NATIONAL BUREAU OF STANDARDS REPORT

6243

THE RAPID SELECTOR DEVELOPMENT PROGRAM AT THE NATIONAL BUREAU OF STANDARDS

by

Thomas C. Bagg and Sidney Greenwald

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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Data Processing Systems Division

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FOREWORD

The Data Processing Systems Division of the National Bureau of Standards, in connection with its information and document retrieval studies, has undertaken the continuation of development of a microfilm file searching device called the Rapid Selector. This report summarizes the Bureau's work to date on an interim machine, which is the third model in a series of developments which had its origin some 25 years ago.

S. N. Alexander, Chief
Data Processing Systems Division

A. V. Astin
Director

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THE RAPID SELECTOR DEVELOPMENT PROGRAM AT THE NATIONAL BUREAU OF STANDARDS

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Thomas C. Bagg
Sidney Greenwald

I. INTRODUCTION

The Rapid Selector discussed in this report is a document retrieval device based on a principal demonstrated by Dr. Vannevar Bush while at the Massachusetts Institute of Technology during the late 1930's. The machine examines at high speed binary-coded patterns which describe the contents of associated documents. Code and document images are on large reels of 35 mm microfilm which go through the machine at five feet per second or 2400 identified pages per minute. Copies of the documents selected by proper code recognition are copied "on the fly" photographically.

During the 1930's Dr. Bush was asked to develop a machine which would search a file for a particular document or documents containing information on specific subjects. He designed and developed a model of a device which made use of a microfilmed file. A code in the form of black or clear dots identified each document either by number, name, author, or contents. In this machine the code appeared on one half of a 35 mm film and a photographic image of the document on the other half, as shown in Figure 1. As the film passed through the selector, the coded area was projected on a photocell. This photocell was masked by a cutout which was the complement of the projected code being sought. Recognition occurred when no light struck the photocell. This initiated a signal which fired a photographic flash lamp when the selected microfilmed document was in the copying position. The light projected an image of the desired document onto unexposed microfilm which became the output of the Rapid Selector. This preliminary machine was used in a limited way by the Navy during World War II and then was returned to MIT where it is now stored.

Following the War, the Office of Technical Services, Department of Commerce, under the direction of John C. Green, had a second better engineered model made by Engineering Research Associates. Dr. Ralph Shaw of the Department of Agriculture's Library encoded

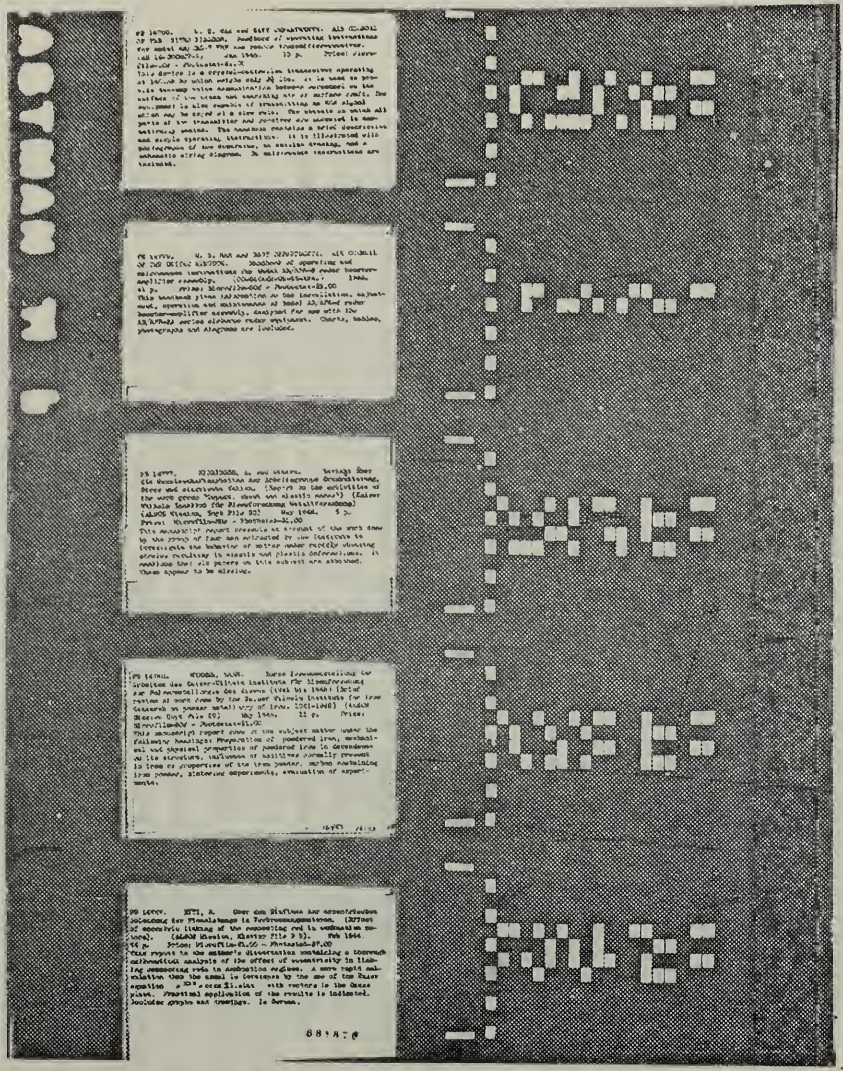

Figure 1. Enlargement of Microfilm Showing Format Used by Bush's Rapid Selector Design

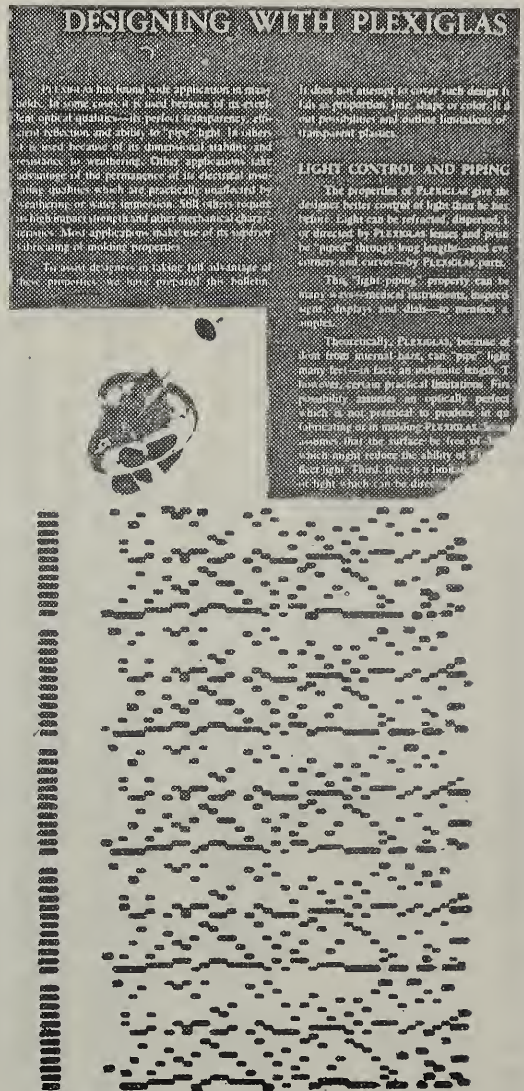

Figure 2. Format of Code and Document Information Used in the Yale University Rapid Selector Development

a group of documents for use with this machine. This selector had code space for 7 decimal characters in the form of 35 black or clear areas (35 bits) and could operate with the film running in either direction.

As did the original machine, the second model used a flash lamp to make the output copies. Successive frames could not be copied rapidly because of the power requirements of the lamp. To overcome this difficulty an anticipator was added to slow down the film when a hit was coming so that the flash unit would be ready to take the next frame if necessary. In operation, certain difficulties were encountered. It was at this point that the National Bureau of Standards was asked to assist in overcoming some of the mechanical troubles. Although most of these difficulties were overcome, the fact that the machine could not copy successive frames without time delays and involved servo systems led to its eventual abandonment. The Patent Office made some further experimental studies before the machine was ultimately turned over to the Smithsonian Institute.

In the early 1950's Yale University undertook the redesign of the selector for use with a large collection of documents which had already been abstracted and coded on IBM cards. Each document required 5 cards or 4800 bits to describe its contents. The new model (No. 3) was required to read far more bits than the previous machines and had to copy successive frames without slowing down. The designers therefore changed the arrangement of the code and documents so that the code area covered the entire film width in 50-bit groups extended along the film as far as required. Five cards worth of bits made a code frame 1 1/4 inches long and thus occupied about the same area as a document image with an 8 to 1 reduction. See Figure 2.

The Yale interrogator read the entire code field simultaneously, using one photocell for each bit desired. The copying of successive documents was achieved by using a conventional continuously lit projection lamp which illuminated the master film as it passed over a slit. The image was focussed onto another slit behind which was unexposed microfilm. The selector controlled the motion of this unexposed film. When a copy was called for, the film was brought up to speed so that a 1 to 1 copy was made. After the necessary copying was finished, the film gate was cleared of exposed film and the machine waited for the next print command.

In addition to using the machine as a document retrieval device Professor Richard Ruggles of the Yale Economics Department demonstrated the use of the device as a statistical machine where only binary information was used on the film. Under such conditions, with a film speed of 5 feet per second, the Rapid Selector could read almost a million bits per minute. Unfortunately, the Yale machine was never completed for operational use.

As part of the cooperative program with the Patent Office, the Data Processing Systems Division at NBS initiated a study to demonstrate the practicality of the Rapid Selector for their use. For this program the Laboratory obtained a portion of the Yale equipment. This report covers the design and development work that has been done since that time. The early part was sponsored by the U.S. Patent Office, while the last year's efforts have been sponsored by the Bureau of Ships, Department of the Navy.

Since many articles have been written on the need for information and/or document retrieval devices as well as the pros and cons of various methods, it is felt unnecessary to discuss them here. It is generally agreed that such devices are necessary and that there will probably be various levels of devices, from very simple inexpensive ten-cent card files to very complex million-dollar search machines of the computer type. The operational requirements of each installation will dictate the type of system needed.

No matter which system is used, multiple access to the file contents is essential. The larger the file the more difficult this becomes. In large files which are used by many people, the integrity or completeness of the file is essential. By this it is meant that if two people need the same material at approximately the same time, the second person does not miss or overlook the material simply because, it is not within the file at the time he makes his search. To minimize or essentially eliminate this difficulty, the file should never be broken. This leads to the conclusion that only copies of the material should be issued to the user.

The Bush type of rapid selector fulfills these requirements. It can search a file rapidly (present speed, 2400 pages per minute), and the file material always remains within the file. When a film reel is in use, there is a blank space in the storage rack indicating that it is in use but will be available within minutes. The output of the selector is processed microfilm, which the searcher can take with him to use as he requires.

The use of photographic images as the storage media permits filing a large variety of documents such as text, maps, drawings, photographs, and charts; and by virtue of the high resolution of photographic film, the bulk volume of the file is greatly reduced over that required by the original documents. In addition, copies of one-of-a-kind or rare documents are available in filmed form, permitting a completeness previously impossible.

Recent advances in the fields of computer circuitry, photography, electromechanical devices, and information handling have permitted new approaches to the design of the rapid selector as proposed by NBS.

The rapid selector development now in progress at NBS is aimed toward a relatively simple machine which will assist in document retrieval either by finding a specific document by number, date, and page, or by finding a document or group of documents whose codes indicate it contains the information desired.

A schematic diagram of the film transport system is shown in Figure 3; a block diagram for a one-word comparator is shown in Figure 4, while Figure 5 is a photograph of the encoder, the device for making the original master films. The operation of the selector by parts is discussed in more detail in the following Sections.

2. THE MASTER FILM FORMAT

The Master Film Format is shown in Figure 6. In the present design the useful film width for documents is 1 inch by whatever length can be photographed. For the usual standard or legal size letter, a 10-to-1 reduction is required. For a 2 1/2 by 3 foot drawing the reduction is 25 to 1. Such reductions are common microfilm sizes and present no problem in the machine for copying on the fly. If the average length of each article on the film were four letter size pages and required only one code area, a 20-to-1 reduction would allow the four pages to appear in the space formerly occupied by a single page and would increase the effective speed of the machine fourfold. Since the details of any specific application have not yet been established, the present format is based on a 15-to-1 reduction for a single page per frame (full width by 1 1/4 inches long).

At present the code frames are 1/4 inch long, containing six rows of 46 bits. Each row is called a machine word and is comprised of 40 information bits and 6 machine control bits. As many code frames can be used as required. The number of bits per word, or bits across the film, is limited by the optical-mechanical tolerance in the original copying camera, the film dimensional stability, the film duplicating equipment, and the film guiding and tracking portions of the selector itself.

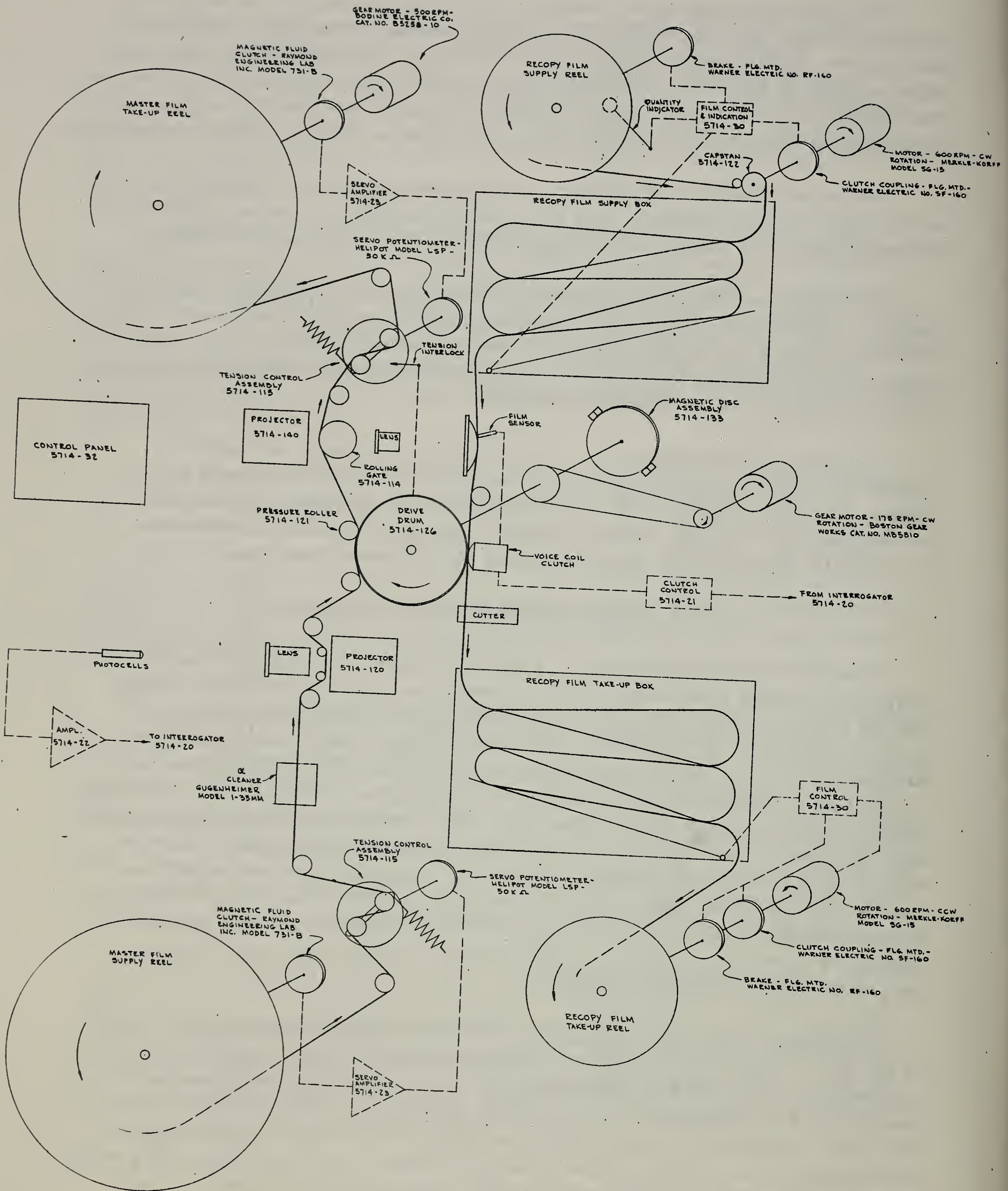

Figure 3. Schematic of the Film Transport System in the Present Model of Rapid Selecto[r]

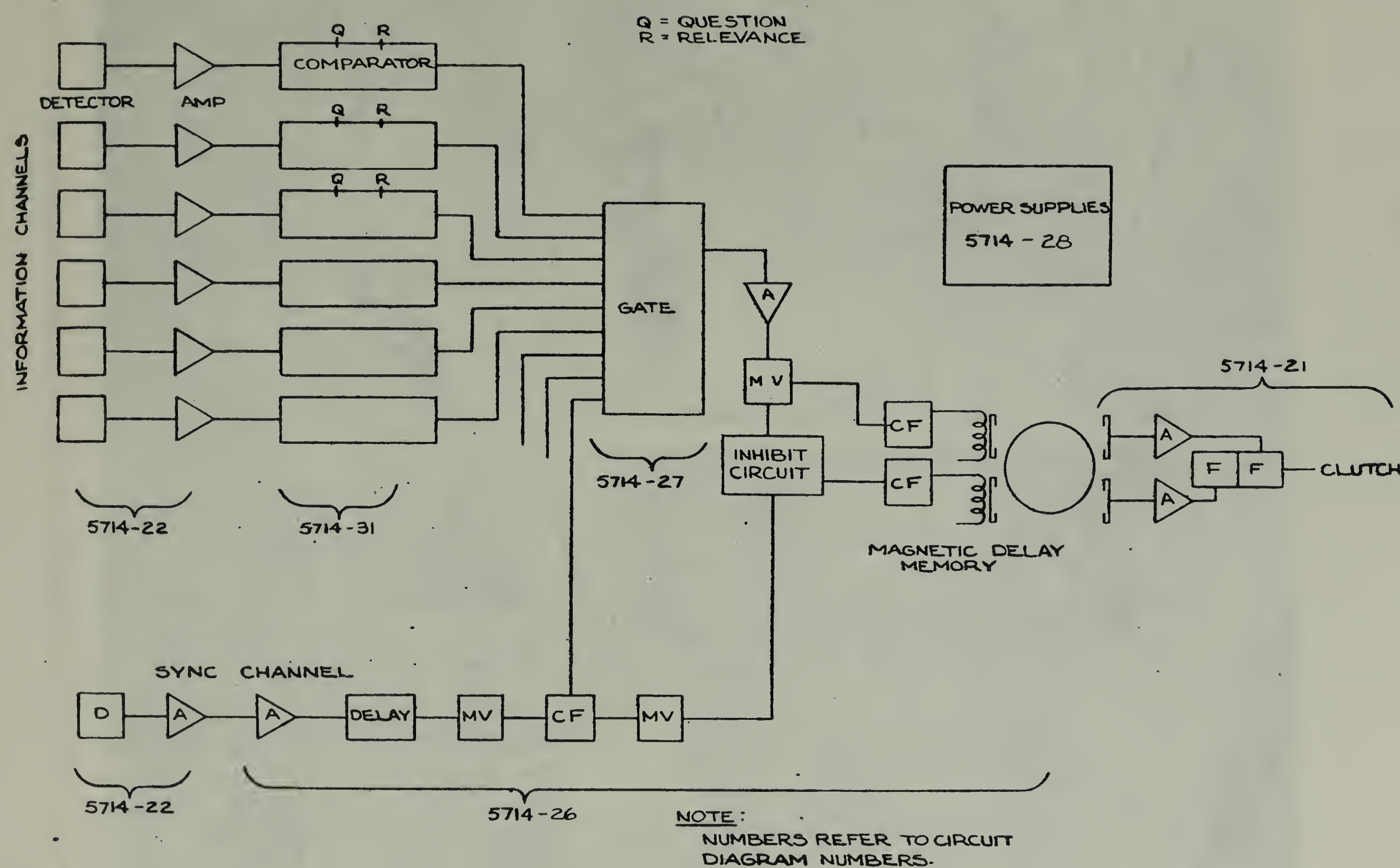

Figure 4. Block Diagram of One-word Comparator in the Present Model of Rapid Selector

Figure 5. The Encoder Presently in Use for Making the Original Master Films

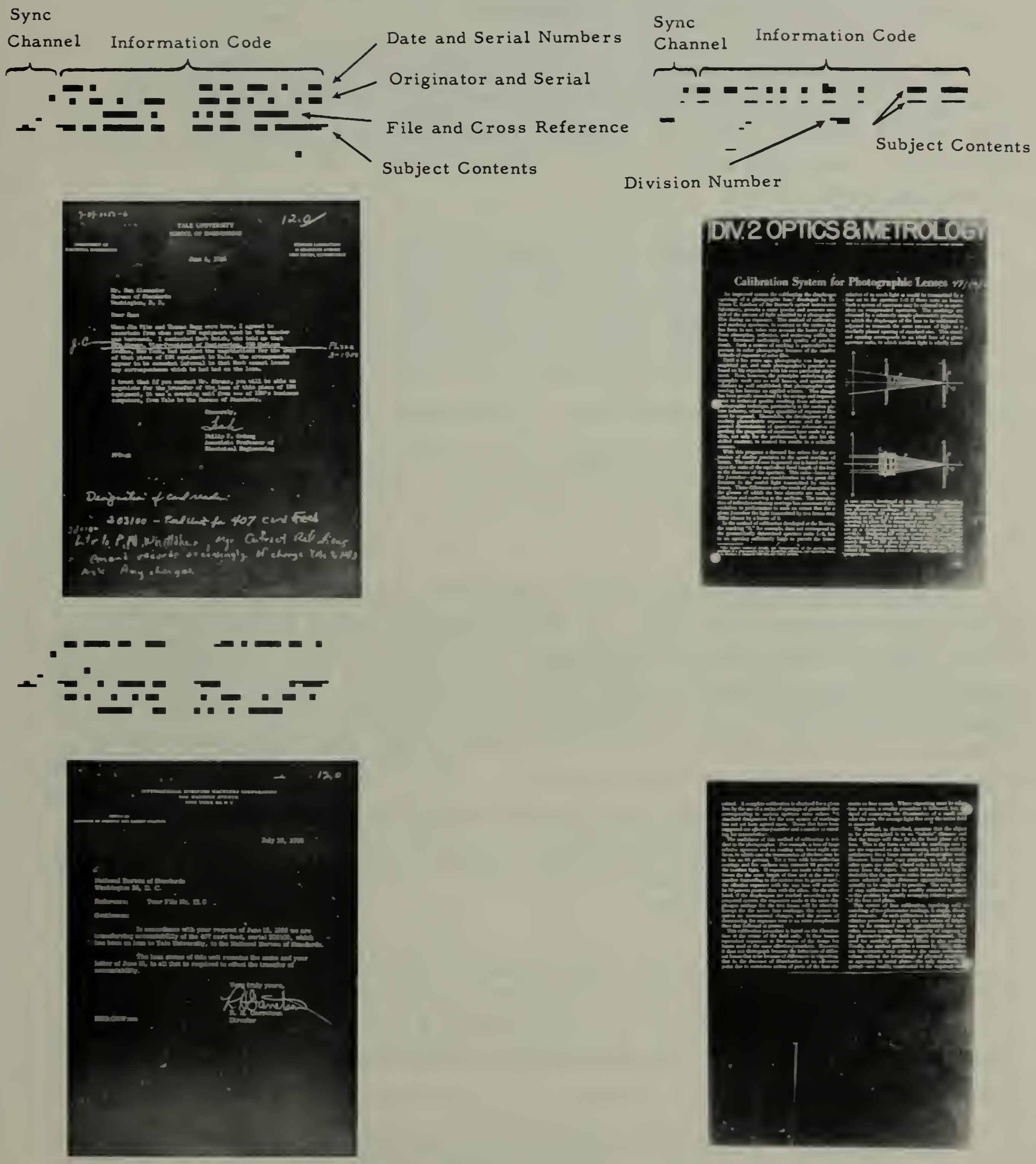

Figure 6. Two Examples of the Presently Used Master Film Format

The present bit size is 0.022 X 0.020 inch, which is magnified eight times in projection to a size 0.172 X 0.160 inch to illuminate an 0.080-inch diameter photo detector. This allows a film tolerance of ±0.005 inch, which seems reasonable.

By modifying the comparator circuits and by controlling film skew in the gate, the 0.020 dimension and the spacing between the code words can be reduced, thereby increasing the code area efficiency, realizing either more code words per unit length or less length per code frame.

With the present electronic system, which is discussed in Section 6, the machine control channel (referred to as the sync channel) must be clear except for the sync bits. This determined the 1 inch width limitation for document frames. For a given application there may be ways of removing or minimizing this restriction thereby allowing the full width for a document frame.

3. FILM EMULSION AND BASES

2.1 Master Film

The master film is that film containing the codes and documents which the machine searches. It must maintain good optical qualities when subjected to severe mechanical wear and stress. In addition the projected images must be opaque in the infra-red as well as the visible region to efficiently use conventional light sources and the small germanium photo detectors. The silver halide and the light-dispersing type images have the required opacity, but the diazo dye images do not. This is unfortunate since direct positive copies can easily be made with diazo dye emulsions, while other types of emulsions make negative copies, thereby requiring two steps instead of one in producing a working master from an original.

The resolution of many photographic emulsions and of the light dispersing bubble or Kalfax emulsions is quite adequate for present Rapid Selector use. Silver dye emulsions are available if greater resolution is required, but such high resolution appears far beyond the present requirements.

The original document copying must be done by the conventional photographic methods using a silver halide emulsion, since no other emulsion is fast enough. This original film can then be edited and amended as required. Such a film represents a great deal of effort and is too valuable to be used as a working film. It becomes the master or security file film. A positive copy is then made from the master file film, which in turn is used to make the working or machine films. If the selector output is to be a negative rather than a positive, the positive copy of the master film can be used as the machine film thereby eliminating one step.

Three types of film base have been studied: (1) monoacetate and diacetate; (2) triacetate; and (3) mylar (cronar) a polyester. The mono/diacetate base is available only with inexpensive photographic emulsion or with a diazo dye emulsion, neither of which is suitable for machine use. In addition, this base has very poor mechanical properties; it is dimensionally unstable, has low tear strength, etc.

Both triacetate and mylar based films have been run many hours through the machine as a master film without difficulty. However, each has some drawbacks. Triacetate is available only with a silver emulsion, while mylar is available only with Kalfax emulsion (diazo bubble process) in 35 mm rolls.

The triacetate permits a better emulsion to base bond, but it does not have the mechanical tear strength of mylar. If the film should catch or start to tear, it may tear along the film length for many feet. It is also more heat sensitive and will take a permanent warp if allowed to remain in a hot projection gate or similar area. Such a warp usually destroys the code alignment.

The mylar is definitely better with respect to tear resistance and can therefore be thinner, thus accommodating 40 to 70 percent more footage in the same volume. However, it cannot be as easily spliced, and it has a tendency to stretch. This is usually in a length-wise direction, which does not affect the code alignment as a rule. On occasion, if one side only stretches, the code field will be skewed beyond use. Stretching difficulties appear most often in the original processing. Emulsion bonding to mylar is very difficult, and some trouble has been experienced where the emulsion peeled or flaked off the base. The photographic film suppliers have indicated that the emulsion-to-base bonding problem is one reason why silver emulsion on mylar as roll film is not yet available.

No study has been made of the various film protective coatings in the market. Lubricants might be helpful but would cause serious difficulties with recopy film acceleration. Cleaning is necessary. Chlorothene is an excellent cleaner, and is inexpensive and available in bulk. Prepared cleaners with antistatic additives are probably helpful but much more expensive. Several emulsion hardeners are claimed to have excellent potentialities, but have not been fully tested.

During operation, tremendous electric fields are developed by static charges developed as the film unwinds from the supply reel or as it passes through the transport system. These charges attract all sorts of dirt and dust which scratches and wears the film, and when it occurs in the code area creates spurious signals. To destroy these fields a radioactive cleaning device is used which is a combination of a polonium alpha source to remove the charges and camels' hair brushes to remove the dirt and dust. An air stream impinging on the brushes is recommended. Periodic thorough cleaning as a part of the rewinding operation should be incorporated as a part of the maintenance program.

Conventional photographic processing equipment is very good in maintaining transverse alignment of the silver emulsion films. The Kalfax equipment is new and may require further adjustment. The complete dry processing of Kalfax is a big advantage and may permit the addition of new document or file material into the working films.

A mylar base film appears best under present conditions for the master film. The normal 2,000 foot reel will hold approximately 3,000 feet or 24,000 pages of 4 mil mylar, while the large 19-inch reel will hold 4,000 feet or 32,000 pages of documents. The film manufactures believe that 2 mil mylar material is adequate for the base. If so the reels would hold twice as many document images.

2.2 Copy Film

The output of the machine is a microfilm copy of the desired information. This film must have reasonable strength since it is subjected to a high acceleration for every document it is called upon to copy. The emulsion should have good resolution and be photographically fast. Only the silver halide emulsions are fast enough. Fortunately, regular microfilm meets these requirements.

4. FILM TRANSPORT SYSTEM

The path of the master and recopy films are shown in Figure 3. On this interim development model both films are driven by a single drive drum. The master film runs continuously at a uniform velocity, while the recopy film is brought up to speed suddenly by the clutch when copying is required. The drive drum controls the velocity of both films so exact copies can be made.

The drive surface consists of two rings or tires, each 1/8-inch wide, which touch the films only on the outer edges where there is no information. Thus the films, particularly the master film, are not scratched or damaged by dirt and dust being imbedded into the emulsion. As seen in Figure 3, the master film is wrapped about the drum for 90° and held by a pressure roller, giving good positive drive.

Acceleration of the recopy film presents some problems. If film wrap-around is used, some method of holding it away from the drum is required when film motion is not desired. With a drum using two rubber rings, mechanical fingers between the tires are possible but here there is a tendency to scratch the soft emulsion surface. Vacuum plates behind the film or air jets under the film are also possible ways of keeping the film away from the drive drum except when required.

The ERA machine was designed to operate without wrap by using a strong speaker type magnet clutch which had a highly polished surface pressing the film against the drum drive. This surface had very little friction while the rubber tires had a considerable amount of drag. This method of recopy film drive is the least complicated and is satisfactory with careful use.

The polished contact surface of the clutch must have a hard coating with a micro-polish (chrome-plated phosphor br nze). A small defect will collect emulsion dust or bits of base material which build up so that it scratches the film. This material gets hot as the film passes over it and changes into a very hard substance which collects more material, slows down the film, and gouges deep grooves. Highly polished chrome surfaces work well.

The biggest problem with a non-wrap type drive is getting enough friction between the drum surface and the film. The force is proportional to the area times the coefficient of friction times the pressure. The pressure is limited to that developed by the magnetic clutch. Space considerations limit the field coil size and inertia limits the size and weight of the movable coil. With the present design using 135 ma (limited by heating) in the field and 300 ma in the coil, 18 oz. pressure is developed. The effective driving area is limited by that resulting from the indentation of the film into the drive drum rubber by the pressure head of the clutch.

So far only solid (not foamed) rubber with a durometer hardness of about 40 has been used. A softer rubber would give more indentation and thereby a larger area to increase the clutch effectiveness. However, the clutch would have to travel further which is not easily achieved. So far the biggest problem has been with the variation in the coefficient of friction of rubber to the film. A clear natural unfilled rubber surface accelerated the film excellently, but most rubbers tend to glaze or become coated with dirt and emulsion dust which greatly reduce the coefficient of friction. The present tires made of Buna N "O" rings contain a large amount of carbon black fill and require frequent cleaning. Tires made of a nonloading rubber developed for microfilm transport systems are being procured.

The present clutch will accelerate and maintain the recopy film at full velocity (5 ft/sec) in 3 milliseconds when the tires are clean. The amount of film passing through the gate during this period is about equal to that required to get unexposed film into the copying position. The distance between the projection gate and the copying gate is so large, that this acceleration time is negligible.

Control of the master film is critical when it is passing through the gates. Good alignment in the projection gate is necessary for proper code recognition, and the film must be flat in the copy gate to give clear undistorted copy. Sapphire guides are used in the projection gate to keep the film in transverse alignment.

The master film supply and take-up reels are controlled by a servo system to maintain uniform tension on the master film while it is in the gates. This servo system is controlled by tension arms connected to voltage dividers. The output of these dividers is amplified and used to control the coupling in a magnetic brake on the supply reel and a clutch on the take-up reel. Tension in the film gates is maintained at 4 1/2 pounds.

It is very important to keep the film clean since dirt in the signal channel may act as a sync bit and either give a false reading or stop a copying run before it is finished. Good practice would dictate that the area in which the machine is operated and the film storage are should have filtered air maintained at about 50% relative humidity. As film unrolls from the supply reel, static charges are built up on the film which attract dust and dirt strongly. It has been found necessary to use at least one radioactive cleaning device (as previously described) prior to the film passing into the projection gate. There is an interlock on the master film which automatically shuts the machine down if the film breaks or runs out.

The recopy film path is straight-forward, as shown in Figure 3. The boxes in which the copy film accordions are low-inertia storage and take-up reservoirs which permit the film to be accelerated with a minimum of force. The quantity of film in each box is controlled by a weight-sensing lever arm which starts and stops the supply capstan or take-up reel.

The cutter permits removing small quantities of exposed film as needed. Several extra feet of film should be run through by pressing the clutch control while the drive drum is running before cutting film. This leader serves as a light shield about the exposed roll when it is taken to the dark room for processing.

It has been proposed that a processor be eventually incorporated into the space now occupied by the take-up reel. There is an indicator on the recopy film supply reel which shows the amount of raw film available without opening the case. To protect the drum and clutch surfaces there is an interlock on the copy film which will cut off this clutch when no film is present.

5. OPTICS

As pointed out earlier, the code is magnified eight times when projected onto the photocells. A lens with the longest focal length convenient should be used since the angle subtended by the photocells decreases as the focal length increases. The field illumination is more uniform with smaller angles, since it is proportional to the fourth power of the cosine. Unless the photocells are mounted well outside the main housing a 35 mm lens is about as large as possible. For good signal-to-noise ratio, 250 foot-candles of tungsten illumination should reach the photo detectors.

The photo detector used is an RCA 7223 germanium photo diode which has a peak sensitivity at 1.5 μs. As shown in the Figure 7, this detector efficiently uses the tungsten radiation. Ordinary glass or pyrex optics transmits the usable radiation; however, heat-absorbing glass, which is frequently used in projectors, passes visible light but attenuates the infrared radiation. Such glass reduces the effectiveness of the system 80 to 85% and therefore should not be used with germanium photo detectors.

Since more infrared radiation is absorbed by the glass optics and film without the heat filter, it is important to maintain good air circulation about the lenses, the film gate, and the source. An interlock control turns off the lights if the film should stop.

The recopy camera optics are more critical in that as much detail as possible is wanted on the recopy film. Here a 50 mm enlarging lens which is designed for copying is used. The light source for the recopy camera need not be as intense as that for the code projection and can make use of heat filters. However, good cooling of the optics and film gate is essential.

In the recopy camera the information is copied on the fly. To minimize distortions over the field a narrow 0.020-inch slit is used. Care must also be taken to keep the recopy side of the machine light tight. Even a small hole can overexpose the recopy film while it is waiting to be used or processed.

6. IDENTIFICATION CIRCUITRY

The circuitry used at present is for the identification of single 40-bit words. Figure 4 is a block diagram of the circuit used. The signals derived by photo detectors are positive pulses for black dots representing bits, which are amplified and fed into a comparator that has independently controlled channels for each bit. The operator determines whether a bit is to be present or absent, or if its presence makes any difference (a condition referred to hereafter as relevant or irrelevant). A master and-gate summarizes the 40 comparator channel outputs.

To indicate the time when code information is to be read as distinguished from the signals generated by other codes or the black and white nature of the documents, a sync pulse is used which is in a clear track between the working edge of the film and one edge of the document. This pulse is amplified, shaped and delayed to form a 60-microsecond

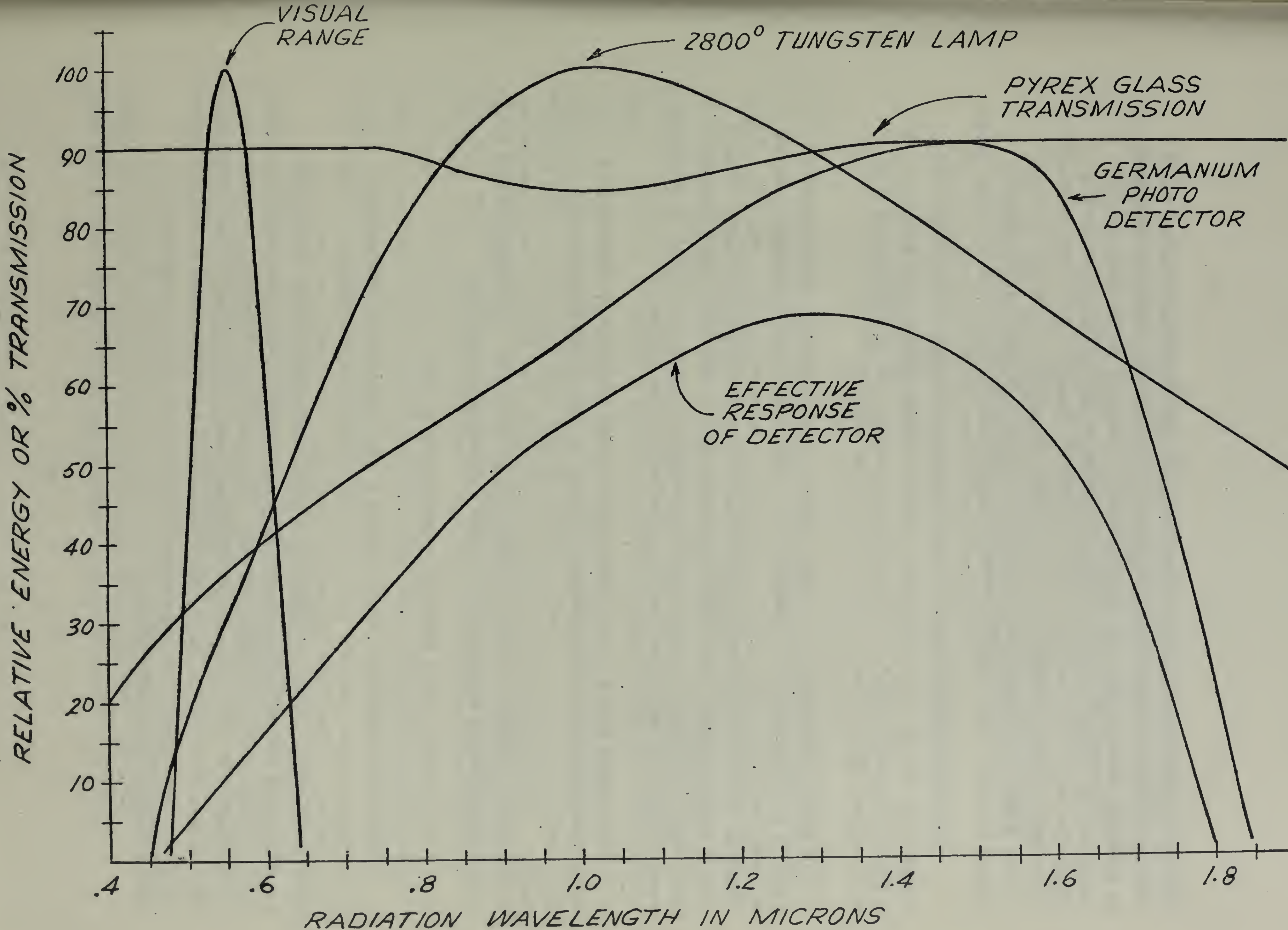

Figure 7. Spectral Characteristics of Code Projection Optics

square pulse which appears at the master gate approximately in the center of the 300-microsecond pulses from the information channels. In addition to entering the master gate, the sync pulse is further delayed and shaped before it passes through an inhibit circuit to a magnetic pick-up head as a "stop" pulse to control the clutch. If all the proper signals from the comparator channels reach the and-gate it will generate a pulse which goes to a clutch control head (print pulse) and into the inhibit circuit where it blocks the sync or stop pulse.

The recopy film clutch is controlled by a bistable flip-flop which turns it on or off. The flip-flop changes state only by the presence of a print or a stop pulse. It is turned on until told to turn off so that any number of documents in a row can be copied.

A delay mechanism for the clutch control signals is required since a given spot on the master film does not reach the copy camera station for some time after it passes the code recognition station. This delay is achieved by using a small two-channel magnetic drum. Mechanical adjustments of the pick-up head control the delay time and the copy time so that no recopy film containing data sits in front of the copy camera slit and becomes overexposed when not in use.

Only some parts of the circuitry for the laboratory model have been transistorized. Preliminary work on other parts has been initiated and may be proved out for incorporation in a copy of the interim model. Transistorized circuitry is advantageous in that much less heat is generated and the power demands are lessened. In addition less space is required which makes for a more convenient machine.

7. PREPARATION OF MASTER FILM

Since documents are selected by a code pattern it makes no difference to the machine what the code pattern symbolizes. It has been stated earlier that it could represent a document number or a series of words which identify the subject contents of the documents. To date, one set of documents has been encoded for use on the selector and a second set is in preparation. First the NBS Technical News Bulletins for a 10-year period were encoded to demonstrate the variety of matter usable with the Selector. A sample lot of correspondence from the Bureau of Ships correspondence file is now being prepared for experimental demonstrations.

For each set of documents several code patterns are used. For the TNB, the code is composed of a numerical code representing the originating division plus a subject contents code. In the case of the correspondence file, there are eight identifying words for each piece of correspondence. They are as follows:

(1) The Bureau of Ships'serial number or accession number.
(2) The date on the piece of correspondence.
(3), (4) The originator and his serial number.
(5), (6) The Bureau of Ships'code or file number and possibly a cross reference number.
(7) The directive number.
(8) A subject contents code.

With the exception of the subject contents code, all of the identifiers used are or can be represented by numbers which give a unique code pattern.

Many schemes have been suggested for subject codes. For demonstration purposes for which it was desired to keep the code field to a minimum, the superimposed random coding scheme originated by Calvin Mooers, Zator Company, was selected. Thus, for a field of 40 bits, seven terms can be used to describe the documents contents. The seven terms are chosen from a list of terms compiled by the document analyst. Each term is chosen from the list in anticipation that a questioner would use it in searching for information.

In analyzing 900 TNB's about 250 terms were found satisfactory. Figure 8 is the list of terms used. The terms have been arranged in the word list by generalized groups to assist the user in locating those he needs. Since many subjects are covered in the TNB, it was found useful to set up a group called Fields. The descriptors for each document should contain at least one of these terms. Each question should also contain at least one of the field terms.

The numbers following each term are chosen from a random numbers table. A document code is formed by collecting together the numbers associated with the seven descriptive terms. Questions to the file are formulated in the same manner. A document satisfies the question if its codes contain all the numbers in the question.

After all of the codes have been assigned for each document, it is found convenient to punch them into cards or paper tape which then controls a code pattern generator used in making the master film.

DESCRIPTIVE TERMS USED TO DESCRIBE ARTICLES IN NBS TECHNICAL NEWS BULLETIN
FOR USE ON RAPID SELECTOR

FIELD

Acoustics 4-28-46-56
Astronomy 8-44-48-76
Aviation 2-48-52-62
Bio., Dent., Med. 6-16-30-60
Building Technology 36-50-60-68
Chart, Code, Table 12-16-72-78
Coatings 18-28-66-76
Component 10-20-36-48
Computer and Data Handling 2-6-24-40
Device 24-56-68-80
Electrochemistry 8-42-72-78
Electromagnetic Radiation 14-28-48-58
Electronic Technology 28-50-60-74
Fluid Mechanics
  Aeromechanics 18-32-60-64
  Hydromechanics 18-36-68-72
Generator 14-20-26-32
Heat and Cryogenics 4-12-26-42
Instrument 34-66-66-76
Materials 20-48-58-62
Mathematics and Statistics 12-26-36-72
Measurement 8-40-54-58
Metallurgy
  Ferrous 34-48-70-80
  Non-ferrous 18-36-44-75
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Counter 20-34-38-44
Crucible 12-60-76-78
Electron 30-32-52-80
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Cesium 4-42-48-50
Chromium 16-22-24-62
Cobalt 6-60-66-74
Columbium 36-40-60-72
Copper 14-64-76-80
Flourine 4-6-20-36
Germanium 20-26-38-76
Helium 38-40-42-60
Hydrogen 4-44-66-72
Iodine 12-32-36-40
Iron 40-68-72-80
Lead 12-22-56-70
Magnesium 4-8-28-68
Manganese 16-44-64-76
Mercury 8-14-24-48
Molybdenum 20-24-56-66
Nickel 6-14-18-28
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Sodium 12-48-52-64
Strontium 8-10-12-18
Sulfur 6-22-56-72
Technetium 36-42-44-52
Tin 20-38-46-64
Titanium 24-32-36-70
Uranium 2-40-72-80
Zinc 20-34-48-78
Zirconium 4-6-34-44

Figure 8. Descriptive Terms Used for Coding the TNB's

Conventional machines are available e. g., Flexowriter, card punch, etc. to produce a machine readable code. By use of cards and tape the code can be verified before the data are photographed. The present input equipment uses an IBM 407 card reader. See Figure 5.

The original film making device consists of a camera, a card reader, a control unit and a bank of lights, as shown in Figure 5. The camera is set up over a glass-topped table with the bank of lights beneath the table top. There are 1,200 lights in the bank arranged in 24 rows of 50 each. Of these 960 are connected to contacts in the card reader, one for each possible card hole. The remaining lights are provided for adding machine control information (sync pulses).

When a push button in the control panel is operated, a card is automatically fed into the reader, the lights for each hole punched in the card come on, and a picture is taken by the camera. This is repeated for each document depending upon the number of cards required for its entire code. Another switch is used to turn on photo flood lights and set the camera for photographing the document. The picture taking is then achieved by pushing the control button once for each page of documentation.

As pointed out earlier, this original film is edited, spliced and kept as a security file. With the presently available techniques, a positive copy is necessary from which as many machine masters are made as required.

Figure 9 is a reproduction of a piece of recopy film. This particular frame was selected by subject from the master film and copied on the fly. The dark bands on either end on the document are due to overexposure of the film while in the recopy gate waiting for print commands. The timing of the print and stop pulses is such that no desired information becomes obliterated. The time required to move fresh film into place is about equal to the interval required to get the recopy film up to full copying speed or to stop it.

8. FUTURE WORK

Experiences in demonstrating the laboratory unit have revealed many details that can and should be improved or redesigned. Many presently obvious minor improvements have been incorporated into the drawings from which an interim machine will be constructed. Equally obvious major changes which can not be incorporated into the design of the Selector until they had been proved reliable have been deferred to the next development phase.

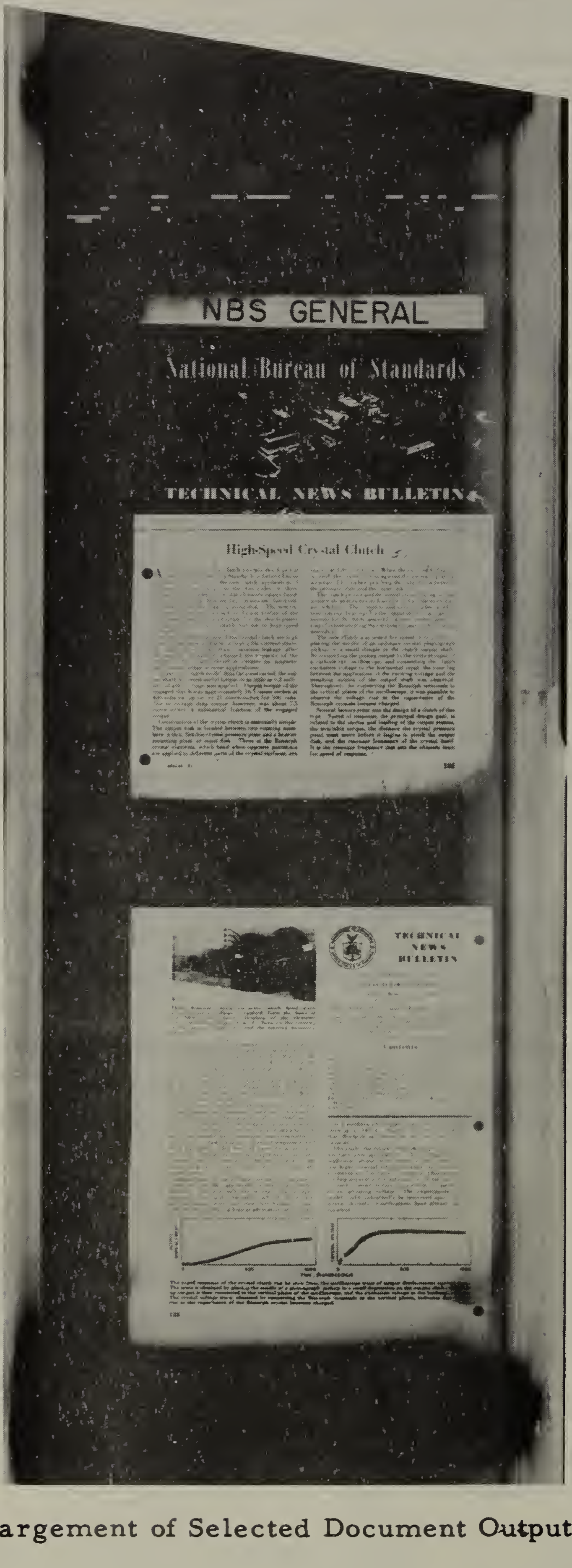

Figure 9. Enlargement of Selected Document Output of Rapid Selector

Some consideration has also been given to the problems of simplifying the film path and eliminating many of the present moving parts. In anticipation of undertaking a major redesign of the Rapid Selector, the following items are under serious considerations:

a. How to increase the life of the master film.
b. How to increase the search rate (primarily by increased speed).
c. How to provide for film movement in both directions.
d. How to simplify the film transport system and thereby the cost.
e. How to utilize magnetic material to permit indexing information of a variable sort which must be regularly updated.
f. How to provide direct hard copy output and thus eliminate the recopy film strip.
g. How to incorporate the machine into a large search computer system.
h. Addition of a film processor to automatically process the recopy film for immediate issuance.

The electronic controls must be increased to provide for reading and handling more than one word per frame and for searching for answers to multiple questions. A "logical" unit should be added so that more complex questions can be asked, e.g., to find all correspondence between certain dates from a particular individual about a specific subject.

Portions of the electronics have already been transistorized, and plans have been made to transistorize all of it in the next phase of development. Packaged circuitry will be used if commercially available.

As soon as an adequate file and retrieval system has been designed, it would be a natural next step to consider immediate improvement of the input preparation equipment. This will involve design of an encoder and translator to go directly from descriptive terms to codes concurrently with the preparation of the camera controlling punch cards or tapes.

U. S. DEPARTMENT OF COMMERCE
Lewis L. Strauss, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

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