AN ABSTRACT OF THE THESIS OF

JULIE LATHAM VINCENT for the M. S.
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Title: AN ECONOMIC COMPARISON OF HOT METAL AND COLD TYPE COMPOSITION OF DISPLAY ADVERTISING

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William Engesser

The objective of this thesis is to examine and compare hot metal and cold type production of display advertising for newspapers. The classical hot metal system uses a lead alloy as its basic building material while modern cold type production uses photographic means. Some advantages of using cold type are the improved quality of the final product, increased versatility in ad composition, possibilities for major labor savings, the lower skills required for the compositor and less production space required for the machinery. Some disadvantages of cold type production are the major investment required for new equipment, higher materials costs, difficulty in producing proofs, labor relations and retraining difficulties, and the durability of the press plates.

The data for the hot metal method consisted of a sample of 195 ads. The eight major operations studied were Markup Time, Type Slips Time, Stereotype Time, Typesetting Time, Composing

Time, Proof Pulling Time, and Correction Time. Thirty-seven factors, such as the size of the ad and the number of lines of type, were hypothesized to effect the operation times. These operation times and factors were analyzed by multiple linear regression analysis to formulate a mathematical model of the hot metal system. For this cold type system, circumstances prevented making a complete model but data for a sample of 15 ads was collected.

The data for the sample of cold type ads was used in the hot metal regression model to determine comparable times for production of the ads by both systems. Experimental results showed that it would take three times as long to compose the ads by hot metal. When combined labor and materials costs are considered, hot metal costs 1.6 to 2.8 times as much as cold type depending on the wage rates considered and the relative productive efficiency of both plants. Administrative and most overhead costs were considered to remain constant no matter what production system was used. The depreciation rate for the cold type operations is 3.06 times that of the hot metal system studied.

Recommendations for further study include:

1. Reevaluate hot metal regression model using transformations in order to reduce non-linearities.
2. Reformulate the cold type system so that equivalent production work can be measured to produce a cold type

regression model.

3. Extend the study of cold type and hot metal into news and classified production.

4. Use the complex regression models to determine major variables so that simplified models could easily be prepared by any interested newspaper.

5. Determine realistic cost comparisons including the effects of unequal depreciation rates, taxes, and interest.

6. Produce a companion study of the social effects of a transition from hot metal to cold type in order to be able to project actual benefits derived from the transition.

An Economic Comparison of Hot Metal and Cold Type Composition of Display Advertising

by

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Professor of Industrial Engineering
in charge of major

Redacted for privacy

Head of Department of Mechanical and Industrial Engineering

Redacted for privacy

Dean of Graduate School

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INTRODUCTION

Printing is the major method of successfully publishing most of the information utilized in the world today. The publication system is composed of an input which is information provided by some author, an operation which has a multiplier effect, and an output which is the original information in a durable form adapted to enable mass distribution (1, p. 1). This paper deals with one segment of the newspaper publication system, the sub-system of display advertising. Display advertising is defined in this study as all advertising found in a newspaper with the exceptions of classified or "want" ads and legal advertisements such as "Notice to Creditors."

A complete model of the hot metal production system has been prepared by the multiple regression analysis technique. Selected ads prepared by cold type composition are compared to the hot metal model. This presentation includes a discussion of the multiple regression analysis technique, the resultant hot metal model, conclusions, and suggestions for further study.

This study investigates the transformation of the input copy from the advertising salesman into the output product as it is ready to be printed. The two production methods to be studied are hot metal and cold type composition. The following descriptions of the hot metal and cold type systems are based on observations made of the two newspapers primarily involved in this study. The Corvallis Gazette-Times was used as an example of the hot metal system and the Albany Democrat Herald was used as an example of the cold type system. Some variations in procedures or delegation of responsibilities might be observed if other newspapers were studied; however, the basic composition functions remain constant.

Hot Metal Composition

Hot metal composition is the "classical" method of composing a newspaper. The term "hot metal" applies to the molten lead alloy (5% tin, 12% antimony) which is the basic material used in construction of the page form.

The display advertising salesman prepares a layout of the ad on a piece of paper with pre-printed columns and inch-length marks. The copy is either typed on the layout, hand-written, or typed on separate sheets. The illustrations for the ad are usually selected from one of a number of sources. The illustrations may be anything from art work, pictures, or advertising service books. These books have pictures of anything from an Easter bunny to a head of lettuce, including a variety of special borders and appropriate seasonal headings such as "Spring Fling" and "Christmas Special." Corresponding to each picture or "slick" in the book there is a heavy cardboard sheet called a mat. These mats are used as the mold for the molten lead to produce a cast for the illustration. The layout with the desired illustrations noted is sent to the dispatch department where the corresponding mats are obtained and placed in an envelope. Customers that regularly run ads may also have a signature block or "sig" that is sort of a trademark for their store. These sigs are placed in the envelope with the mats. It is from this point that the data for this study was collected.

The first step in the actual composition is called markup. The markup man checks the cuts and mats in the envelope against the layout. He then marks the type styles, sizes, and the length of the lines. If the copy is hand written and the markup man feels that it is not easy enough to read, he may send the copy back to the dispatch department to have it typed. He may also have it typed if there is a great deal of copy of different sizes so that he can distribute the copy among several machines. The typed copy would then be returned to the markup man for more markup.

The mats are then sent to the flat casting division of the stereotype department. In this step, the mats are prepared for casting by cutting them to the desired size and taping out any undesirable lines. The cast is made by pouring the molten lead against the mat in a casting box. When the cast has solidified it is planed and cut

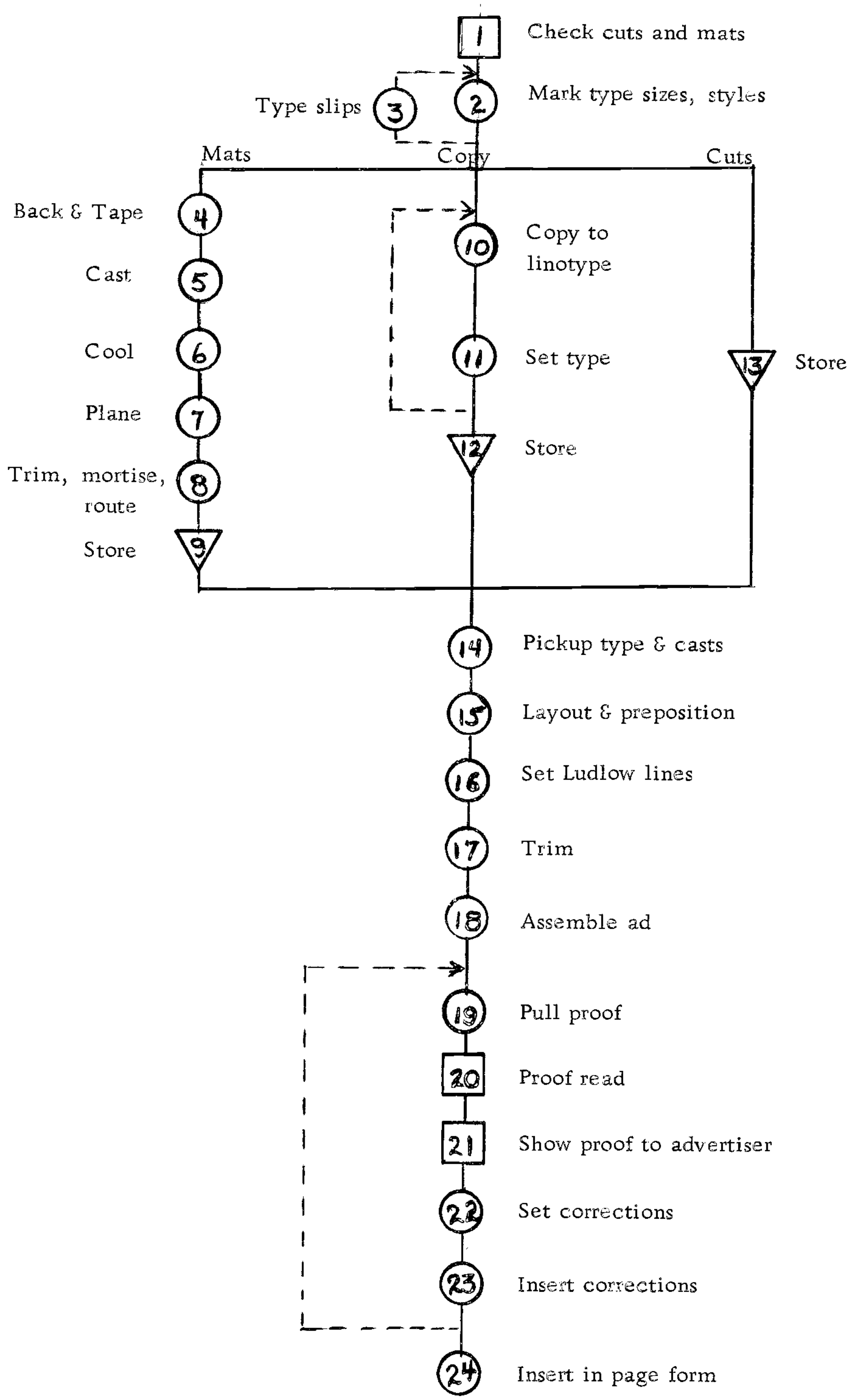

Figure 1. Partial flow chart for hot metal system.

to the size and shape prescribed by the layout.

In the meantime the copy to be set is distributed among the linotypes. Each machine contains a certain number of type sizes and type faces. If only one copy is available and more than one linotype is required to set the type, the copy is given to the first machine and the operator sets all his type face copy and then passes the copy to the next operator.

The next step is to collect all the components set by the linotype, the cuts and the casts made in the stereotype department. The flat casts and some type may be prepositioned on the page form. The compositor works from the layout prepared by the display salesman to arrange the type and illustrations. The larger lines that have to be hand set are set on the Ludlow machine. These lines may need to be trimmed or sawed to fit the space allowed. The type from the linotypes is set on "slugs" or a metal base by the machine. Since the casts are not on a base material either a plastic or metal base must be used to mount the cast or engraving.

When the ad is constructed it is taken to a proof press where the metal is inked, a sheet of paper is laid over it, and the impression printed on the paper. This proof is sent to the proofreaders to be checked against the original copy for errors. Errors are marked by the proofreader and the proof may be returned directly to the composing room or may be taken to the advertiser for his approval or for him to make any changes.

When the proof is returned any lines that need to be corrected are reset on the linotype or Ludlow and put in the ad in place of the erroneous lines. If a great many mistakes were made or major changes are to take place, a revised proof of the ad may be pulled. The corrected ad is then ready to be placed in the page chase along with the news and other features. From the flat page form a mat is made which is, in turn, placed on a cylindrical casting box and a cylindrical press plate is cast for the rotary press.

In the case of hot metal composition, all the metal type from the linotypes and Ludlow and in the flat casts and press plates is reversed. It therefore takes some skill to be able to make corrections since the type cannot be read directly.

Cold Type Composition

In the 17 years since the installation of the first commercial phototypesetting machine, the method of cold type composition has finally risen to the attention of newspaper publishers (3, p. 2). Some of the greatest benefits of cold type composition are derived in the display advertising area.

The display salesman prepares the layout of the ad in a slightly different manner. The layout is of a heavier paper than the hot metal composition layout because this paper usually ends up in the page form. The copy is either typed on a separate sheet or hand written in a blue non-reproducing pen. The salesman also has the option of making hand-lettered finished copy for an advertiser. Also any original artwork might be directly put on the layout. It is therefore conceivable that an ad will never enter the "production" phase of the system under study.

In the case of hot metal, the illustrations were selected from available mats. In cold type, the same books of illustrations are available but there is no longer a need for the mats. This in itself saves considerable storage space. The salesman will normally preposition the slicks on the layout. In hot metal composition the salesman would indicate a border by a heavy black felt pen mark. In cold type composition the salesman may choose the border he wants and put it on the layout. A variety of borders are available in the form of an adhesive tape much like Scotch Tape which varies in width and style.

After the salesman completes the preliminary work, the layout is sent to the phototypesetting machine. In this particular plant there is no markup as a distinct operation. The typesetter figures the line length and selects the appropriate type sizes and faces to fill the copy.

In hot metal typesetting a casting mat is dropped for each letter stroked on the keyboard and a cast is made of the full line. In cold type typesetting a picture is made of each character as it rotates on

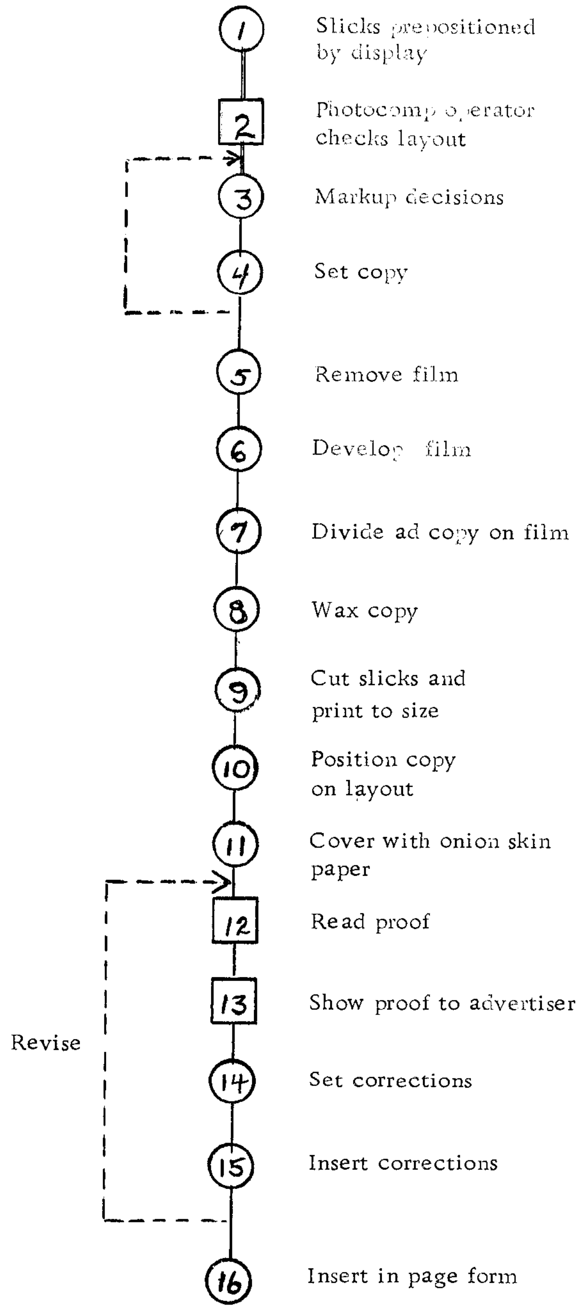

Figure 2. Partial flow chart for cold type system.

a disk and the image is flashed on photographic film. The size of the letter is determined by the lens arrangement used. When a number of lines have been set, approximately three to five feet of film, the film is removed from the machine and taken into the dark room to be developed. The type is then produced on a glossy white paper ready for composition.

Cold metal composition is called paste up. The copy is run through a waxing machine. The paste up girl cuts out the correct copy and places it in a position according to the layout. After the ad is assembled it is rolled with a rubber hand roller to secure the position of all copy. The ad is covered with an onion skin sheet used for marking corrections. The ad layout is read or checked against the original copy if it is available. The corrections are marked on the covering tissue. This tissue also acts as a protective shield if the layout is shown to the advertiser.

Any corrections are set on the phototypesetting machine. In hot metal composition when an error is made in a word, the whole line must be reset because it is set on a slug. In cold type only the word need be reset because it can be cut out and pasted over the incorrect item. Of course if the error affects the spacing the line would have to be reset.

After the corrections have been made, the ad is placed on the page form with the news and other features. From this page form a negative is made. Any flaws or dirty marks may be opaqued. This negative is then placed over a flexible, light-sensitized metal press plate and exposed to strong light. The press plate image is developed and lacquered and the plate is ready for the press.

In the case of cold type composition, all the copy on the layout and in the page and on the press plate are right-reading as opposed to the reversed image of hot metal type.

One point should be clarified before looking at the advantages and disadvantages of cold type composition. The previous sections have described the two methods of composition, hot metal and cold type. Correspondingly there are two types of presses, the letter-press which uses the reverse image plates of hot metal composition and the offset press which uses the right-reading photographically produced plates. It is possible to use cold type composition with a letterpress if a metal engraving is made. This process is the same as that used in producing photographs in the hot metal operation. Some papers use this method for ad production.

Value of Cold Type

There are several questions to consider in an examination of the value of cold type composition:

1. How many papers are using photocomposition?
2. To what extent is cold type used, for all composition or

just for advertising?

3. What are the relative advantages and disadvantages of cold type?

An answer to the question of how many papers use photocomposition was reported by C. Norton Grubb in a July, 1967 publication. He quoted a reliable trade press survey that found approximately 290 daily newspapers and more than one-third of all weekly newspapers (approximately 2700) are printed by offset. A projected 500 more newspapers will shift to offset in the next five years (11, p. 2). Another article quoted a Wall Street Journal item as saying that 325 of the nation's 1750 daily newspapers make some use of cold type composition, up from about 125 in 1964 (21, p. 4). A wider study presents figures of 1859 photo units and 1095 separate special-purpose phototypesetter keyboards in use throughout the world. Seventy percent of these units are in the United States (3, p. 1).

The second question, "To what extent is cold type used.... ?" may be answered by looking at several examples. The Portland Oregonian is now using photocomposing and engraving for their advertising composition. They found that they saved enough manpower using Photon composition to more than pay for the relatively high engraving costs of the final copy. The Oregonian claims 40% more efficient production of advertising (13, p. 133). The Alameda Times-Star started printing offset in 1963 but returned to setting hot metal for straight matter in 1965. They found costs of reproducing newsmatter on film paper too expensive (13, p. 79). Many newspapers have found the cold type composition and engraving combination an excellent method of gaining variety in ad composition.

The biggest question to deal with is the relative advantages and disadvantages of cold type composition and offset production. A partial list of advantages and disadvantages points out some factors of interest.

Advantages of Cold Type Composition:

1. Improved quality of final product.
2. Increased versatility in ad composition.
3. Major labor savings attainable.
4. Lower skill level required for compositor.
5. Requires less production space.

Disadvantages of Cold Type Composition:

1. Major investment in new equipment required.
2. Increased materials cost.
3. Difficult to produce proofs.
4. Labor relations and retraining difficulties.
5. Durability of press plates.

The advantage of quality is quite obvious. A finer-finished paper is used for printing and better quality pictures are produced by photographic composition. Increased versatility in ad composition is also obvious when paste up is used. It is much easier to paste little pieces of paper and arrange them at odd angles than it is to do the same thing with metal. Most papers installing phototypesetting equipment note increases in productivity. One company noted that with the installation of photocomposition advertising that, "We experienced a substantial increase in hot metal efficiency. This could be because the old hot metal process was no longer burdened with the complex ads taken over by photocomposition" (13, p. 149). One "unsolicited comment" from the Fresno Guide found in an Intertype ad claimed that by using phototypesetting, makeup time on a full page ad was reduced from six to less than two hours. They also claim 70% savings as the result of the paste up process (10, p. 2). Furthermore, it is obvious that lower skill levels are required for pasting up an ad than those required for handling metal composition. Space is conserved by eliminating the stereotype department, the metal storage, and the metal page forms and chases. The Albany plant cut their required shop space approximately in half.

Although the cold type composition has many advantages, there are many problems involved for an established paper to make the transition. First of all is the cost of purchasing entirely new machinery including a new press. The general manager of the Albany paper estimated their conversion costs at $390,000 including building remodeling (6). The general manager of the Corvallis paper anticipates a $400, 000 investment in the basic machinery alone when they go offset (17). This cost is amplified by the presently low resale value of the hot metal equipment. Since most newspapers are considering going offset they logically will not invest in new hot metal equipment. An example of the drastic reduction in demand for hot metal equipment, mentioned in a trade publication, is represented by the sales record of one of the leading manufacturers of linotypes. The manufacturer reports a drop from an average sales of 200 machines per month to nine machines in December, 1967 (4, p. 3). Another problem to be considered is the material costs. Here hot metal does have an advantage since the lead can be melted and remelted with very little replacement necessary. Cold type, in contrast, uses film, print-out paper and aluminum press plates which are not reusable.

Another problem is that of pulling proof. It is a simple operation in hot metal but in cold type composition it requires a photographic process or a copying process such as a large Xerox. This turns out to be more time consuming and more expensive if it is used. The other option is to show the layout but this can be inconvenient to the page makeup staff.

One of the big problems connected with the installations of the cold type process is that of retraining the present personnel or training new personnel. Whereas skilled hot metal compositors are fairly easy to hire, it is difficult to find experienced cold type personnel. There are definite human relations problems created by lowering of skill levels required of composing room personnel. For smaller papers this could be an ideal way to simplify procedures but with middle size papers the problem of trying to retrain all present personnel is likely to result in overstaffing. Although most papers try to use attrition as an answer to overstaffing, it is not always possible due to union contracts. This problem grows with the size of the paper and attrition has not been found to be an acceptable answer for metropolitan papers. A very detailed study on the subject of union and publishers views of automations was made by two graduate students at Harvard. The report, AUTOMATION IN NEWSPAPERS, was published in 1966 (13).

Originally offset presses were not able to produce copy as fast as the letterpress. The press speed has gradually been increased with improved technology to where the offset press now matches the speed of most letterpresses. One of the greatest problems holding back large metropolitan papers from using offset is the durability of the press plates. Present plates have a maximum life of 20,000 to 30,000 impressions (16). To run a paper such as the New York Times with 100 pages and 1,000,000 circulation would require so many stops to complete the issue it would be impossible to meet the deadlines.

In order to more objectively evaluate these advantages and disadvantages a complete mathematical model was prepared for the hot metal system.

DATA COLLECTION

Original plans for the collection of data for this study included the preparation of mathematical models for both the hot metal and cold type composition systems. However, in trying to collect the data for the cold type process, too many uncontrolled variables were found to derive a valid, representative model of the new method. The particular cold type operation studied has been installed slightly over a year and the system was not entirely debugged nor had the training period been completed. Other influencing factors included several serious illnesses among the staff which complicated the system; and the week chosen for data collection was an unusually heavy work load causing much overtime and resulted in less than peak-efficiency production. Since time limitations did not allow for collecting data for a new model, a sample of ads was chosen to use for comparison purposes.

Previous Studies

The display advertising system is complicated by the wide variety of ads. On a trial run, the extremes for composing time ran from one minute to 12 hours. Because of the large variation of the data, it was decided to make a regression model rather than use any of the more common timing techniques such as a stop watch study.

Previous studies on ad composition time have been attempted using Method Time Measurement and Regression Analysis. The Method Time Measurement study at the Aurora (Illinois) Beacon-News was not satisfactory according to the Production Engineer, Dennis Coyle. He stated that "The aforementioned study was very time consuming and expensive. In addition, the study proved to be of little value when compared to the cost and time consumption" (5).

The Regression Analysis project was started in 1955 by Sidney Davidson and Robert Roy as a joint project between the American Newspaper Publishers Association Research Institute and the Institute for Cooperative Research of The Johns Hopkins University. From this rather complete study, the investigators hypothesized that the mathematical relationship to be found would be:

$$T = k + tU$$

Where:

T = total composition time, exclusive of advertiser corrections

k = a constant representing various get ready and put away elements

t = time per assembly unit

U = number of assembly units (7, p. 799)

And where an assembly unit is any individual slug of type, or cast, or section of border. The experimental results showed that the function was nonlinear.

$$\text{Log } T = k + t \text{ Log } U + s \text{ Log } C$$

Where:

s = time per column line

C = size in column lines (7, p. 800)

Hot Metal System

This regression study was chosen as a basis for the research for this paper. However, many refinements were introduced into the model in order to be able to pinpoint the savings derived from cold type composition.

Rather than lumping all ad composition under one heading, eight separate categories of operations were chosen: Markup Time, Type Slips Time, Stereotype Time, Typesetting Time, Composing Time, Proof Pulling Time, Correction Time, and Unavoidable Delay Time.

In order to determine the variables that affected each of these time elements, several meetings were held with the personnel of the hot metal plant chosen for study. Those attending the meetings represented management, the display staff, the dispatch department, the composing room and the stereotype department. The following list describes each element and those variables affecting the elements.

1. Markup Time - The time it takes the designated person to gather the copy to be marked, mark the type face, size and length for distribution to the linotypes.

    a. Lines of type to be set - The number of linotype and Ludlow lines in the ad.

    b. Number of mats - The number of individual mats that have to be cast and trimmed.

    c. Number of type styles - Must be 0, 1, or 2, where 0 would indicate no type set for an ad, 1 would indicate regular type styles are used, and 2 would indicate that both regular and Bodoni styles were used.

    d. Number of type sizes - The number of different sizes (8, 10, 12, and 14 point) of all type styles.

    e. Quality of the copy - A qualitative factor scaled from 1 to 6 on the legibility of the copy. The factor 3 would represent an average layout, not too precise and probably hand lettered, factor 1 would indicate neatly typed, exact layout; factor 6 would indicate misjudged size of layout, illegible handwriting or some poorly reproduced copy.

    f. Number of lines to be typed - Number of lines typed by dispatch personnel for distribution to separate linotypes.

2. Type Slips Time - This is the time previously described as the time for the typist to type the requested copy.

   a. Number of slips to be typed - The number of separate units the typist prepares for various machines.

   b. Lines of copy to be typed - See 1f.

3. Stereotype Time - The time it takes to collect, strip and cast the mats and cut and plane the casts.

   a. Number of mats - See 1b.

   b. Size of mats - The space in column inches occupied by the cast material.

   c. Shape of flat cast - A qualitative factor (1 to 6) measuring the difficulty in trimming the metal cast. Factor 1 represents a square or rectangular cast; 3 represents an irregular shape but not tediously small to handle; 6 represents an irregular shape with numerous angles, tediously small.

   d. Number of times use mat - The number of times a mat has to be recast.

   e. Readiness of mat - This variable not used in the final mathematical model as it appeared only rarely.

4. Typesetting Time - The time it takes an operator to set either linotype or Ludlow lines for an ad.

   a. Number of Ludlow lines - The number of lines, whether on one or more slugs, set on the Ludlow.

b. Length of Ludlow lines - The linear length of the Ludlow lines measured in picas.

c. Number of linotype lines - The number of lines, whether on one or more slugs, set on the linotype.

d. Length of linotype lines - The length of the linotype lines measured in picas.

e. Number of type sizes - see 1d.

f. Number of magazine changes - The number of times a linotype operator is required to replace one font of type molds with a different font or magazine.

g. Number of lines to saw - Number of metal lines which have to be sawed to size.

h. Number of light-dark changes - Number of times an operator changes from light face to bold face type in a single line.

5. Composing Time - The time it takes for a compositor to gather the components and assemble the ad.

a. Number of flat casts - The number of mats plus the number of previously prepared casts used in the ad.

b. Size of the flat casts - The space in column inches occupied by the flat casts.

c. Lines of type - See 1a.

d. Inches border and rule - The length of border and rules measured in inches (excluding that around boxes.)

e. Number of boxes - Number of units placed in separate closed rectangular borders.

f. Number of angular units not floated - This variable was not used; it appeared rarely.

g. Complexity of copy - A qualitative factor (1 to 6) attempting to judge the difficulty of an ad where factor 1 represents an ad mostly of mat with a few lines of type; factor 3 represents an ad with quite a bit of copy and several mats; factor 6 represents an ad with a lot of type crowded into small spaces and the use of many small casts and odd angles.

h. Number of cuts and mats to come - Number of cuts and/or mats not originally sent down with the ad.

i. Number of mortises - Number of units that have to be fitted into metal borders or casts. This requires precise routing or saw work.

j. Number lines pickup type - Lines of type held over from a previous ad to be run again.

k. Number of inches plastic based - Number of column inches of an ad which is placed on plastic base.

(Remember that casts require a base.)

1. Number inches metal base - Number of column inches which are raised by means of metal base material.

6. Proof Pulling Time - The time required to take an ad from the dump, ink the type, and make the required number of proofs.

   a. Size of the ad - The length of the ad in inches multiplied by the number of columns width.

   b. Number of proofs required - The number of proofs to be made of the ad.

7. Correction Time - The time it takes to reset and replace all lines with changes or errors and make all other revisions necessary. A change designates a replacement of copy by the advertiser. An error designates a replacement of copy due to a mistake made in producing the copy.

   a. Number of changes and errors in Ludlow lines - The number of lines that have to be reset on the Ludlow.

   b. Number of changes and errors in Linotype lines - The number of lines reset on the linotype.

   c. Number of changes in mats - Number of lines that must be deleted from the flat cast to make changes for the advertiser.

d. Number of errors in flat casts - Number of burrs or stray lines that must be chipped out of flat cast.

e. Lines transposed - Number of lines placed in wrong position or in the wrong order.

f. Number of type sizes involved in errors - The number of different type sizes that have to be used in setting corrections.

8. Unavoidable Delays - This element was not used because of the small number of reported incidences.

The actual data was collected from 7:30 A. M., Thursday, April 11, to 5:30 P. M., Wednesday, April 17. Collecting the data in this manner gave a representative sample of a week's production. The activity times were obtained by using work logs attached to the layout of each ad. The variables were determined by observation of the layouts, original copy, proofs and correction sheets. The total number of ads processed was over 300, however, for the purpose of this study, all "pickup" ads were neglected. A pickup ad represents an ad that has run previously and is stored, therefore no production work is involved in rerunning these ads. They were neglected in the study because the time to collect these ads is a function of the filing system used and not the production method. The number of regular ads used in the data sample was 195. The number of observations for each individual element varied for several reasons. The first for the variance was that elements did not occur for every ad; type slips time occurred in only five instances. The other major reason that elements did not occur was due to the manner of taking data; some of the ads were already in the middle of the procedure when the study was started, and some were not completed at the end of the study. The Summary of Data Table (see page 41) describes the experiment in more detail.

The method chosen for analyzing the data was regression analysis. The regression equation hypothesized was in the form:

$$Y = b_o + b_1x_1 + b_2x_2 + \ldots$$

Where:

Y = the dependent variable representing Markup Time, Stereo Time, etc.

b_o = a constant time unit.

x_1 = an independent variable such as the lines of type to be set or the number of mats.

b_1 = a constant in time per units of the independent variable such as minutes per line of type.

The following pages are examples of the forms devised to collect the data for the hot metal model.

Work Log

ADVERTISER ______________________ SIZE __________ DATE __________

Operation Number	Remarks	Date	Time Start	Time Stop

AD FORM - 1

Operation Code Explanations:

1. Markup Time - starts when markup man gathers copy to be marked and ends when the copy is distributed to the linotypes. It does not include the time spent by the typist in Dispatch typing the slips.
2. Type Slips Time - starts when the typist arranges the copy to be typed and finishes when she delivers the slips to the markup man.
3. Stereo Time - starts when the mats are collected to cast and finishes when the finished flat-cast is ready to go to the assembly area.
4. Typesetting Time - starts when the operator is ready to set the copy (either linotype or Ludlow) and finishes when the set lines are ready to go to the ad assembly area.
5. Composing Time - starts with the compositor gathering the type and casts for the ads and finishes when the ad is ready to be proofed. It does not include time spent waiting for cuts or mats or other similar delays.
6. Proof Pulling Time - starts when the ad is taken from the dump to the proof press and finishes when the ad is returned.

7. Correction Time - is the time spent by anyone making corrections rather than setting original copy.

8 Unavoidable Delays - Any delay that causes an operator to be held up as well as an ad such as waiting for the saw or hunting for a mat. It does not include the time spent waiting for a proof to return.

Please note the cause of delays in the remarks column.

LIPMAN'S 3 X 10 SAMPLE FORM

Operation Number	Remarks	Date	Time Start	Time Stop
1		2-10	8:01	8:12
3		"	8:32	8:50
2		"	8:15	8:20
1		"	8:30	8:32
4	Mach 6	"	8:40	8:43
4	" 8	"	8:42	8:50
4	Ludlow	"	8:45	9:02
8	Wait for saw	"	9:02	9:05

Number of mats	2
Quality of copy -- legible or illegible	2
Number of lines to be typed	—
Number of slips to be typed	—
Size of mats (percentage)	50%
Shape of flat cast - regular or irregular - Stereo	1
Number of times use mat in one ad	1
Readiness of mat	1
Number of flat casts	2
Complexity of copy (0 to 6)	3
Number of cuts or mats to come	—
Size of ad	4x21
Number of proofs required	1
Quality of layout	1
Markup Time	1 min
Type Slips Time	—
Stereo Time	15 min
Typesetting Time	21 min
Composing Time	25 min
Proof Pulling Time	1 min
Correction Time	10 min
Unavoidable Delays	—
Time of day	—
Number of ads on floor at time of delay	—
Number of people working	—
Lines lost or misplaced type	—
Amount of missing copy	—
Number of mats held up by stereo	—

SAMPLE DATA COLLECTION FORM

Lines of type to be set	31
Number of type styles to be used	1
Number of type sizes to be used	7
Number of Ludlow lines	6
Length of Ludlow lines	65 pi
Number of linotype lines	25
Length of linotype lines	332 pi
Number of magazine changes	—
Number of lines to saw	—
Number of light-dark changes within lines	3
Inches of border and rule	46"
Number of boxes	—
Number of angular units (not floated)	—
Number of mortises	2
Lines of pickup type	5
Number of inches plastic based	—
Number of inches metal based	50%
Number of changes in Ludlow lines	1
Number of errors in Ludlow lines	—
Number of changes in linotype lines	—
Number of errors in linotype lines	4
Number of changes in mats	—
Number of errors in flat casts	—
Number of wrong mats	—
Number of Magazine changes involved in errors	—
Number of type sizes involved in errors	3
Number of irregular units involved	—

SAMPLE DATA COLLECTION FORM

Multiple Regression Analysis

Multiple regression analysis is a technique used to obtain an equation that will best fit a set of observations (9, p. 191). The term "regression" became popular with the work of Sir Francis Galton in the 1880's. Galton's studies on the relationship between the heights of parents and their children introduced the basics of modern correlation techniques. He found that children of tall parents tended to be shorter on the average than their parents and children of short parents tended to be taller. Galton's conclusion was that the children's heights tend to "regress" back to an average (8, p. 674).

The multiple regression equation in a linear form would be:

$$Y = b_o + b_1X_1 + b_2X_2 + b_3X_3 + \ldots$$

Where Y is the dependent variable, X_1 is an independent variable, and b_n is an experimentally determined constant. Nonlinear equations may also be solved from experimental data by combining variables, using exponential powers, or logrithmic functions.

The usual statistical method for solving a regression equation is the method of solving simultaneous equations. The system of simultaneous equations to be solved for two independent variables would be:

$$\Sigma Y = b_o + b_1 \Sigma X_1 + b_2 \Sigma X_2$$

$$\Sigma X_1 Y = b_o \Sigma X_1 + b_1 \Sigma X_1{}^2 + b_2 \Sigma X_1 X_2$$

$$\Sigma X_2 Y = b_o \Sigma X_1 + b_1 \Sigma X_1 X_2 + b_2 \Sigma X_2{}^2 \qquad \text{(14, p. 338)}$$

It is obvious that for large number of variables a great number of calculations are required making a computer program desirable. Since the data for this study required from 2 to 11 independent variables for 7 dependent variables the Stepwise Multiple Linear Regression Analysis program supplied by the Oregon State University Computer Center was employed.

The stepwise procedure yields valuable intermediate results which are not determined by normal calculation methods. These results are used to control the following calculations. The intermediate results are obtained without a significant increase in the arithmetic procedure. The following excerpt from the explanation of the program should make the procedure clearer.

> At any stage of the stepwise procedure only one variable is either entered or removed from the equation to be added. The contribution a variable makes in reducing the variance is considered for all variables in the equation. If the contribution of a particular variable is insignificant, this variable is removed; otherwise the variance reduction for all variables not in the regression is considered. The variable which most significantly reduces the variance is then added to the equation. If there are no more variables to examine or both of the above significance tests fail, the algorithm is terminated.

If X is a variable under consideration and R_{II}, R_{IY} are simple correlation coefficients, then the statistical significance of the reduction in variance is calculated as follows:

$$F = \frac{V_I(D.F.)}{(1-R^2-V_I)} \qquad (1a)$$

where

$$V_I = \frac{R_{IY} \times R_{YI}}{R_{II}} \qquad (1b)$$

and R^2 = multiple correlation coefficient.

A check is made on the size of R in order to reduce the possibility of degeneracy resulting from an independent variable being approximately a linear combination of the other independent variables. If such a case were encountered, the variable in question would not be entered into the equation.

It should be pointed out that the method does not guarantee that the total explained variance attained for a particular subset of the independent variables is the largest attainable for any subset of the same size. However, the method has been used satisfactorily as a feasible substitute for the much longer procedure of computing the total explained variance for every possible subset. As with any regression program the equation should be continually evaluated and used with extreme caution, if at all, beyond the region of the experimental data (18, p. 1-2).

In the equation 1-a the F stands for a test statistic which measures the improvement of fit of the model obtained by entering a particular variable X into the regression equation. The D.F. term represents the degrees of freedom for the variable under consideration. R^2 is the multiple correlation coefficient and measures the

the similarity in data between the variables under consideration. The simple correlation coefficients R_{II}, R_{IY}, and R_{YI}, measure the correlation of the independent and dependent variables (9, p. 192). R_{II} represents the correlation of the values of any variable with the determined regression line of that variable. R_{YI} represents the correlation of the values of Y with the regression line of I while R_{IY} indicates the correlation of the data of I with the regression line of Y.

Cold Type System

Since the study plan originally included a complete system model for the cold type system in a manner similar to that used in the hot metal system study, a similar form was designed for data collection purposes. Some changes had to be initiated because of the system differences. The four dependent variables studied in the cold type system were Markup and Typesetting Time, Developing Time, Pasteup Time and Correction Time. The following variables, four dependent and 28 independent, composed the hypothesized cold type model.

1. Markup and Typesetting Time - The time it takes for the Photon 200 operator to decide the type styles, sizes and line lengths and set the copy of the ad.
   a. Number of lines to be set - The number of lines set on all machines used.
   b. Number of type styles to be used - In this case again only two styles are considered, Bodoni and all other styles.
   c. Number of type sizes - Number of different height

letters (10, 24, and 30 point).

d. Quality of copy - Same as hot metal quality factor, measures legibility of layout.

e. Amount of slicks used - Amount of space occupied by the slicks.

f. Number of Photon 200 lines under 28 point - Number of lines with type sizes 28 points and under.

g. Number Photon 200 lines 28 point and over - Number of lines with type sizes 28 point and larger. This division in type sizes is made because it takes three times as long to imprint letters of the larger type sizes. The longer exposure time is required to obtain the proper blackness of the letter.

h. Length of Photon lines under 28 point - Length in picas of lines less than 28 points high.

i. Length of Photon lines 28 points or greater - Length of all lines 28 point or over.

j. Number of Photon 713 lines - The Photon 713 is used occasionally on ad production as a backup machine. No examples of this occurred in our study so this factor is neglected.

k. Number of lens changes - Number of changes in type sizes within mixed lines that require corresponding lens changes.

2. Developing Time - The time it takes to remove the film from the Photon 200, take it to the dark room, process the film through the developer, bring the printed sheet out and make some separation of the ads.

   a. Length of film - An inappropriately named variable reflecting the lines set on the photocomp machine. The length of the ad was measured on the hard copy output of the Photon 200. Therefore no type sizes were reflected but only the number of lines.

   b. Number of ads on film - The number of individual ads set on any developed unit of film.

3. Paste Up Time - The time required for the paste up girl to cut apart the copy units, wax them and position them, also to add any slicks or border which had not been previously placed on the layout.

   a. Amount of slicks - See 1e.

   b. Number of slicks - The number of individual slicks or illustrations used in an ad.

   c. Lines of type - Number of individual lines of all type sizes.

   d. Inches border and rule - Length of all border and rule tapes used with the exception of that used around boxes.

e. Number of boxes - Number of enclosed rectangular units.

f. Number of angular units - Number of units not in horizontal position.

g. Complexity of copy - Qualitative judgment factor based on the difficulty of composing the ad. (See hot metal model 5g.)

h. Copy to come - Amount of space held open in an ad for copy which had not been received.

i. Lines of pickup type - Number of lines held over from previous ads.

4. Correction Time - The time it takes to reset any incorrect lines, and paste them on the layout or make any other changes necessary.

a. Number of changes and errors in 28 point or over lines - Number of individual changes whether it was a line or a word to correct in type sizes 28 point or greater.

b. Number of changes and errors in less than 28 point lines - Number of units correct in lines of type less than 28 point.

c. Number of wrong slicks - Number of slicks that had to be replaced due to changes or errors.

d. Number of changes in slicks - Number of corrections made within a slick such as a price change.

e. Number of type styles involved - The number of type styles in the erroneous lines.

f. Number of type sizes involved - The number of different type sizes used in setting correction lines.

The original plan of this study was to determine which variables had the most effect, that is which variables increased the time the most. Since it was not possible to complete the study within the time limits, a new method was devised for making the comparison. A sample of 15 ads was selected on the basis of the completeness of the data obtained and the representativeness of a cross-section of the ads. It was decided to handle the ads as if they had been composed by the hot metal process by substituting the required data into the hot metal formula. Although most of the information required by the hot metal model was available, it was necessary to determine the following factors which were not accounted for by the cold type model.

1. Shape of the flat cast.
2. Number of times used mat.
3. Readiness of mat.

4. Lines of type to be set.

5. Number of Ludlow lines.

6. Length of Ludlow lines.

7. Length of linotype lines.

8. Number of linotype lines.

9. Number of magazine changes.

10. Number of lines to saw.

11. Number of light-dark changes.

12. Number of mortises.

Changing the cold type ads into hot metal data required some subjective judgment. As much as possible the same type sizes were considered but some change in type style would probably occur due to the hot metal use of the Ludlow for larger type sizes. Another factor was the use of overlapping numbers in prices, a common occurrence in cold type ads. In hot metal, the markup man would, no doubt, have marked the type size smaller to avoid having to mortise the numbers. However, it was decided to count the number of mortises as they appeared so as to find what time was required to set an ad of the same appearance since this will also reflect the flexibility in cold type pasteup.

EXPERIMENTAL RESULTS

Although the experimental results are less complete than originally anticipated, a great deal of information can be derived from the study. The computer program used on the hot metal system supplied a variety of statistical information as well as the regression formula. The sample data taken for the cold type system allows a production time comparison to be made.

Hot Metal Data

Table 1 represents a summary of the data used in preparing the hot metal model. (See page 41)

The output of the Stepwise Multiple Linear Regression program used to solve for the various coefficients included:

1. The raw sums of squares and cross products.
2. The residual sums of squares and cross products.
3. Simple correlation coefficients.
4. Sum, mean, and standard deviation of each variable.
5. Each step of the regression analysis.
6. Predicted versus actual results for each Y value.
7. Diagonal matrix elements which represent the relative error in goodness of fit of each variable.

For each step in the regression analysis, the variable entering

Table 1. Summary of hot metal data.

Variable	Occurrence	Sum	Mean	Std. Dev.
MARKUP TIME	166	480	2.89	5.22
Lines of type		5509	33.19	61.11
Number of mats		323	1 95	3.44
Number of type styles		174	1.05	.29
Number of type sizes		804	4.84	3.45
Quality of copy		277	1.67	.91
Number lines to be typed		504	3.03	18.17
TYPE SLIPS TIME	5	94	18.80	11.28
Number slips to be typed		87	17.40	6.43
Lines copy to be typed		408	81.60	44.67
STEREO TIME	106	1874	17.68	13.89
Number of mats		310	2 92	3 92
Size of mats		3147	29.69	38.53
Shape of flat cast		119	1.12	.36
Number times use mat		116	1.09	.49
TYPESETTING TIME	175	3993	22.82	38.56
Number of Ludlow lines		508	2.90	7.04
Length Ludlow lines		6589	37.65	96.38
Number of linotype lines		5302	30.30	54.04
Length linotype lines		61094	349.11	702.29
Number of type sizes		827	4.73	3.35
Number of magazine changes		21	.12	.37
Number of lines to saw		14	.08	.72
Number light-dark changes		119	.68	3.66
COMPOSING TIME	165	4536	27.49	45.95
Number of flat casts		238	1.44	2.98
Size of flat casts		3690	22.36	35.53
Lines of type		5417	32.83	61.84
Inches border/rule		4864	29.48	53.66
Number of boxes		65	.39	2.25
Complexity of copy		304	1.84	.87
Number cuts and mats to come		15	.09	.38
Number of mortises		47	.28	1.08
Lines pickup type		277	1.68	4 36
Number lines plastic base		1185	7.18	27.50
Number lines metal base		2883	17.47	29.93
PROOF PULLING TIME	149	275	1.84	2.12
Size of ad		6868	46.09	62.80
Number proofs required		219	1.47	.70
CORRECTION TIME	85	1229	14.46	21.80
Number errors in Ludlow		35	.41	1.05
Number errors in linotype		554	6.52	10.02
Number changes in mat		21	.25	1.23
Number errors in flat cast		11	.13	.53
Lines transposed		49	.58	1.50
Number type sizes involved		169	1.99	1.87

that stage was listed. The two statistics used in selecting the best step, the best combination of variables, were the multiple correlation coefficient and the standard error of Y (the dependent variable). The value of the multiple correlation coefficient lies between 0 and 1. A coefficient of 1 represents a perfectly linear relationship between the variables involved while a coefficient of 0 implies that no linear relationship exists. The standard error of Y is a measure of the variance of Y from the regression equation. A value of 0 would indicate a perfect fit.

In order to determine the contribution of each variable to the elemental time, Table 2 has been prepared. This chart shows the coefficients of the step which had the highest R^2 and lowest standard error of Y or the best combination thereof. By multiplying these coefficients by the mean value of any variable, a relative time contribution can be calculated. (See page 36.)

The multiple correlation factors indicate a satisfactory linear relationship for Markup, Typesetting and Composing Times. The correlation coefficients for Type Slips, Stereotype, Proof Pulling, and Correction Times show that only 50 to 70% of the variance of the data is accounted for by the regression model.

As an additional trial run of the data a small sample (50 observations) was chosen from the Composing Time data and some data transformations tried. Since the original study by Roy and Davidson showed a logarithmic function, it was decided to use a common log transformation of all the data. This proved to be rather difficult since the data contained many zero level observations and the log of zero is undefined. Therefore, all zero data points were changed to a 0.1 level. The best solution to the regression equation had $R^2 = .952$ and the standard error of $Y = 17.98$. The variables used in the model were:

1. Number of flat casts
2. Size of flat casts
3. Lines of type
4. Inches border/rule
5. Number of boxes
6. Number of mortises
7. Log (Number of flat casts)
8. Log (Size of flat cast)
9. Log (Inches border/rule)
10. Log (Number of boxes)
11. Log (Cuts and mats to come)
12. Log (Number of mortises)
13. Log (Number of metal base)

This sample showed that some non-linearity of the data could be accounted for by including a log function in the regression model. The Composing Time model improved 9% in its correlation coefficient by addition of the non-linear term. This determination of non-linear terms in the regression equation should have been made to improve the model; however, time limitations did not allow for re-punching and further experimentation into the data.

Table 2. Major variables in hot metal system.

Variable	Coefficient	Mean	Time Contribution	% Time
MARKUP TIME: $R^2 = .869$	Standard error of Y = 1.923			
Constant	-	-	1.199	* 30.3%
Lines of type	.076	33.19	2.522	* 63.7
Number of mats	.061	1.95	.119	3.0
Number type styles	.437	1.05	.459	* 11.6
Number type sizes	- .060	4.84	- .290	* -7.3
Quality of copy	- .073	1.67	- .122	-3.1
Number lines to be typed	.024	3.03	.073	1.8
TYPE SLIPS: $R^2 = 0.515$	Standard error of Y = 11.111			
Constant	-	-	-14.733	-9.6%
Number slips to be typed	3.605	87.00	313.635	*205.2
Lines of copy to type	- .358	408.00	-146.064	*-95.6
STEREOTYPE TIME: $R^2 = .651$	Standard error of Y = 8.289			
Constant	-	-	6.854	* 38.8%
Number of mats	1.907	2.92	5.568	* 31.5
Size of mats	.177	29.69	5.255	* 29.7
TYPESETTING TIME: $R^2 = .959$	Standard error of Y = 8.289			
Constant	-	-	- .976	- 4.3%
Number Ludlow lines	-1.305	2.90	- 3.785	*-16.5
Length Ludlow lines	.128	37.65	4.819	* 21.1
Number linotype lines	.423	30.30	12.817	* 56.1
Length linotype lines	.015	349.11	5.237	* 22.9
Number type sizes	1.023	4.73	4.839	* 21.2
Number magazine changes	-2.052	.12	- .246	- 1.1
Number light-dark changes	.188	.68	.128	.6
COMPOSING TIME: $R^2 = .861$	Standard error of Y = 17.698			
Constant	-	-	- 3.121	*-11.4%
Number flat casts	1.636	1.44	2.356	* 8.6
Size of flat casts	.381	22.36	8.519	* 31.0
Lines of type	.394	32.83	12.935	* 47.1
Inches border/rule	.100	29.48	2.948	* 10.7
Number of boxes	.931	.39	.363	1.3
Complexity of copy	4.452	1.84	8.192	* 29.9
Number cuts, mats to come	-5.634	.09	- .507	- 1.8
Number of mortises	6.821	.28	1.910	* 7.0
Number of plastic base	- .334	7.18	- 2.398	* -8.7
Number of metal base	- .215	17.47	- 3.756	*-13.7

* Indicates major factors

Table 2. Continued

Variable	Coefficient	Mean	Time Contribution	% Time
PROOF PULLING TIME: $R^2 = 6.71$	Standard error of Y = 1.221			
Constant	-	-	- .177	*- 9.6%
Size of ad	.022	46.09	1.014	* 54.9
Number proof required	.688	1.47	1.011	* 54.7
CORRECTION TIME: R = .695	Standard error of Y = 12.500			
Constant	-	-	- .124	- .9%
Number errors in Ludlow	1.919	.41	.787	* 5.4
Number errors in linotype	1.434	6.52	9.350	* 64.7
Number changes in mat	.573	.25	.143	.9
Number erros in flat cast	-1.884	.13	- .245	- 1.7
Lines transposed	3.226	.58	1.871	* 12.9
Number type sizes involved	1.356	1.99	2.698	* 18.7

Negative Coefficients

An interesting outcome of the regression models is the resulting negative coefficients. These negatives were not anticipated and explanations can only be suggested. The negative coefficients indicates that with the presence of the particular variable the composing time is decreased. In trying to explain these factors, all factors which contribute less than 5% to the total elemental time are neglected as being minor factors.

The first negative coefficient occurs in Markup time in the number of type sizes. An explanation of the factor might be that if the markup man used more type sizes he would have less trouble getting all the lines the right length but he would also lose the consistent appearance of the ad. The constant for each elemental time would normally be thought of as a set up time but in the case of Type Slips, Typesetting, Composing and Correction times the constant is negative. In checking the reasons for this it was found that the negative coefficients were found with those elements where there was some correlation between factors. For example in Typesetting time there was a high correlation between the length of the linotype lines and the number of light-dark changes. Therefore a negative constant could be considered to be an adjustment for correlated variables.

The next negative coefficient occurs in the Type Slips time. Again this negative was probably meant to explain the high correlation of the factors, .98. In the Typesetting function the number of Ludlow lines has a negative coefficient. This factor may be due to the fact that the more Ludlow lines used in the ad, the fewer total number of lines are needed to fill the space since Ludlow lines are nearly all large type sizes.

The coefficients for the number of inches of metal base and the number of inches of plastic base are both negative in the Composing time section. This would indicate that the more base used means the more casts used and the less actual composition work required.

Without further explanation of the hot metal data, it would be well to introduce the cold type data so some comparisons can be made.

Cold Type Data

A sample of 15 ads was taken from the data gathered at the cold type plant studied. These ads which had originally been evaluated for the cold type model were reevaluated according to the hot metal variables. Unfortunately insufficient information was available to get the data for the Correction Time variable at the time the system was reevaluated. Therefore in all the future comparisons, correction time is not included.

By using the coefficients derived in the hot metal operation the time to compose each of the cold type produced ads can be calculated and compared to the time recorded by work logs for the cold type operation. Assumptions were made that no slips were typed for distribution to the linotypes and that only one proof was required since the cold type operation got by with just showing the layout. Table 3 summarizes the calculations and shows the time comparison.

The results of our comparison data show that it would take 28 hours 37 minutes to compose the 15 ads by the hot metal method while it actually took 9 hours 23 minutes to compose the same ads by the cold type method. The hot metal method would take just over three times as long to produce the sample ads according to our regression model calculations.

The Markup and Typesetting operation takes 1.56 times as long in the hot metal method. This increase in speed may be due to the relatively quick response of the photocomposition process as opposed to the more time consuming mechanical response of the linotypes used in hot metal production. The Developing time is practically insignificant compared to the total time for composing the sample ads. One of the real gains of cold type is shown in the $6\frac{1}{2}$ hours required for Stereotype time which is completely eliminated by photographic production.

The ease of handling paper and scissors as compared to handling metal and a saw is demonstrated by the difference in the Composing times. Here it takes 3.4 times as long to compose an ad using metal as it does by using paper. The Proof Pulling operation is probably a bit misrepresentative. The formula shows $28\frac{1}{2}$ minutes required for proofing time for the hot metal system. If the offset operation being studied did use a proofing system it would reduce the advantage of the cold type system. The most common time for pulling a proof was about one minute in the hot metal system. If a cold type proof were printed from a plate rather than just reproduced, it would take time to shoot and develop the plate as well as make the proof. But in considering the particular newspapers studied and accepting their systems, the cold type production method shows a 67% savings in production time over the hot metal method.

A study done by the Fresno (California) Guide and Bakersfield

Table 3. Hot metal vs cold type production time for sample data.

Variable	Sum	Coefficient	Hot Metal Time	Cold Type Time
MARKUP AND TYPESETTING				
Constant	15.0	1.199	18.00 min.	
Lines of type*	726.0	.076	55.10	
Number of mats	109.0	.061	6.65	
Number of type styles*	17.0	.437	7.43	
Number type sizes*	85.0	- .060	- 5.10	
Quality of copy	24.0	- .073	- 1.75	
Constant	15.0	- .976	-14.62	
Number Ludlow lines*	94.0	-1.305	-122.67	
Length Ludlow lines*	1425.0	.128	182.40	
Number linotype lines*	633.0	.423	267.76	
Length linotype lines*	4941.0	.015	74.11	
Number type sizes*	85.0	1.023	86.96	
Number magazine changes	2.0	-2.052	- 4.10	
Number light dark changes	0.0	.188	0.00	
			469.84	300.00
DEVELOPING TIME			-	11.42
STEREO TIME				
Constant	15.0	6.854	102.81	
Number of mats*	109.0	1.907	207.86	
Size of mats*	281.8	.177	49.88	
			360.55	-
COMPOSING TIME				
Constant	15.0	-3.121	-46.82	
Number of flat casts*	109.0	1.636	178.32	
Size of flat casts*	281.8	.381	107.66	
Lines of type	726.0	.394	286.04	
Inches border/rule*	578.0	.100	57.80	
Number of boxes	59.0	.931	54.93	
Complexity of copy*	28.0	4.452	123.66	
Number cuts and mats to come	0.0	-5.634	0.00	
Number of mortises *	24.0	6.821	163.70	
Number of plastic base*	54.0	- .334	-18.04	
Number of metal base*	228.2	- .215	-49.06	
			858.29	251.50
PROOF PULLING TIME				
Constant	15.0	.177	2.65	
Size of ad*	708.0	.022	15.576	
Number of proofs required*	15.0	.688	10.320	
			28.55	-
TOTAL TIME			1717.23 min.	562.92 min.

* Factors that had major time effects in hot metal operation.

News-Bulletin four ads were composed by both methods and the times compared. All four ads were typographically complicated. The ads were composed in 1005 minutes by cold type and 1935 minutes by hot metal. Here the improvement ratio has dropped to just under twice the advantage for cold type (20, p. 38).

Some of the factors that influence the validity of the experimental results of the regression analysis are: 1) The sample of ads chosen; 2) The relative production efficiency of the plants studied; and 3) The goodness of fit of the regression model. The sample of ads chosen for the study range from rather simple ads to fairly complex grocery store ads. The sample of ads used at the Fresno study included only complicated ads and used a smaller sample (20, p. 38). The relative production efficiency would influence the comparison factor if a highly efficient hot metal system was compared with a newly formed cold type system. Finally the goodness of fit of the Stereotype and Proofing times could be improved according to the multiple regression coefficient. Therefore, it is allowed that there is some degree of error in the comparison but, with the data available and the time limitations as they were, it is felt that the results are sufficiently good to use in an economic comparison.

ECONOMIC COMPARISON

The previous section pointed out a labor savings of 67% with the use of cold type composition. However, it is necessary not only to look at labor savings but also to consider the increased materials costs.

Labor Costs

In order to compare the costs, it is desirable to convert all costs to a per page of advertising basis. A page is represented by 189 column inches of advertising. Since it took 562.92 minutes to produce 708 column inches for the cold type system it would take 150 minutes to produce 189 column inches. By the experimental model it would take three times as long or 450 minutes to produce a page in the hot metal system.

Another factor to consider is whether the cold type operation pays union or non-union scale wages for the paste up operation and the other composition tasks. Using non-union employees usually means less time is required than the more extensive apprenticeship training period required of union employees.

From the data collected at the hot metal operation, another time for completion of a full page can be determined. By adding the mean elemental times and dividing by the mean column inches per ad, a time of five hours production time per page is derived. This indicates a factor of two times the efficiency in cold type production. This factor corresponds to the Fresno study mentioned earlier.

Rather than figuring just one labor cost, a table has been prepared to show how the labor costs can change under differing production efficiencies and labor conditions.

Table 4. Labor costs per page of advertising.

Activity	COLD TYPE LABOR COSTS		HOT METAL LABOR COSTS	
	Cost based on non-union scale wages	Cost based on union scale wages	Cost Based on Time Values from Table 3	Cost based on Adjusted Time Values from Table 3*
Markup & typesetting	$ 5.15	$ 5.33	$ 8.20	$ 5.45
Developing	.19	.20	-	-
Stereotype	-	-	6.30	4.20
Composing	2.66	4.47	15.00	10.00
Proof	-	-	.50	.35
TOTAL	$ 8.00	$10.00	$30.00	$20.00

* Regular time values based on Table 3 use the experimental results which indicate that it would take a hot metal operation 3 times as long to compose identical ads to those of the cold type sample. The adjusted times indicate the labor costs if the hot metal operation composed the ads in their own styles rather than the exact cold type style.

Material Costs

For both hot metal and cold type systems the per page materials costs are figured from entering the markup and typesetting functions through the preparation of the plate through the press. In discussions with the general managers of the two papers involved it was discovered that the advertising mat services used by the newspapers had the same average cost. Although the cold type operation did not require the mats, the advertising service provided a higher quality paper with a better finish for cold type users (6, 17).

For the hot metal system the only major page costs involved are the cost of the metal and the cost of the mat used to form the press plate. Since the metal is used and reused, the method for determining the cost was to find the total cost of the metal purchased during a year and distribute it over the number of pages. This gave a cost of 13 cents per page for metal. The cost of the mats for the press plate was 64 cents per page. This gives a total page cost of 77 cents per page for hot metal operation (15).

The materials cost of the cold type operation are more complex. According to Mr. Cushman the materials cost per page was $3. Of this $3, over $1 was for chemicals used in the developing procedures. The cost of producing a press plate is 85 cents for the single page negative and 70 cents for the double size metal plate, or

$1. 25 total per page. The other 75 cents per page material cost is accounted for by the film used for typesetting at $9. 30 per 100 foot roll; borders and rules which cost an average of $1. 25 per 27 foot roll; and odds and ends such as wax, onion skin correction papers and layout sheets (6).

Labor and Materials Cost

In making inquiries about costs for both the hot metal and cold type systems, questions were asked about administrative and overhead costs. It was determined that these costs are relatively constant and do not change with the production system.

By combining the labor costs from Table 4 and the materials costs, an overall cost can be calculated.

By adding the materials cost to the labor costs, the cost of hot metal in comparison to cold type is at least 1. 6 and at greatest 2. 8 times the cost of cold type production.

Table 5. Direct labor and materials cost per page.

	Labor Cost*	Materials Cost	Total Cost
Cold Type (non-union scale)	$ 8.00	$3.00	$11.00/page
Cold Type (union scale)	$10.00	$3.00	$13.00/page
Hot Type	$30.00	$ .77	$30.77/page
Hot Type (adjusted)	$20.00	$ .77	$20.77/page

* from Table 4

The other consideration in analyzing costs is depreciation. Since cold type production requires a major investment, a higher depreciation rate is used thereby partially offsetting the new machinery costs. In the two newspapers studied the ratio of depreciation rates was 3.06:1 for cold type compared to the hot metal system. However, this is not a realistic comparison since different rates of depreciation are used. Usually a high depreciation rate occurs in the first years of the life of new equipment. Since old equipment is usually completely written off, maintenance and repairs are then the only annual costs. Also, the depreciation comparison is not the full picture of overhead as it does not include differences in building and space requirements and taxes and interest.

SUMMARY AND CONCLUSIONS

The objective of this study was to make an economic comparison of hot metal and cold type production of display advertising. To do so, it was first necessary to thoroughly understand the methods used in both systems. The hot metal system used a metal building material while the cold type system uses photographic means of reproduction. Claims made by the cold type advocates include better quality newspaper, more variability in ad composition, increased productivity and lower labor costs. Disadvantages of the cold type system include high initial machinery costs, labor relations problems, increased materials costs, as well as the difficulty in making proofs.

A sample of 195 ads was used to prepare a multiple linear regression model for the hot metal operation studied. This model can be used to calculate the production time required for an ad. A table was prepared (Table 2) to show which factors made major contributions to the time required for each element.

For the cold type model, the data consisted of a sample of 15 ads. These ads were evaluated by the hot metal regression model and it was found that it would take three times as long to compose the ads by hot metal production as it would by cold type.

Using these factors an economic comparison was made of the labor and materials costs. The total cost ratio for hot metal as opposed to cold type varied from 1.6:1 to 2.8:1 depending on whether union scale wage rates were used and whether the production efficiency of the cold type system was twice or three times as great as the hot metal system.

Conclusions

There are several factors for any newspaper man to consider when determining the value of cold type production for his paper. He should first of all know how good a job of production he is doing presently. He should know his page costs and labor costs and know whether or not they are reasonable. He should consider whether or not he has ample press capacity and ample plant capacity and be able to estimate how long his present facilities will meet production demands. He should seriously consider what benefits he will actually derive from initiating cold type production. He should realistically evaluate anticipated labor savings according to the labor relations conditions of his plant and the possibilities for retraining. Considering these factors as well as others is only preliminary to studying the many systems of machinery available. As with any major system change, the key to success is thorough planning.

It is obvious that this study has only begun to evaluate the differences in hot metal and cold type production. There are many things that can be done to increase the value of this study. The following recommendations are for future studies.

1. Reevaluate the hot metal regression model by using transformations on the data.

2. Reformulate the cold type system and make a regression model.

3. Extend the study of cold type and hot metal into news and classified production.

4. Use complex regression models to determine major variables so that simplified models can be made.

5. Determine realistic cost comparisons, including the effects of unequal book values, building and equipment depreciation rates, taxes and interest.

6. Produce a companion study of the human elements of a transition from hot metal to cold type in order to be able to identify the technological replacement training problems.

The first recommendation is to reevaluate the hot metal model by using transformations. An example of the improvement that can be made by using these transformations was the use of the log function to reduce the non-linearity of the Composing Time element.

Since the data for the cold type model did not turn out due to illness and newness of the system, a study at some later date might achieve the objective of the data for a regression model. All care should be taken to insure measurement of the same work in both systems.

When the models are made for the advertising systems, it would be desirable to extend the study to the news and classified divisions so that a total system analysis could be made. This extension is desirable to determine total productivity gains.

When the systems can be compared, it is desirable to simplify the model so it can be easily applied. Perhaps a sampling technique could be devised to replace the quantity information gathering process now required. Considerations should be made as to how to apply the formulae to a wide variety of newspapers from weeklies to the large metropolitan dailies.

It is obvious that in order to get an accurate comparison of costs, all factors must be considered. Unequal depreciation rates and the neglect of taxes and interest might prove to prejudice the picture in favor of one of the production methods.

Finally, no system analysis is complete without considering the effect on the human reaction to change. If the feelings against cold type operation are very strong, management may well be better off deferring new equipment rather than trying to institute unpopular changes. In addition to gaining better acceptance by the people involved, a further advantage of deferrment could be the opportunity to choose a more advanced system resulting from rapid technological advances.

There is an exciting future for newspapers today. The technological changes of the electronic era are just beginning to touch the newspaper. The cold type production method coupled with offset printing offers many advantages to the publisher who knows when and how to use it.

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