Research into the influence of Speed on essential Factors in Web-Fed Gravure Printing

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Research into the influence of speed on essential factors in web-fed gravure printing

A paper given at the annual conference on July 23, 1963

ABSTRACT By the research programme 'Investigations into the effect of speed on important printing process factors in rotogravure presses,' the Institut für Druckmaschinen und Druckverfahren (Institute for Printing Machines and Printing Processes), Darmstadt, proposes to solve important problems arising from the tendencies towards an increase in machine speed and automation in rotary gravure printing. Above all, the results will provide the designer with data for the optimum dimensioning of important parts and the most advantageous design of different units. In addition, by investigating various disruptive factors in the printing process, pointers towards eliminating or favourably influencing them can be obtained. A specially developed experimental printing unit with numerous test possibilities is available; this unit also meets the requirements involved in the actual production process. It is designed for a maximum speed of 30 000 r.p.h. and has two plate cylinders of 550 mm ($21\frac{11}{16}$ in) and 1 100 mm (43 in) circumference.

STATEMENT OF PURPOSE

The modern photogravure industry requires well planned streamlining of the different working processes—especially in the preparation of printing cylinders—combined with thorough training of new skilled labour on the one hand and a continuous development of printing machines with a view to increased production and better quality on the other.

With increasing production speeds and growing web widths, rotary presses should be versatile and deliver perfect print under conditions of the greatest possible operational safety, with due regard to care and maintenance, while combining these with minimum space requirements.

If machine design and construction is to answer these operational requirements, it is necessary that the practical designer be given the required theoretical background in addition to available empirical knowledge and know-how. This is the duty of research which must pass on its findings and discoveries promptly; for research, after all, must serve industries based on sound economics.

In recognition of this need the Darmstadt Institute has, in co-operation with the German Research Society for Printing Machines, decided on the project presented here as one of its research goals.

We wish to investigate the relationship existing between variable printing speeds and printing pressures, pressure distribution, bending of cylinders and their displacement, the heating of rubber pressure rollers, the pressure and pressure distribution on the doctor blade, the drying process and paper tension. While doing so it is necessary to consider the relationship between the dimensions of cylinders and the cylinder arrangements; furthermore the material and thickness of the roller covering must also be considered. Special investigations regarding the behaviour of different doctor blade constructions are scheduled to follow, especially for large-sized gravure presses.

It should be stated that special research planned on doctor blade pressure, the drying process and paper tension has not yet been started on the present test printing unit. However, some results from earlier institute studies on gravure presses are available. Experimental research began in summer 1961 and will be concluded during the coming year.

TEST PRINTING UNIT AND MEASURING INSTRUMENTS

A rotary gravure press unit built in co-operation with the German firms represented in the Research Society was erected at the Institute and used in this research project. It is a specially-developed test printing unit with numerous measuring possibilities; moreover it meets the requirements of the production process. It is designed for a maximum speed of 30 000 r.p.h. and has two forme cylinders of 1 100 mm (43 in) and 550 mm ($21\frac{11}{16}$ in) circumference respectively. The intermediate rollers of

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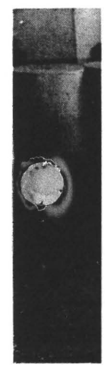

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110 mm and 80 mm respectively have a Perbunan cover which is available in varying thicknesses and hardnesses; the pressure roller diameter is 250 mm (one roller is solid; the other is bored out for water cooling). The possible arrangements of the cylinders are vertically above each other or with the intermediate roller off centre either in front of or behind the pressure point. The main drive is supplied by one 27 kW d.c. motor of regulation 1 : 70; the speed ratio is 1 : 10 within the working range (Fig. 1).

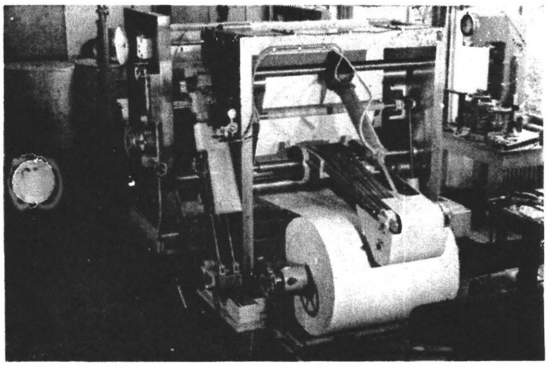

Fig.1. Experimental gravure press.

The necessary measuring bridges, recording devices (oscillograph and recording unit), supplementary gas chromatographic apparatus, electromechanical converters and assorted auxiliary equipment which were tested in earlier research were available.

RESEARCH RESULTS SO FAR

Printing pressures. The pressure forces applied to the pressure roller by means of adjustment spindles and bearings were first measured by capacity-type recorders. Inasmuch as several distorting influences occurred with this method it was replaced by a measuring device made of transistorized induction type recorders built into a spring-washer assembly. These recorders give voltage differences proportional to the movement of the spring-washers which, after calibration, indicate changes in printing pressure.

Special measuring elements were developed to establish the pressure distribution along the cylinder length which depends on the stability of the printing unit.

At the same time a measuring system was developed in the Institute permitting the testing of normal and tangential forces in the printing unit during the printing process. This is of importance in the study of the conditions prevailing during the passage of the web through the nip. We note that the two-component tester which registers normal forces by means of resistance strain gauges and tangential forces by piezoelectric means, is, so far, suitable only for measurements in letterpress machines.

Distribution of line pressure. Fig. 2 shows the distribution of line pressure across the length of the forme cylinder as established by mathematical methods with the help of the electronic computer. Fig. 3 illustrates the arrangement for measuring the

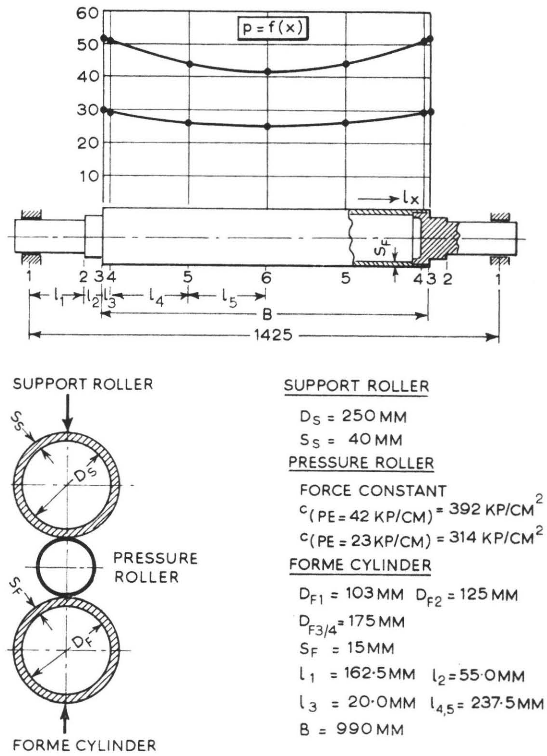

Fig. 2. Pressure distribution across the cylinder: minimum pressure 42kp/cm (upper curve) and 23kp/cm (lower curve).

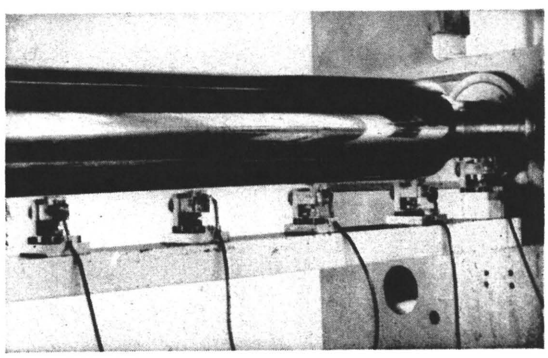

Fig. 3. Arrangement for measuring cylinder bending.

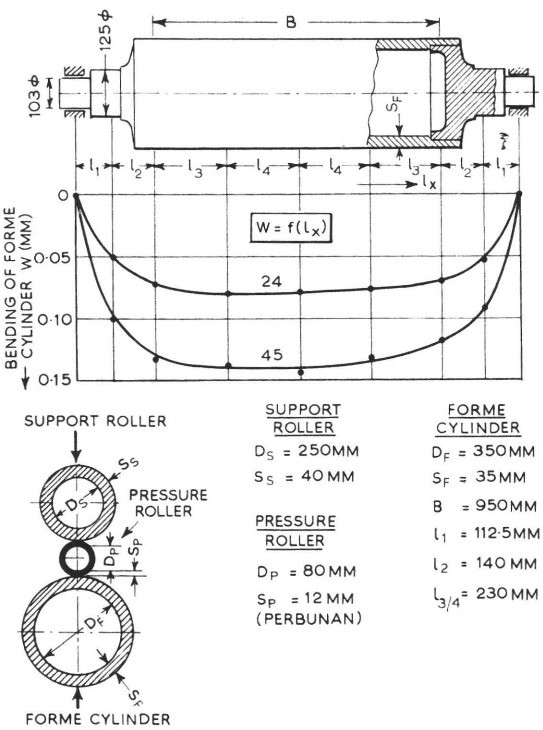

Fig. 4. Effect of pressure on cylinder bending: upper curve for minimum pressure of 24 kp/cm, lower curve for 45 kp/cm.

degree of bending and Fig. 4 shows the bending at different loads.

The mathematical methods and programme used allow the establishment of nomograms for determining the normal degree of bending and one is illustrated in Fig. 5.

Experiments have confirmed these calculations and further experimental studies are in progress.

Temperature in pressure rollers. Experimental tests on the heating of pressure rollers were first run without paper because the reel feed and re-reeling installation had not been completed.

Even though the influence of paper could not thus be established, it was nevertheless possible to study different experimental situations in relation to speed of rotation and running time.

Measurement of pressure roller temperature was by means of six thermoelements, consisting of penetration elements of 0·2 mm diameter mounted elastically in a supporting bar and distributed evenly over the length of the pressure roller. (They are insulated against the carrier bar both thermally and electrically.) The main results are now given and have been reported more fully elsewhere.[1]

Up to a certain limit the temperature of the pressure roller increases almost linearly with the speed of rotation and also with line pressure. In order to measure the increase in temperature within the pressure roller as a function of running time, two different depths of the pressure roller cover were measured, special attention being given to the influence of the cooling effect of the support roller. (We can also expect a certain cooling effect from the paper web.) Owing to heat accumulation the temperature maximum is found near the middle of

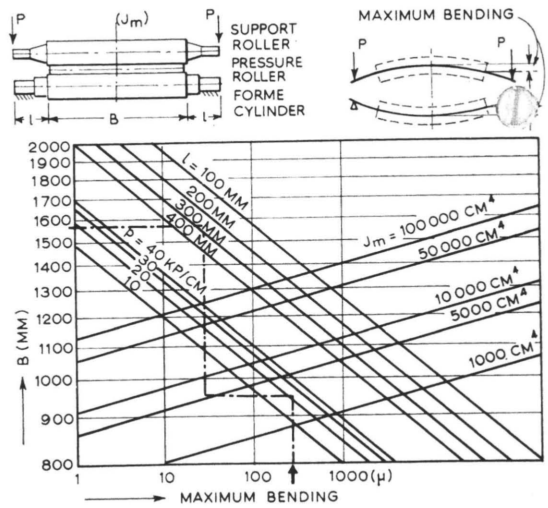

Fig. 5. Nomogram to determine maximum bending of cylinder. Example shows bending of 265μ for B 1570mm, *l* 260mm, J_m 5600cm^4 and p 23 kp/cm.

the pressure roller, depending essentially on the diameter of the pressure roller, the number of contact lines, the character and thickness of the covering and the type of cooling applied. (Increased temperature radiation is effective from the frontal area of the pressure roller.) It may be noted further that the temperature increases with increased thickness of cover and that a natural rubber cover shows a stronger heating effect than a comparable cover of Perbunan. One test series indicated a 12% smaller temperature rise with a water-cooled support roller than with a roller without cooling.

Fig. 6 shows the temperature distribution across a cylinder. As a consequence of pressure roller heating an increase in the line pressure can be expected. Experiments with different roller combinations and, later, with paper webs are to be carried out.

The following research items have been under preparatory study.

Doctor blade pressure and its distribution. First experiments were conducted for the determination of ink generated forces by means of small manometers. Observations for orientation purposes were made on the flow characteristics of ink between doctor blade and forme cylinder using glycerine as the ink. A contrast medium was added to this liquid to make possible filming by means of high-speed cinematography of the flow pattern under the doctor blade. (Fig. 7 illustrates schematically the flow of the test liquid under the doctor blade.)

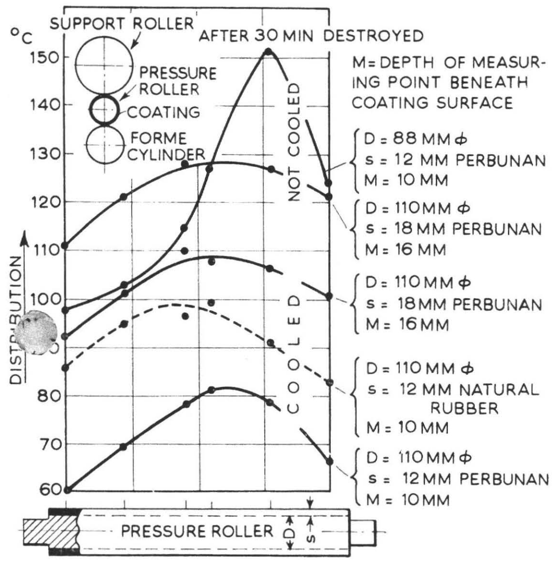

Fig. 6. Temperature distribution across impression roller after 60 minutes running at 1,200 r.p.h. with pressure of 20 kp/cm.

Research into the usefulness and applicability of photo-elastic methods for the determination of the force distribution along the entire doctor blade is still in progress.

The drying process. To reduce register trouble in multi-colour printing as much as possible, the drying distance must be as short as possible even at high printing speeds. The drying process in gravure printing depends on many factors of a physical and chemical nature and last but not least on the design of the drying unit. This Institute intends to investigate primarily the technological aspects of this problem, as far as the machine is concerned, and this necessitates a critical review of the factors influencing the drying process. There are no conclusive research results as yet, so some of the research methods used are only outlined here. The results should, however, assist in determining the influence of the temperatures in different heating systems, of machine speed, of the jet construction, of the fresh air volume, etc.

In order to study the drying behaviour of the printed web under differing drying room conditions we chose the following course of action. Solvents, or rather the degrees of solvent evaporation, represent the decisive criteria for the drying process in gravure. As a means of measurement, it is possible to use either quantities of solvents which have been released from the freshly printed paper web into the drying chamber or of the solvent remaining in the printed paper. The solvent concentration in the drying chamber is in inverse proportion to the residual solvent content of the paper web. It was possible to build an experimental system in which undesirable intake of 'side air', for example the air of the ink fountain with varying concentrations of solvents, could be eliminated, in other words there was an air barrier.

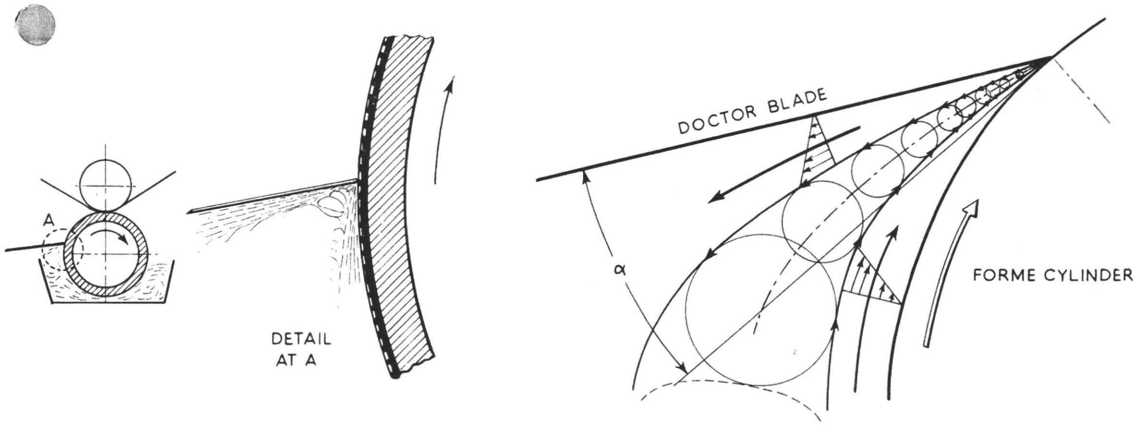

Fig. 7. Flow of ink under the doctor blade.

To determine solvent quantities gas chromatography was used with a fractometer and hydrocarbon detector.[2] These instruments make it possible to observe the vapour phase of solvents in the drying chamber as well as within the laminary layer over the paper web. The residual solvent content within the printed paper web was determined by extracting and weighing. Summarizing, there remains the problem of finding out which drying system will remain effective at very high web speeds and yet still contain sufficient reserves for an improved drying process. One report has been published[2] and further results will be given at a later date.

Paper tension. On this problem we refer to an Institute publication[3] which contains information on the testing and development of tensiometers of miscellaneous design for moving paper webs and on the measurements that have been obtained with these instruments. We are now attempting, in addition to using the tensiometers, to measure average values of tensions by means of strain gauges mounted directly on machine components for transporting paper. Supplementary investigations in this field will follow and will consider mainly the factor of machine speed (Fig. 8 from a high speed film, shows creasing of the web in an autopaster).

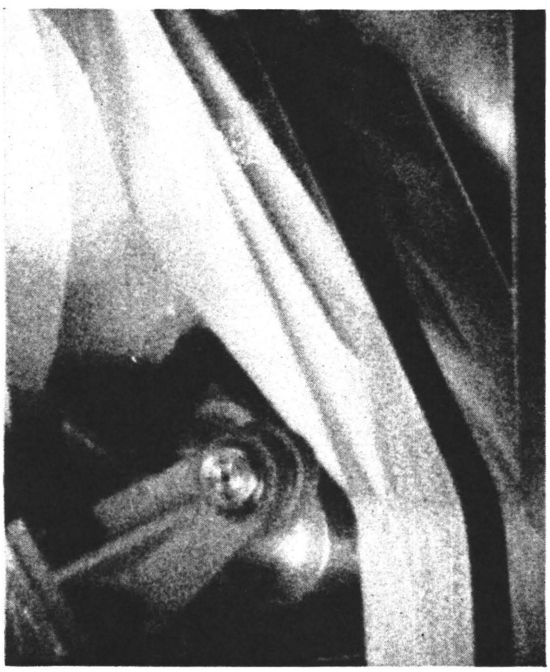

Fig. 8. Creasing of web in autopaster.

SUMMARY

It has only been possible in this paper to give a short survey of the research work carried out. It should be mentioned that this subject calls for attention to certain other problems, for instance that of static electricity which increases as speed increases, and which is particularly troublesome on rotary gravure

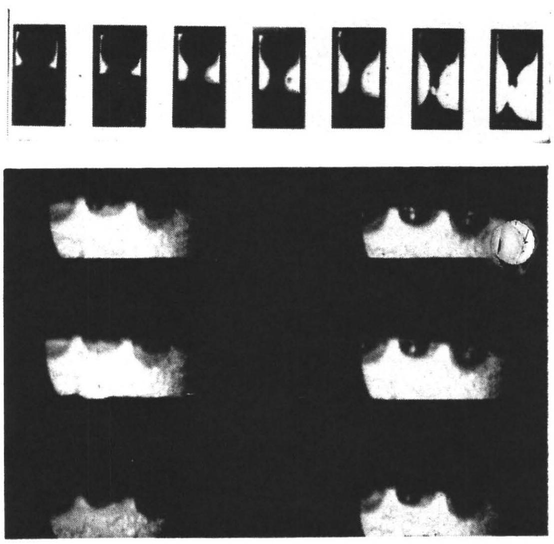

Fig. 9. High-speed photographs of (above) ink transfer from letterpress dots and (below) ink transfer from gravure cells of width 0·12mm.

presses. The Darmstadt Institute, as well as other research establishments, devotes attention to such research and conducts studies on production machines into the magnitude of electrical charges, and their fluctuations in relation to conditions of humidity. We have measured +70 kV/cm on one side of an impression unit and −55 kV/cm on the other.

Yet another problem is the mechanism of ink transfer around the screen dot on running printing presses. High-speed cinematographic investigations made by the Institute in the field of letterpress and gravure have already given encouraging results. The time sequence of the ink separation process can be studied on real screen dots (Fig. 9).

Miscellaneous publications of the Institute, some of which have been mentioned, are already available. It is to be hoped that the engineers of the industry will be willing and in a position to put the results of this research work into practical use quickly.

In conclusion I wish to thank the German Ministries (Wirtschaftsministerien des Bundes (AIF) und der Länder Baden-Württemberg, Bayern und

Hessen) and the Research Society for Printing Machinery for financing the research projects of the Institute for Printing Machinery and Printing Processes at Darmstadt University as well as all my co-workers.

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DISCUSSION

Chairman: *H. M. Cartwright*

The Chairman: When glycerine is used instead of photogravure ink, how does glycerine compare in its behaviour with the ink?

W. Eschenbach: We used glycerine at the beginning, but later on we expect to use inks of various viscosities. We only used glycerine at the start because we conducted certain experiments whereby we could show the turbulence occurring under the doctor blade and so on. This research is still in progress, and what I have had to say has concerned merely the first results.

A. E. Field: Since an even surface on a photogravure cylinder builds up an uneven pressure, how is this remedied?

W. Eschenbach: The curves show the bending of the centre of the cylinder and the only remedy for relieving undue pressure is to make the ends of the axle of the cylinder especially strong. According to our findings and calculations, we have succeeded in programming this problem in a computer and have achieved results which tally very well indeed with practical observations. I think the results agreed to within about 10%, which is very good.

We are now able to give figures and data for every cylinder width. These are fed into the programme to find out how to prevent this difference in pressure which results from bending. We have charts which make it very easy to read the answer to these problems.

E. H. Plaut: I have a small question on the overheating problem. With one of the rubber cylinders, why was the distribution of the temperature asymmetrical? Why was it on one side only that it actually destroyed the rubber cylinder?

W. Eschenbach: These curves are from actual measurements and the temperature is definitely higher in the centre of the cylinder that at both edges. Apparently the heat loss is greater at the edges where you have free air. Accumulation of heat whilst running, makes the diameter grow with time and so the heat generation increases with time. In the centre of the cylinder the temperature rises much more quickly and becomes higher than at the edges.

E. H. Plaut: There was one particular curve of the rubber roller which was actually destroyed during the process. This was not in the centre but it was asymmetrical. Was the roller cooled differentially or was this just an experimental fact?

W. Eschenbach: It was an uncooled cylinder, not a cooled one. There is not a proper explanation for this. We suppose that there was a fault in the rubber. It was a synthetic rubber and we believe that it was not properly adhering to the surface of the cylinder. In that way the heat was much greater than it normally is, and so the rubber just tore off.

R. Uhrig: Professor Eschenbach mentioned the pressure between the rubber cylinder and the forme cylinder. Was there an increase of pressure during the actual running of the machine and did the pressure increase with the speed?

W. Eschenbach: The conditions for all the tests were identical, and it was only in this case that the cylinder behaved so differently. There was no increase in speed or in pressure. It is probably just due to the fact that there was an air bubble or something else underneath, and so the adherence to the surface of the cylinder was not sufficient and it burst.

R. Uhrig: Professor Eschenbach measured the tension, the pressure, the temperature and the bending. Were those experiments done simultaneously or was the paper tension measured separately, the pressure separately, and so on?

W. Eschenbach: The tests were not done simultaneously when we measured these various quantities. There were separate tests, and the curves give the final results together.

J. Elphick: Obviously the pressure distribution on the press depends a great deal upon the hardness of the rubber material used, and also on the thickness and type of material used. Can you give some information on this please?

W. Eschenbach: That is quite correct. Naturally, the hardness of the rubber is quite important. As you have seen, the curves vary very much according to the hardness and the thickness of the coating. Even the different types of rubber—natural or synthetic rubber—have shown considerable differences according to these findings. We know now that thickness, hardness and the characteristics of the material are very important for pressure behaviour. That is the first result. Later, we have to find out which type of rubber is best.

Another point is the area of contact. The pressure roller has a counter roller to hold it straight. There is contact of the actual line of impression, and the contact of the counter roller, and sometimes there are two of these. If possible, the areas of contact should be in one straight line and there should not be two counter pressure rollers because that makes the rubber suffer and gives a wavy impression.

V. H. Rees: Why is it that these experiments show no relation between pressure and temperature? The diagrams illustrate that there is more pressure at the ends of the cylinder, and one would imagine that there would be a higher temperature. Why is this not so?

W. Eschenbach: It is a fact that the rubber warms up more quickly in the centre. Apparently, the effect of the air cooling is stronger than the increase in diameter through the bending of the cylinder. The rubber grows more in the centre than at the sides. This is an interesting phenomenon, and the reason for it has yet to be discovered.

V. H. Rees: I can only comment that on a newspaper press which I have run the rollers had a tendency to burn off with excess pressure at the ends and not in the centre.

W. Eschenbach: There is a basic difference between a letterpress rotary and a photogravure rotary because of the different mechanical conditions. In letterpress the destruction is due more to mechanical causes than to heating as in gravure.