

## BANK NOTE PRINTING

The Bank of England have the task of ensuring that there is at all times an adequate supply of clean and unmutated bank notes available to the public. A new design becomes news for a short time and is generally felt to represent a change for the worse, although by the time the new design is itself replaced it has often come to be considered in a new light. Occasionally a short paragraph in the newspapers records the discovery of a note regrettably bearing some flaw which has escaped notice before issue. Apart from such exceptional events the existence and availability of bank notes is, very properly, taken for granted.

There are some 1,500 million notes in circulation, weighing over 1,500 tons. Such a number of notes cannot be kept in good condition and reasonably clean without a great deal of work in a good many places. The commercial banks play a most important part: they withdraw from circulation and return to the Bank of England, as they receive them from their customers, those notes that they consider to be unfit for further circulation. The face value of such notes is credited to the account at the Bank of England of the bank concerned. Similarly, a bank's account is debited with the face value of the notes issued to it and in fact almost all new notes reach the hands of the public through the commercial banks. To provide an adequate supply the Bank of England produce rather more than six million notes every working day, each one a complicated product made to precise standards, and bearing a different serial number.

The Bank have a long experience of designing, producing and issuing notes: they first issued notes in 1695 and have printed them on their own premises since 1791. In 1914 H.M. Treasury issued their own notes for £1 and 10s. produced by commercial printers; responsibility for these denominations passed to the Bank of England in 1928 as a result of the Currency and Bank Notes Act of that year. The Bank's printing operations outgrew their London premises after the last war and

by 1956 were rehoused in a new works, specially designed, at Loughton in Essex. Some 1,600 people are now employed there.

The Printing Works provides nearly half a million square feet of floor space, including a main printing hall with an uninterrupted floor space almost 300 yards long. While it incorporates many unusual security devices, the works is in other respects a normal production unit using budgetary control, work study and research to maintain and improve efficiency.

New production techniques (discussed below) are being developed, but in common with practice in other countries, the Bank have for many years been using sheet-fed printing machines, some of which are adaptations of machines that are in general use while others have been designed specifically for bank note printing. Each sheet of paper is large enough to produce twenty-four £1 notes and a stack of sheets is placed on the feed-board of a machine; the machine feeds the sheets automatically, prints them and stacks them again. The stack is then stored in a safe until the ink is dry enough for the next of the several printing operations. When the major printing processes are complete, the sheets are examined, numbered and cut to produce single notes which are then finally examined, counted and packed. The most important printing process is the so-called 'plate printing' which reproduces all the subtle variety in width and depth of line that is found in an artist's engraving, but instead of his flat copper plate there is a chromium faced electro-formed nickel plate attached to a cylinder; and instead of his hand press there is a large power-driven machine which squeezes the plate against the paper with the pressure of a metal strip-rolling mill. This printing deliberately overlaps other surface printings in a way which is intended to deter the counterfeiter. The whole cycle of manufacturing operations described here takes place over a period of several weeks.

Counting machines play an important part in security control of the sheets: these machines count at a rate of twenty-five sheets a second

by a mechanism which operates on one free corner while the sheets remain clamped together in a stack. Although these machines were originally invented especially for bank notes, they are now widely used in the paper industry.

All Bank of England notes are printed on special paper manufactured by Portals Limited. Besides having a characteristic feel, other security features in the paper which deter the counterfeiter are the metal thread and the shaded watermark. The metal thread was introduced by Portals in 1939 and has been a feature of every Bank of England note printed since.

Almost 20,000 million of the old issue of £1 notes were printed between 1928 and 1960, the year in which they were replaced; annual production of this note rose from 356 million in 1929 to 975 million in 1958. With production on this scale it is not easy to ensure that the product is kept uniform over such a long period for in the course of time many printing plates are worn out. Few articles are so complex and made to such close tolerances and in such quantities as bank notes. Viewed in this light, it is plain that a note is neither a simple document nor a picture and that it is worth lavishing a great deal of care on its design, for even a small flaw in the original engraving work can lead to a printing difficulty which would unnecessarily increase production costs.

Bank note design is subject to the same considerations as apply to industrial design generally; the aim is to produce at reasonably low cost an article which is functionally adequate yet pleasant to look at. The design is not necessarily a good one merely through being beautiful and cheap to reproduce: more important than either is that it should satisfy its functional requirements. The chief of these is security against counterfeiting. This is not an imaginary danger: it is well known that during the last war Bank of England notes were forged on an enormous scale abroad in the hope of damaging the U.K. economy; and private enterprise is active in this field on a small scale from time to time. There can be no infallible single security feature which will invariably defeat the forger. The security of a note depends on a multiplicity of features and a variety of arts and crafts: the special

paper with shaded watermarks and embedded metal threads mentioned above, portrait and vignette engraving in steel, lettering and micro-lettering, geometric lathe-work in black line and white line, special inks and special printing techniques. The artist has to understand and make use of this variety of aids and yet evolve an acceptable design which is fit for mass production.

It is not enough to design a note that is difficult to counterfeit, or one of which a forgery is obvious to an expert. The art is to design so that a forgery is obvious to the public at a casual glance: forgers are caught by the vigilance of the public followed by good police work. This sets two requirements: first, that notes should be produced to such close standards that the genuine note subconsciously registers in the mind as an invariable fixed image; second, that their design should be laden with known difficulties without appearing overburdened in a way which would confuse the public. Pre-eminent amongst the obstacles to forgery which should be included in the design is geometric lathe-work—the rosettes and delicate tracery of fine regular lines and multiple crossing points. A portrait engraving is also useful because the expression is so easily and noticeably changed by the smallest variation. The lettering needs to be of an original design so that a potential forger cannot purchase type. Beyond these there is little scope for hand-engraving work. For instance, one hand-engraved acanthus leaf, however beautiful, looks much like another, and although a misplaced line may be noticed by the expert it will not be seen by the public. The fact that usually not more than a few hundred forgeries of Bank of England notes, other than of the old black and white type, come to light in most years suggests that the current designs are not easily forged.

In modern conditions bank note design can never be static. Facilities for counterfeiting improve with the years and must be combatted by improved printing techniques. The advantages conferred by these techniques cannot be fully exploited unless the Bank are prepared to change the designs of notes more frequently than has previously been the practice in this country.

Security designs and printing machinery have advanced significantly in Europe in the last



ten years. The Bank of England's contribution has been to develop a printing process in which reels of paper are converted into finished notes in one continuous operation, instead of the traditional sheet-by-sheet process. The machine which has been designed is able (through the development by the Bank of a combination of suitable inks and heat-drying methods for security printing) to apply in sequence to the paper, as it passes once through the machine, all the different printing operations which in conventional methods are necessarily separated by periods of storage. Machines for printing from reels of paper are common and it may seem surprising that there should be any difficulty in using them to print notes. The reasons start with the paper which, being chosen for its toughness, is not as simple to print upon as softer commercial papers. The note design moreover involves several different printing processes and these are deliberately intended to be, as far as possible, different from commercial counterparts. Consequently it was difficult to find a machine maker with all the knowledge to design a composite machine or ready to afford the development costs, and in fact the Bank themselves assembled the necessary team of engineers, physicists and chemists to pursue such a project. Early in 1960 notes were produced by the new process on an experimental machine and in August 1961 a test run provided 500,000 notes for issue; prototype production machinery is to be installed during 1962.

The results of the Bank's researches have been made available to other interested parties and at least one other country is already preparing to produce notes by this method.

There is however, much yet to be done to make the process as reliable and as automatic as possible. The practical work now in progress is chiefly concerned with the improvement of inks and the development of electronic controls both to ensure that successive prints overlap each other precisely and for automatic inspection. As in the works of other note printers, each finished Bank of England note is examined visually for flaws, and large numbers of people are occupied in this task alone. Together with an electronics firm, the Bank devised five years ago an electronic comparison scanner to perform this task automatically as the paper flows from the printing

machine. The comparison scanner is still in the course of development; it promises to be a very useful machine but, as it can be highly critical of all it sees, it sets a new standard in the accuracy required of the whole printing process.

Anticipating the final perfection of the scanner some progress has been made with the devices which could follow it. The delivery end of the machine has to be able to cut the paper to single notes at speeds up to twenty a second in each row, to extract the faulty notes indicated by the scanner and to batch and pack the remainder in hundreds. When these devices are fully developed it will be possible to produce packed bank notes untouched by hand. There will be obvious security advantages during manufacture if no one is called upon to handle either single notes or sheets of notes. Large stores of work in progress will also be eliminated. Naturally, new processes and devices must be introduced with great care for in bank note printing there is no room for breakdown and error; and the change-over to the new methods of printing will therefore be gradual. It will be planned to match the normal run-off of labour so that there is not likely to be any redundancy.

One feature of the new process is that the alignment of print to watermarks is more difficult to obtain. With sheet production, the leading edge of each short sheet of paper is first cut in relation to the watermarks and because the grippers of the printing machine then align the sheet to this edge there is automatically an appropriate fit between print and watermark. In using a reel containing a 'sheet' about two miles long it is much more difficult to fit print to watermarks. It was therefore resolved to avoid the problem—at least for the present—by designing the new £1 note with continuous watermarks in a band extending the whole length of the reel, which only requires the paper to be reasonably well steered through the machine.

The specification for the new note also laid down that it should be equally suitable for production by the existing sheet-fed machinery and by the new process, so that it would be possible to bring the new machinery into production as it became available. With sheet-fed machines any size of note can be made,

merely by leaving unused some of the available surround on the printing plate; and paper need not be wasted, because the sheets can be cut to an appropriate size beforehand. When the paper is continuous however, the circumference of the printing cylinders needs to be filled up with bank note images in order to avoid a waste of paper at each revolution. For this reason the exact sizes of future notes will be related to the standard cylinder circumference. It is probably well known that the £1 note has been reduced in size so that the £5 and £10 notes which are to be produced later can be different in size and yet all conveniently fit the wallet.

Reference has been made to the very large scale of the operations called for in maintaining the note circulation. The number of notes of each denomination issued is determined ultimately by the public. The demand for each denomination is no more static than the total demand for notes. The £5 note, for instance, has been gaining rapidly in popularity since the introduction of the new note in 1957 and now accounts for more than 40% of the value of the circulation. By comparison with

other countries however, this figure seems still an extraordinarily low one, some other countries having twice as high a percentage of their notes in denominations of this order of value or higher. The result of this is that the Bank are obliged to print, examine, count, issue, transport and eventually withdraw, check and destroy, a volume of notes which, by comparison with other countries, appears to be disproportionately large; and also that banks and businesses throughout the country have a larger number of notes to count, to store and guard, to collect and despatch, than seems really necessary.

Though in designing notes, the Bank are inevitably preoccupied first and foremost with security, it is an obvious duty to give the public, as far as possible, notes that besides being difficult to forge are convenient, attractive and in the denominations that are wanted. A continued shift of public demand in favour of notes of higher denominations is to be expected and this would make it possible for an adequate number of notes to be provided and handled with less effort and at lower cost to everyone than at present.

#### NUMBER OF NEW BANK OF ENGLAND NOTES ISSUED

<i>Millions</i>		1950	1956	1957	1958	1959	1960
10s.	...	286	387	401	416	430	452
£1	...	640	917	903	927	983	1,063
£5	...	13	34	75	66	86	112

#### AVERAGE TIME DURING WHICH BANK OF ENGLAND NOTES REMAIN IN CIRCULATION

10s.	...	...	...	...	...	...	...	5½ months
£1	...	...	...	...	...	...	...	13¼ "
£5	...	...	...	...	...	...	...	22 "

NOTE ISSUES: UNITED KINGDOM COMPARED WITH THE UNITED STATES OF AMERICA  
AND EUROPEAN COUNTRIES (BASED ON 1959 FIGURES)

	United Kingdom <sup>(a)</sup>	United States of America	European countries <sup>(b)</sup>
Number of notes in circulation per head of population ... ..	32	19	21
Value of circulation per head (expressed in £)	41	63	73
Average value per note in circulation (expressed in £) ... ..	1.3	3.3	3.5
Number of notes printed per head per year	32	10	9

(a) Figures relate to Bank of England notes only.

(b) Average for: Austria, Belgium, Denmark, Finland, France, the Netherlands, Norway, Spain and Sweden—the choice of these countries has been governed solely by the availability of relevant statistics.