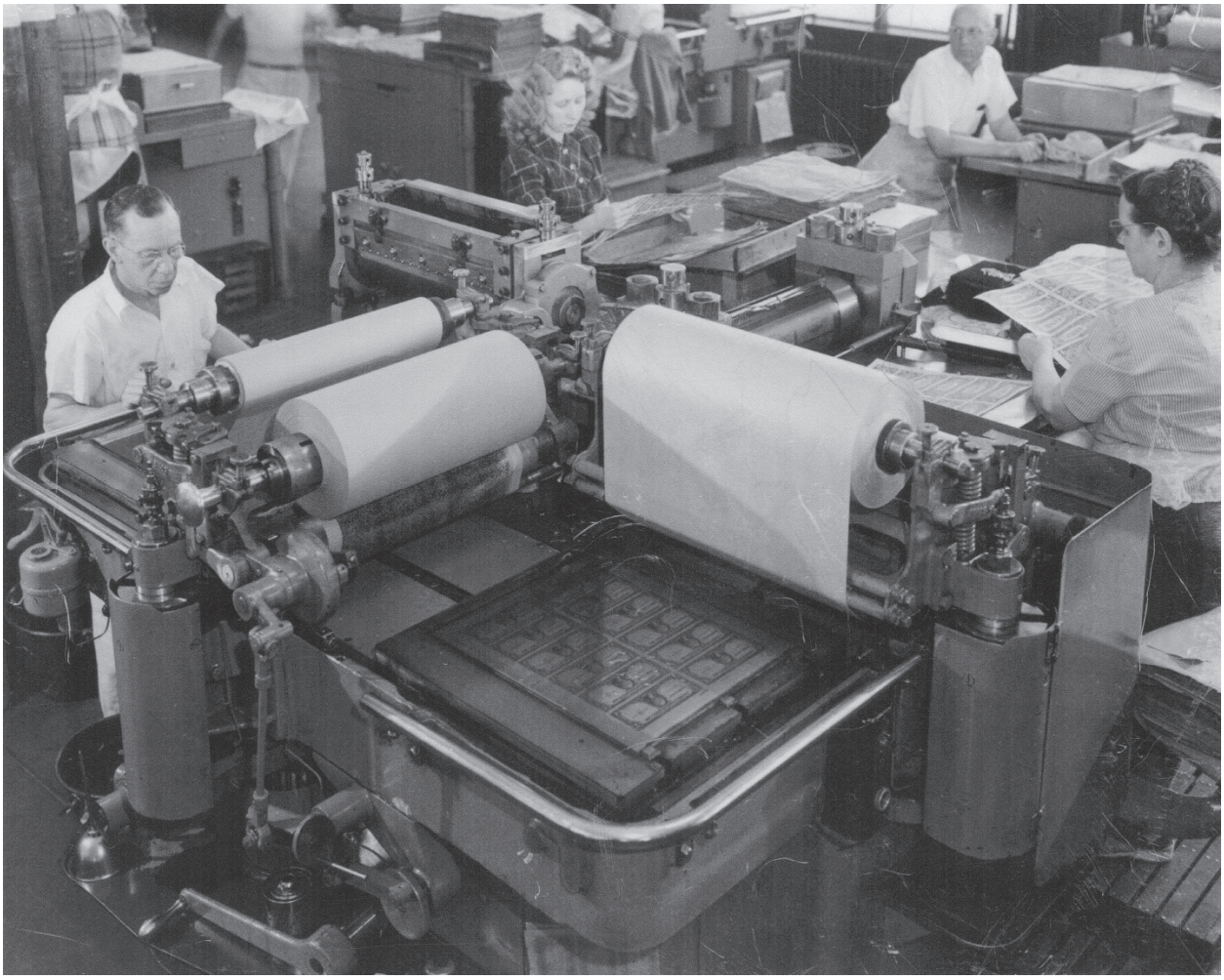

Figure 1. 12-subject $1 silver certificate plates on a 4-plate power press. There are four plates that move counterclockwise around the press. The tower between the printer and women at the far corner inks the plates. The roll of paper in front of the printer wipes the excess ink from the plates. The roll of paper to the right polishes the plates. The women with her back towards us feeds the sheets. The black roller in front of her presses the sheets against the plates as the plates and paper pass under the roller. The women in the far corner removes the printed sheets from the press and interleaves them with tissues. Bureau of Engraving and Printing photo.

into the grooves sufficiently to pick up the ink. Traditionally it was the practice to use wetted paper in order to soften the paper so that it would deform more easily.

Here is the agonizing process used to print the backs and faces before the advent of non-offset inks.

1. The paper was wetted.
2. The back was printed.
3. A tissue was inserted between the printed sheet and the previous sheet to prevent offsetting of the ink.
4. The sheets were dried to set the ink but, at the same time, the paper itself dried.
5. The tissues were removed.
6. The paper was rewetted.
7. The face was printed.
8. Tissue was inserted.
9. The sheets were dried.
10. The tissues were removed.

Finally, after a period that usually took 10 days, the generic back- and face-printed sheets then progressed on to the numbering and sealing presses where the individual notes were simultaneously cut from the sheets and collated.

The 10-step process outlined above does not include the onerous security counts and quality control inspections at each handling! Now that you have the picture, imagine pushing 196,372,000 sheets through this process, which is exactly what was done during fiscal year 1952 (Hall, 1952, p. 84).

The big bottleneck of inserting and removing the tissues could be eliminated if they could develop non-offset inks. Furthermore it would be unnecessary to dry the sheets so they could move directly from the back to the face printings without rewetting the paper. The typical processing time of 10 days between back and face printings could be eliminated so the faces could be printed within a day of the backs, and all but 2 inspections and counts eliminated (BEP, 1962, p. 157-159).

Now consider a further innovation. Instead of receiving dry paper from the paper mill, what if the mill delivered wet paper in sealed containers so that the BEP could get rid of their wetting machinery (BEP, 1962, p. 163).

BEP chemists worked for years to develop non-offset inks and finally succeeded first with non-offset green ink in 1950, and then non-offset black ink in 1952. The tedious wetting and drying operations could now be eliminated. Differential paper expansion and shrinkage was minimized using mill-wet paper thus giving the sheets greater dimensional stability. At last, plate size could be increased to more than 12-subjects.

The power presses at the BEP carried four plates that circulated around the bed of the press, each passing through a different station as they moved to the impression roller that pressed a sheet against the plate. There were inking, wiping, polishing and printing stations, all operating simultaneously as the plates moved.

The BEP had a huge fleet of the 4-plate power presses that they were automating, so rather than buy new machines that could handle really large sheets, they asked how many subjects could they squeeze onto the working surfaces of their existing presses. The answer turned out to be 18. This alone would boost output by 50%. Concurrent automations such as automated plate wiping, automated feeding and centering of sheets, and automated sheet takeoff, greatly increased productivity well beyond the initial 50% gain from increased plate size. Clearly the development of non-offset inks yielded an entirely new horse race.

$1 18-Subject Experiments

The BEP plate makers produced two full sets of four experimental 18-subject $1 back and face plates plus a spare of each in May 1952 to test the concept of 18-subject production. These plates were identical in all respects to the production plates that followed. There was nothing on them to reveal that they were experimentals such as EP in front of the plate serial numbers as we usually observe on more modern experimental plates.

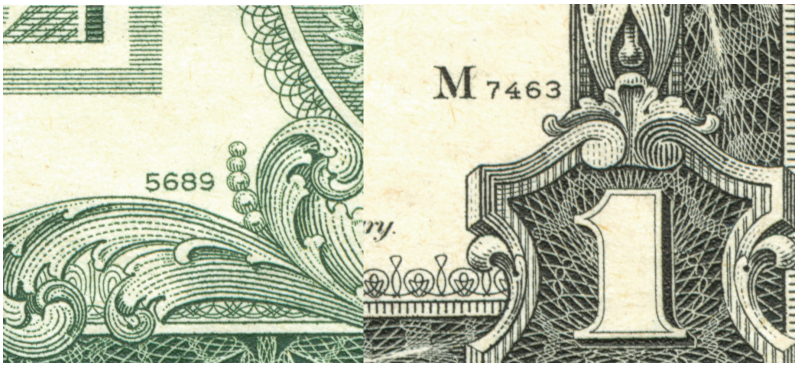

Figure 2. Detail showing the plate serial numbers from the first $1 silver certificate 18-subject back and face plates. These were experimental plates made in May 1952. We don't know if production from these plates reached circulation, but it is likely. Photo courtesy of the National Numismatic Collection, Smithsonian Institution.

The experimental plates are listed on Table 1. The term iron electrolytic on the table refers to plates made using electrolytic deposition of iron in the duplication process. Iron was the primary metal used in 1952 in contrast to nickel today. Those labeled steel were made by traditional Perkins roll transfer technology from a master die.

Table 1. $1 experimental Silver Certificate 18-subject plates made in 1952. Date from BEP (various dates).

	Treasury Plate No.	Plate Serial No.	Certification Date	Type of Plate
Backs				
	162567	5689	May 14, 1952	steel
	162581	5690	May 15, 1952	steel
	162583	5691	May 15, 1952	iron electrolytic
	162385	5692	May 20, 1952	iron electrolytic
	162595	5693	May 22, 1952	iron electrolytic
1935D Faces				
	162582	7463	May 12, 1952	iron electrolytic
	162584	7464	May 20, 1952	iron electrolytic
	162590	7465	May 22, 1952	iron electrolytic
	162596	7466	May 22, 1952	iron electrolytic
	162600	7467	June 4, 1952	iron electrolytic

Hall (1952, p. 58) chronicled that the first paper for printing 18-subject currency was received in the wetting section, processed on May 21, 1952, and sent to the experimental room for printing. Printing of 18-subject currency was started in Section 1 on June 16, 1952. By the end of the fiscal year on June 30, 27,647 back impressions and 22,664 face impressions already had been printed from the experimental plates.

Processing of the sheets could not proceed owing to the lack of 18-subject overprinting capability. However, the viability of 18-subject intaglio back and face production was demonstrated so 18-subject $1 production plates began to be made.

What is unknown at this time is whether production from the experimental plates ultimately was sealed, numbered and issued. Let us know if you find these plate serial numbers on your notes. Such a find would not be a surprise.

12- to 18-Subject Changeover

The first 18-subject production plates began to be made in July 1952, but it took a year before all classes and denominations were switched to the new size. In the meantime 12-subject plates continued to be made as needed, and printings continued from 12-subject plates.

Table 2 summarizes the changeover in the manufacture of plates for all classes and denominations. The cutoff between the plate sizes was abrupt in time for all but the $1 faces and backs, although one early 18-subject back plate was made for both the $10 and $20 denominations.

Table 2. Certification dates for the last 12-subject and first 18-subject production plates. Data from BEP (various dates).

	12-Subject Plates			18-Subject Plates		
Den	Series	Plate Serial	Date Certified	Series	Plate Serial	Date Certified
Face Plates:						
Silver Certificate						
1	1935	7500	Sep 12, 1952	1935	7469[a]	Jul 11, 1952
5	1934D	2171	Aug 21, 1952	1953	1	Mar 31, 1953
10	1934D	257	Sep 7, 1952	1953	1	Apr 21, 1953
Legal Tender						
2	1928G	516	Sep 24, 1951	1953	1	Mar 26, 1953
5	1928F	683	Jul 24, 1951	1953	1	Mar 31, 1953

Federal Reserve						
5	1950	144	Aug 28, 1951	1950A	145	Apr 1, 1953
10	1950	187	Jan 28, 1953	1950A	166[b]	Feb 13, 1953
20	1950	105	Nov 26, 1951	1950A	106	Apr 2, 1953
50	1950	22	Dec 19, 1952	1950A	23	Jun 9, 1953
100	1950	22	Dec 22, 1952	1950A	23	Jul 9, 1953
Back Plates:						
1		5735	Oct 14, 1952		5694[a]	Jul 10, 1952
2		390	Apr 14, 1952		391	Mar 26, 1953
5		2096	May 28, 1952		2097	Mar 31, 1953
10		1456	Jan 8, 1953		1448[c]	Feb 13, 1953
20		821	Jan 2, 1953		815[d]	Jul 1, 1953
50		166	Aug 8, 1944		167	Jun 9, 1953
100		132	Jul 28, 1944		133	Jul 9, 1953

a. See Table 3 for mixed 12- and 18-subject $1 faces and backs.
b. 18-subject $10 faces 166 and 181 were made prior to 12-subject 187, which was the last 12-subject plate.
c. 18-subject $10 back 1448 was made prior to 12-subject 1456, which was the last 12-subject plate.
d. 18-subject $20 back 815 was made prior to 12-subject 821, which was the last 12-subject plate.

We have arrived at the point where we can examine the changeover from 12- to 18-subject plate size for the all-important $1 silver certificates. One overriding constraint overshadowed this changeover; specifically, production of $1s could not cease while the BEP retooled. The 18-subject plates had to be phased in while the 12-subject plates were phased out. There would be 15 months of simultaneous production from both, where some of the power presses were set up for 12-subject production and others 18-subject.

Both $1 12- and 18-subject plates were made during the transition. Table 2 reveals that the first non-experimental 18-subject $1 silver certificate face and back plates were certified respectively on July 11 and 10, 1952, whereas the last 12-subject face and back plates were certified September 10 and October 14, 1952 (BEP, various dates). The back and forth numbering of the plates is detailed on Table 3.

Table 3. Intermixed numbering of $1 Silver Certificate 12- and 18-subject plates during the 12- to 18-subject transition. No proof usually means the plate was defective so it was not certified. Data from BEP (various dates).

Faces	No. Subjects	Backs	No. Subjects
7462 and lower	12	5688 and lower	12
7463-7467	18 experimentals	5689-5693	18 experimentals
7468	no proof	5694-5698	18
7469-7472	18	5699-5700	no proofs
7473-7474	no proofs	5701-5702	12
7475-7476	12	5703-5704	no proofs
7477	no proof	5705	12
7478-7481	12	5706	no proof
7482	no proof	5707-5714	12
7483-7488	12	5715-5733	18
7489-7491	18	5734-5735	12
7492	no proof	5736 and higher	18
7493-7498	18		
7499-7500	12		
7501 and higher	18		

The manufacture of 18-subject plates for all the other classes and denominations began in March 1953. The changeovers were abrupt as shown on Table 2, except for a single early 18-subject back plate for both the $10 and $20 denominations.

The delivery data on Table 4 demonstrates that there was simultaneous 12- and 18-subject production for all but the low demand types during the transition period. The conversion was completed with delivery of the last 12-subject Series of 1950 $100 Federal Reserve notes for New York on September 9, 1953 (Hall, 1953, p. 65).

Table 4. Last deliveries of notes printed from 12- and first deliveries from 18-subject plates to the Treasury by the Bureau of Engraving and Printing. Data from Shafer (1967).

		Last 12-subject	First 18-subject
SC	$1	Oct 16, 1953	Nov 20, 1952
	$5	Oct 1, 1953	May 12, 1953
	$10	Apr 14, 1953	May 12, 1953
LT	$2	May 6, 1953	May 4, 1953
	$5	Apr 27, 1953	May 6, 1953
FRN	$5	Sep 1, 1953	Jul 6, 1953
	$10	Oct 1, 1953	Apr 3, 1953
	$20	Sep 1, 1953	Aug 13, 1953
	$50	Aug 28, 1953	Dec 7, 1954
	$100	Sep 9, 1953	Dec 8, 1954

18-Subject Overprinting

Because the Bureau did not possess 18-subject overprinting presses at the beginning of July, 1952, they planned to acquired "suitable flatbed cylinder presses" to accommodate overprinting of the $1 silver certificates on an interim basis (Hall, 1952, p. 1). The cylinder on each press was an impression roller that pressed the sheet against the flat bed of the press, which contained the inked elements. The first were mono-color presses operated in tandem, one for each overprinted color, and were used to overprint $1 silver certificates (Martin and others, 2015).

One characteristic of these presses was that 36 serial numbering registers were mounted in or on the flat bed of the blue presses along with the 18 seals. A press of similar design had been used to seal and number 4-subject national bank note sheets between 1926 and 1929 (Hall, 1926, p. 6-7).

The first recorded use for the tandem flatbed presses involved the overprinting of $1 Series of 1935D star notes on July 29, 1952 when serials *00000001D through *00144000D were printed (BEP, undated). The GG serial number block was assigned to the first regular 18-subject production with first deliveries to the Treasury on November 20, 1952 (Hall, 1953, p. 65). This was followed by the NG block for 18-subject production.

Figure 3. $1 Series of 1935D star note from the first group of 18-subject notes that were numbered July 29, 1952, which included serials *00000001D to *00144000D. The sheets were fed through newly acquired mono-color flatbed cylinder presses operated in tandem, the first used to print the black and second to print the blue colors. Photo courtesy of Derek Moffitt.

Figure 4. The GG serial number block was the first assigned to 18-subject Series of 1935D $1 production. Notice that this note is from the Q plate position from the new row of subjects on the right side of an 18-subject plate.

All the GG block notes were Series of 1935D. The changeover to the narrow back designs already had taken place so all GG production was of the narrow variety. The NG block bridged the 1935D and E series. Serials up through N46944000G were 1935Ds and those beyond were 1935Es. The intervening HG through MG blocks were assigned to 12-subject 1935D production. There was no 1935E 12-subject production.

The Bureau had "five one-color and four two-color typographic presses" in operation by June 30, 1953 (Hall, 1953, p. 42-43) as other denominations and classes of currency began to be converted to 18-subject format. Of course, the appeal of the two-color presses was that both colors could be applied simultaneously on the same press. The first overprints from the two-color presses probably consisted of the first 18-subject Federal Reserve notes that were delivered on April 3, 1953, which were $10s (Hall, 1953, p. 65).

The first of the 16 newly designed 18-subject bicolor rotary overprinting presses came on line in March 1954. Their one-pass overprinting capability, coupled with the greater speed of rotary presses, materially increased production rates. These machines arrived fairly early during the Series of 1935E $1 silver certificate era so most of the Series of 1935E notes were numbered on them.

All 16 of the new 18-subject rotary overprinting presses were in operation by April (Holtzclaw, 1954, p. 92). Consequently, the use of the flatbed cylinder overprinting presses - both tandem mono-color and single two-color - ceased in April 1954.

The last batch of Series of 1935E star notes printed on the tandem flatbed presses consisted of 4444 and 8/18 sheets bearing numbers *6112001D-*61200000*, which were numbered on April 1, 1954. That printing had been preceded by rotary press star printings, the first of which occurred on March 20th, so there was a transition period lasting at least 10 days during which both the flatbed and rotary overprinting presses were in use (BEP, undated).

The 18-subject sheets, regardless of press, were numbered consecutively through the stack rather than down the half sheets. Consequently, consecutive notes had the same plate position letter, rather than cycling through the letters on a given half sheet as before. The notes generally were numbered in production units of 8,000 sheets (144,000 notes) so serial numbering advanced by 8,000 between the subjects on a given sheet. Numbering progressed from the high to low serial numbers within the production units.

Neither the 18-subject flatbed nor new bicolor rotary presses possessed the capability to cut the notes from the sheet in contrast to their 12-subject rotary predecessors. The notes had to be cut using guillotines as a separate operation.

Innovation

The change from 12- to 18-subject sheets allowed for major restructuring in how the work progressed through the BEP, and greatly streamlined and reduced costly counts and inspections.

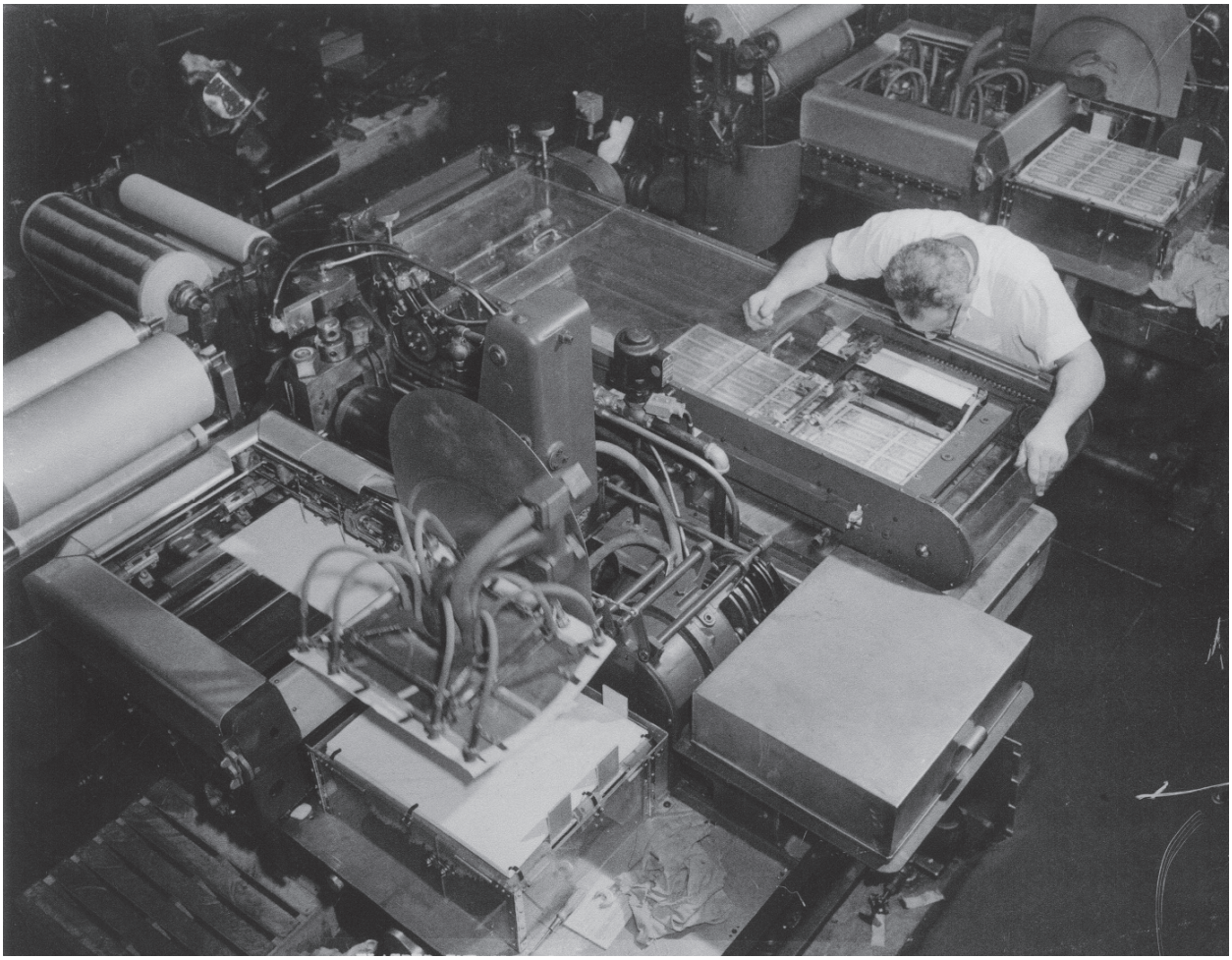

Figure 5. Fully automated 4-plate power press printing 18-subject backs. The 4 plates are traveling counterclockwise around the bed of the press. The plates are inked to the left of the printer. The roll of paper with dark smears of ink wipes the plates. The clean roll to the left polishes the plates. The vacuum mechanism in the foreground lifts, places and centers unprinted sheets onto the plate. A sheet, half of which is visible, is moving with a plate toward the printer where on the way it is being pressed by the impression roller against the plate. The printed sheets are discharged to the left of the printer where a takeoff device moves them toward the right and stacks them directly under his gaze. Notice that he is looking into a plastic housing that encloses the takeoff mechanism. This housing prevents drying of the paper so that the still wet work can be passed off to the press behind him, which prints the faces before the paper dries. Even though the paper remains wet, the non-offset inks set and do not offset onto adjacent sheets in the finished pile. Bureau of Engraving and Printing photo.

Obviously, the change required retooling in many guises, including the design and construction of entirely new overprinting presses to accommodate the larger sheet size. By numbering through the stack, they eliminated the need to separate and collate the notes within the overprinting presses as individual sheets were numbered. Instead they could wait to separate the notes after all the sheets in a given batch were numbered. The result was that the 18-subject overprinting machines were far simpler than their 12-subject predecessors, and, more importantly, much faster.

The entire interlinked chain of innovations chronicled here was about increasing economic efficiency through improved processing speed. The thing that set the whole in motion was the development of non-offset inks. We found it astonishing that something as seemingly benign as reformulating ink recipes could have such major ramifications.

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