

Automatic Traffic Counters

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This paper discusses the design of a new type of traffic counter and interpreter presently being used in North Dakota. Basically, the method evolves around the principle of moving a tape a certain distance for each vehicle passing the counter. The interpreter reads this tape, converts the hourly tape travel into number of vehicles, and punches these hourly totals in the proper field on a tabulating machine punch card along with their identification data. This equipment eliminates all the manual operations previously necessary in the analysis of the field tapes, punching of the cards, and related activities in the office.

• **TRAFFIC STUDIES** have been one of the principal activities of the State Highway Planning Survey since its beginning in the mid-1930's. Many items of information are gathered in a traffic study, but one of the most important is the information gathered by the fixed-type automatic traffic counters.

In North Dakota, five IBM model 3900 traffic counters were installed in 1936. In succeeding years, additional counters were installed and by 1961 there were 34 fixed-type automatic traffic counters operating in the State. These counters printed the cumulative hourly totals on a tape and the hour volume was obtained by manually subtracting the preceding cumulative total from the succeeding cumulative total. These hourly totals were then listed on coding sheets, punched in tabulating cards, and verified before they were available for mechanical analysis.

Over the years these traffic counters have been remodeled and improved, but regardless of this, certain critical parts of the equipment are original parts. Because of this, the equipment was becoming more susceptible to failure, repair parts were difficult to obtain, and their cost was often hard to justify. Replacement of this equipment as well as obtaining additional equipment was necessary, but no equipment was available that met the State's requirements.

OBJECTIVES OF EQUIPMENT DEVELOPMENT

The State's requirements, as set up, covered existing deficiencies in the operating equipment as well as improvements desired. The following were major requirements:

1. All manual operations now necessary for determining the hourly volumes had to be eliminated.
2. Traffic counts and the time interval had to be recorded on a medium that could be readily interpreted.
3. The interpreter had to read the medium quickly and accurately, and punch the hourly volumes and other identification data directly on tabulating cards.
4. The recorder had to give continuous and accurate operation regardless of power-line outage for a reasonable period.
5. The recording equipment had to be economical to construct and simple to maintain.
6. Changes in temperature, particularly low temperatures, should not affect the recording unit.
7. Repair parts had to be readily available.

With these requirements as a guide, it was decided to attempt to design and determine the feasibility of equipment to meet the needs of Items 1 and 3, first. This unit is called herein the interpreter. When it became apparent that no unusual difficulties would be encountered in the interpreter, work on the traffic counter was begun and development of both units was carried on simultaneously.

TRAFFIC COUNTER

Synopsis of Operation

Figure 1 shows an automatic traffic counter station on Interstate 94, and Figure 2 is a close-up of the counter. Figure 3 is an inside view of one of the counters, showing the arrangement in the counter case of the recorder, power supply, amplifier, and delay circuit. The smaller case holds the 12-v storage battery.

With the successful development of this new counter, the number of locations has been increased from 34 to 50, and it is expected that even more will be installed as the urban studies are expanded and additional interstate mileage is completed.

Every traffic counter is inspected twice each month, at the beginning of the month when the tapes are removed and again about the middle of the month. All maintenance is carried on from the central office. Equipment in need of testing or major maintenance is replaced in the field with spare equipment carried by the maintenance crew.

The tapes, as removed from the traffic counter, are forwarded to the central office shortly after the first of the month. The hour of the tape removal from the field recorder is marked on each tape. This hour of removal is the total hours cumulated since zero hours on the first day of the preceding month. The cumulative time, in hours, for the current month is then reset in the counter.

Features of Design

The traffic counter unit described in this paper includes only those items of new design and does not include any item previously in use. The equipment shown in Figure 4 is a front view of the "recorder." Figure 5 is a rear view of this unit. The purpose of the recorder is mainly tape and time control. Figure 6 shows the power supply unit. These are the only parts of the traffic counter discussed.

Assuming that the traffic counter is ready to operate, it is only necessary to set the time. To do this, it is necessary to loosen the lock screw at top of H (Fig. 4) and move



Figure 1. Automatic traffic counter station, Interstate 94.

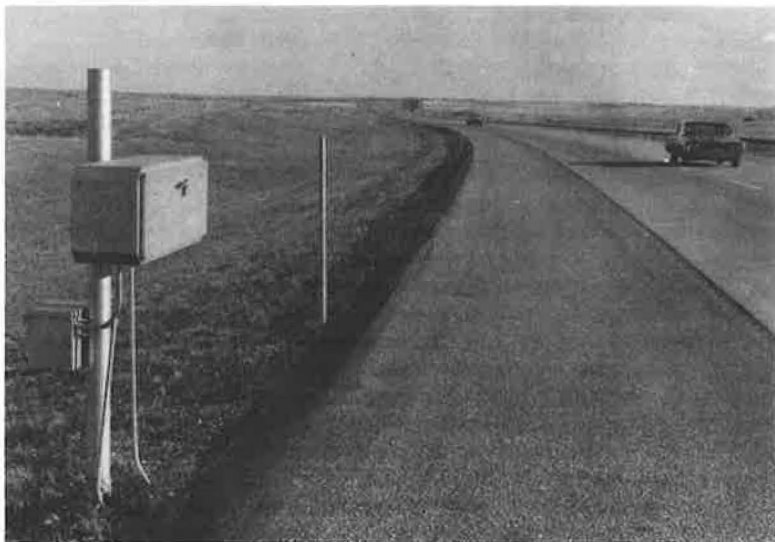


Figure 2. Close-up of counter.

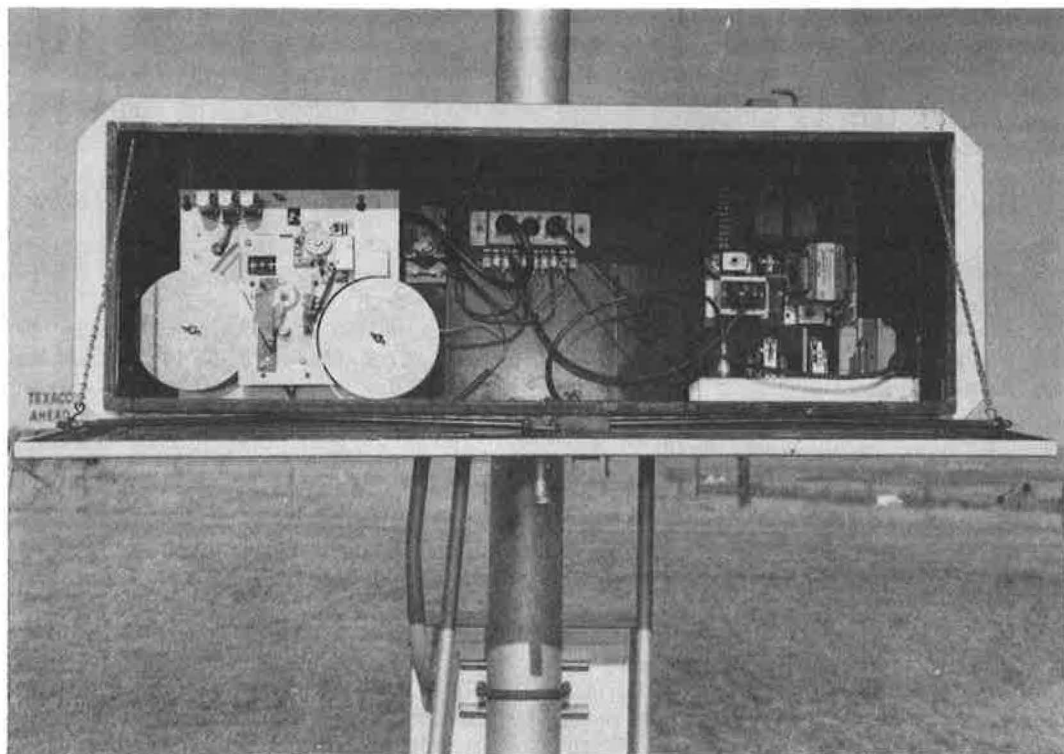


Figure 3. Inside of counter.

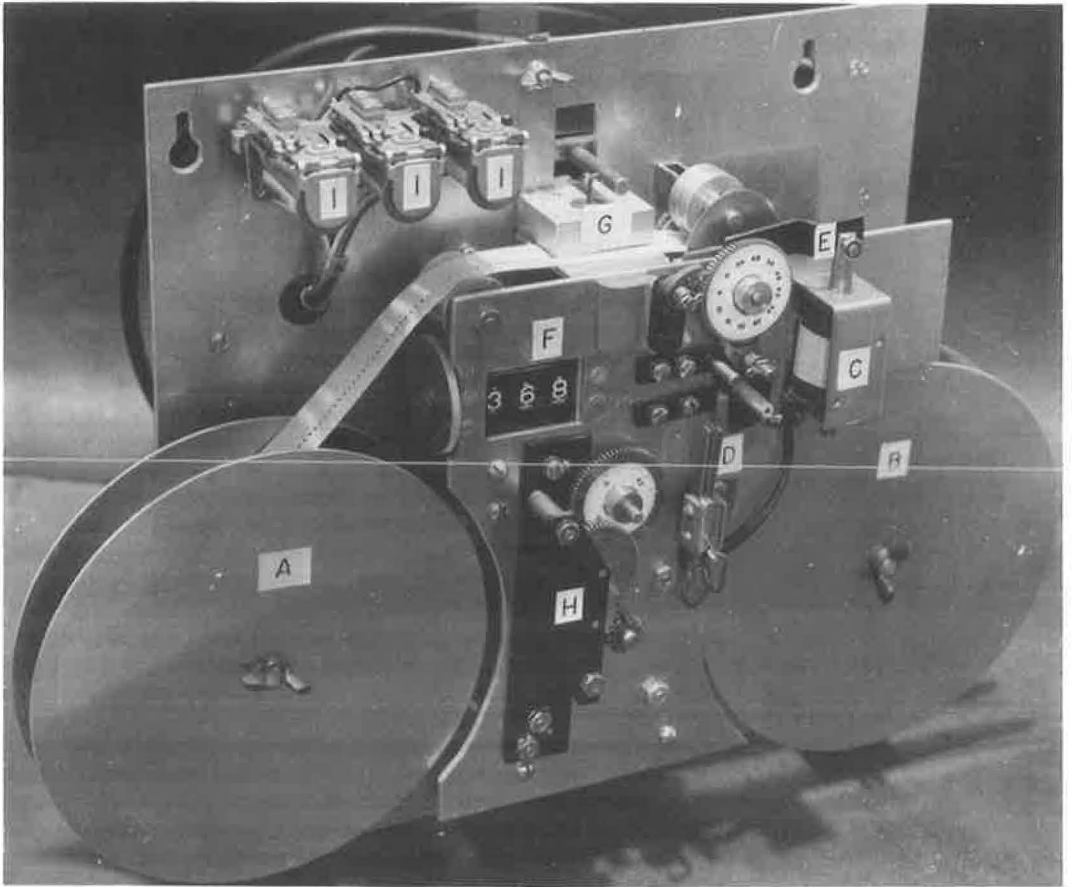


Figure 4. Recorder, front view: tape supply reel (A); tape takeup reel (B); counter solenoid (C); counter cutout relay contact (D); tape advance operating arm (E); hour indicator (F); hour hole punch and die (G); timing gear train (H); cutout relays (I).

the assembly to disengage the timing gear train, then set the hour indicator F (Fig. 4) at the total hours cumulated in the current month. The minute wheel is set to show the proper minute and the gear chain re-engaged and locked. The counter is now started by switching it on the 110-v power and the storage battery. The timing motor operates from the 110-v line, and the rest of the counter operates from a 12-v storage battery.

A vehicle passing the station generates a voltage in the road coil, which is amplified and activates solenoid C (Fig. 4). This in turn moves the tape $\frac{1}{30}$ in. The movement of the tape must be positive and exact. To insure this, the mechanism identified by X and Y (Fig. 7) was developed. The extrusions on the tape driving wheel fit in the holes of the tape and the groove of the riding wheel, thus insuring positive and accurate tape movement for each passing vehicle.

If no traffic were to pass the stations some hour, the tape would not move and the hour punch would repunch the previous hour hole and the time sequence indicated by the hour holes would be lost. To avoid this, a cam (R, Fig. 5) causes the counter to add four extra counts each hour and this moves the tape enough so that the hour holes are separate and distinct and the time sequence is not lost. Provision has been made in the interpreter operation to eliminate these four extra counts.

The hour punch solenoid (P, Fig. 5) is actuated by the hour snapswitch which is controlled by the timing motor, (K, Fig. 5). The timing motor also controls, through the timing gear train (H, Fig. 4), the cumulative hour indicator (F, Fig. 4), and the minute indicator.

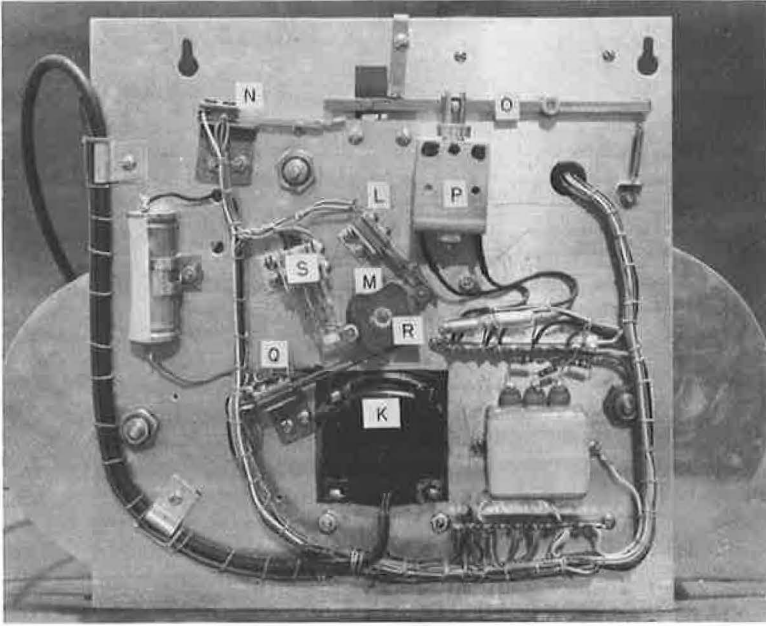


Figure 5. Recorder, rear view: timing motor (K); hour snapswitch (L); hour cam (M); hour hole punch relay cutout contact (N); hour hole punch operating arm (O); hour hole punch solenoid (P); hour snapswitch cutout contact (Q); extra count cam (R); extra count and counter relay cutout snapswitch (S).

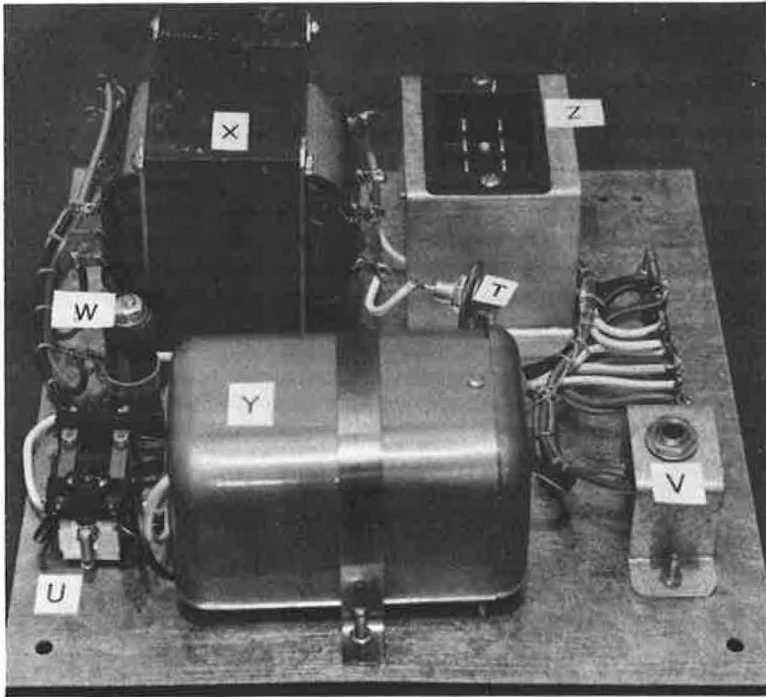


Figure 6. Power supply unit: silicon rectifier (T); AC relay (U); charging rate meter jack (V); charging rate adjusting resistor (W); rectifier transformer (X); inverter (Y); connection plug (Z).

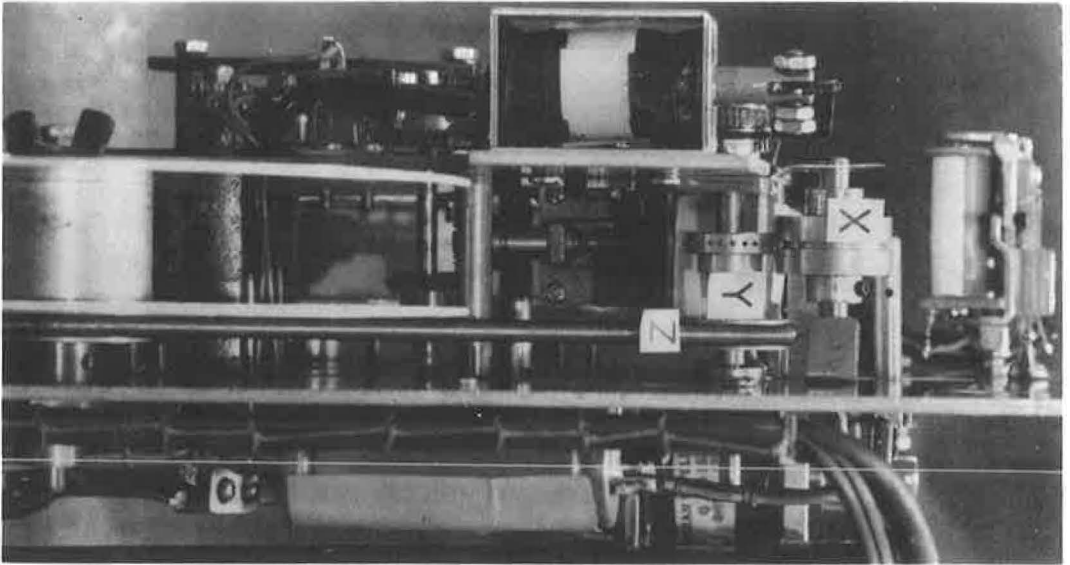


Figure 7. Tape-moving mechanism: tape riding wheel (X); tape drive wheel (Y); takeup reel drive spring (Z).

The power supply unit is shown in Figure 6. As previously stated, all power for the counter is obtained from a 12-v storage battery except for the timing motor which operates from the 110-v power line. If the line power fails, the AC relay (U, Fig. 6) drops out and connects the battery to the timing motor through the inverter (Y, Fig. 6), and, if the power is not restored, the counter will continue to function for about 30 hours. If, in the meantime, power is restored, the AC relay will pick up, again placing the timing motor on the 110-v line. The battery will begin recharging and no interruption in counter service will have occurred.

Figure 8 shows the relationship of the main components of the traffic counter.

INTERPRETER

Synopsis of Operation

The interpreter is shown in Figure 9. There are two units, A and B. Although this is true mechanically, they are connected electrically and together comprise the interpreter.

The purpose of the interpreter is to read the tape that has been produced by the field

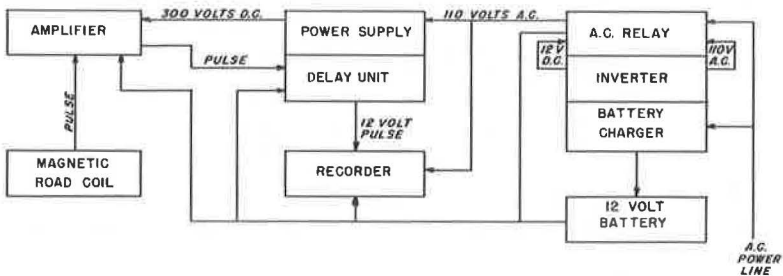


Figure 8. Relationship of main components of traffic counter.

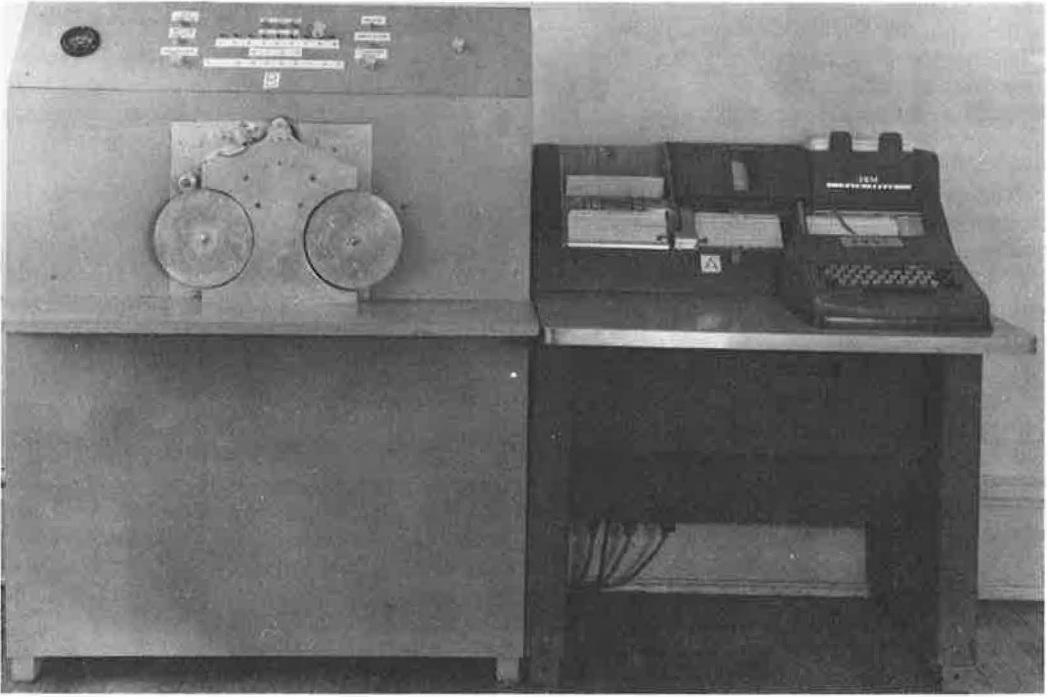


Figure 9. Interpreter.

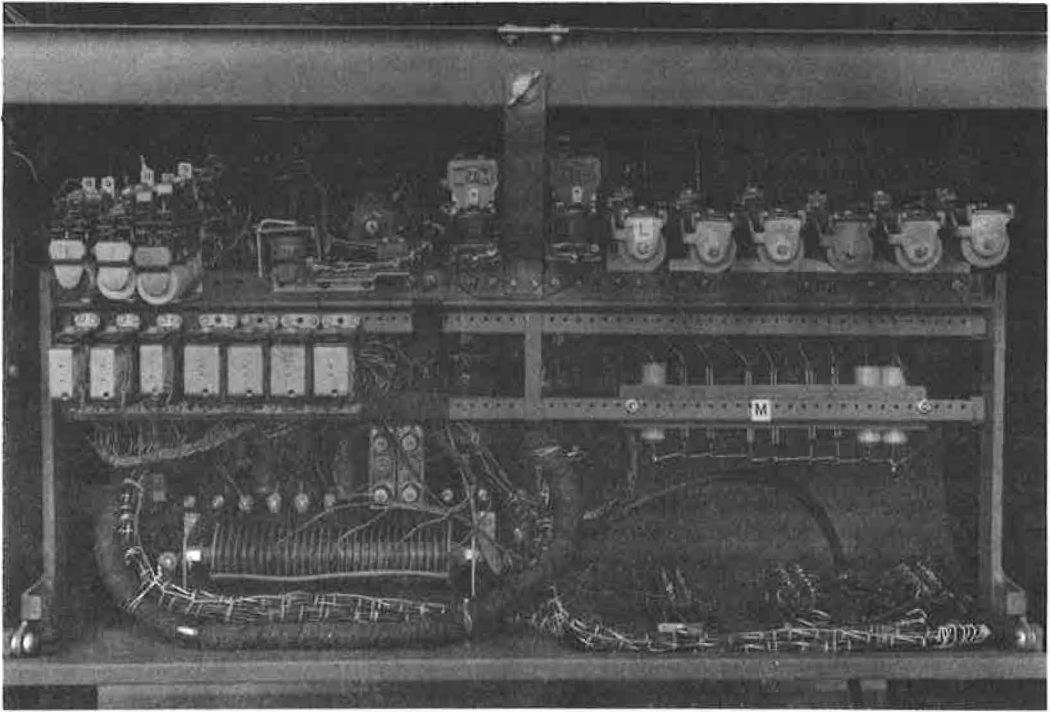


Figure 10. Rear view, Unit A (Fig. 9): program relay bank suppressor (L); spark suppressor condensers (M).

traffic counter and make a proper record of the data. The equipment that was modified or designed to do this is shown in Figure 9. Unit A in this figure is an IBM punch machine that has been modified, as explained later. Unit B is a specifically designed mechanism that reads the tape and stores the data until such time sequence is arrived at that the data are ready to be punched in the tabulating card. At that time, Unit B transmits the data, in proper sequence, to Unit A which punches the data as received, in the proper field on an IBM punch card.

The interpretation of the hourly volume data on the tape and the translation of these data to punch cards are accomplished much more accurately and rapidly than by the previous manual operation.

Salient Features of Design

It was the desire of the State to maintain as simplified a design as possible, and yet one that would produce the desired results. It is likely that through use and experience the mechanism can be further simplified. Several additional figures show portions of Units A and B in Figure 9.

Figure 10 is a rear view of Unit A (Fig. 9), which shows the added relay bank and wiring. This relay bank consists of three relays for the traffic volume, two for the date, and one each for date advance, control, reset, and control of the clutch solenoid. These additions in no way affect the original purpose of the equipment and it may be used as a manual punch machine at any time desired.

Figure 11 shows the tape reading unit and control panel. This is a close-up of Unit B (Fig. 9). The control panel has 14 indicator lights for the date, 9 jacks for selecting the starting date, 3 toggle switches for the number of days in a particular month, 2 momentary push buttons for manual reset of the stepping relays, and toggle switches for starting and controlling the photo cell amplifier and counting circuits.

Figure 12 is a rear view of the tape reading unit appearing in Figure 11.

As previously stated, the traffic counter tape is picked up some time after the first of the month. When it is picked up the station's number and total cumulated hours, as

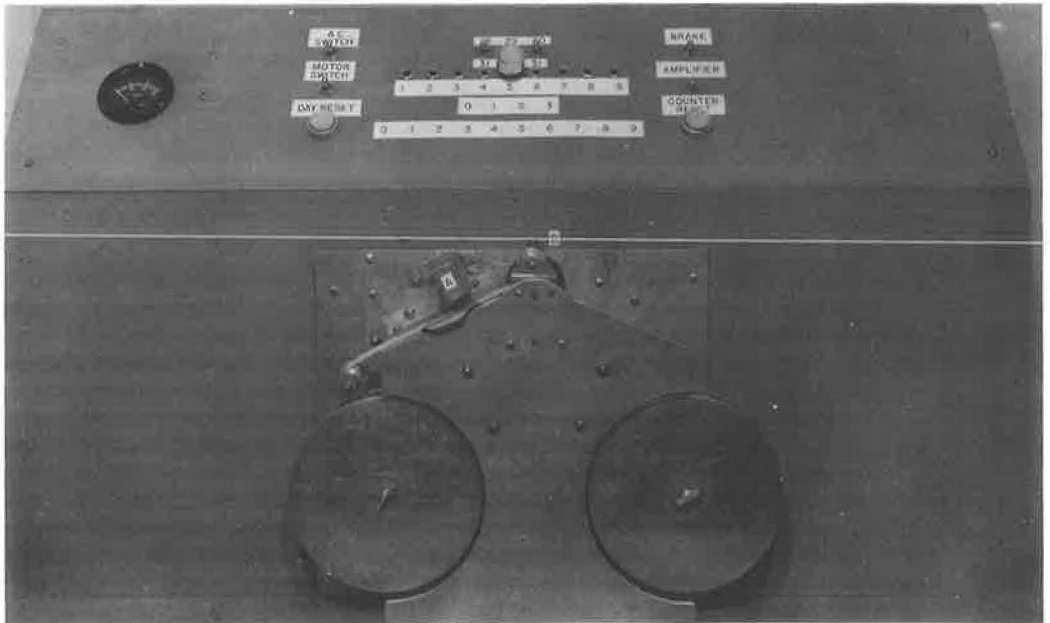


Figure 11. Tape reading unit and control panel: photo cell light source (A); tape transport mechanism (B).

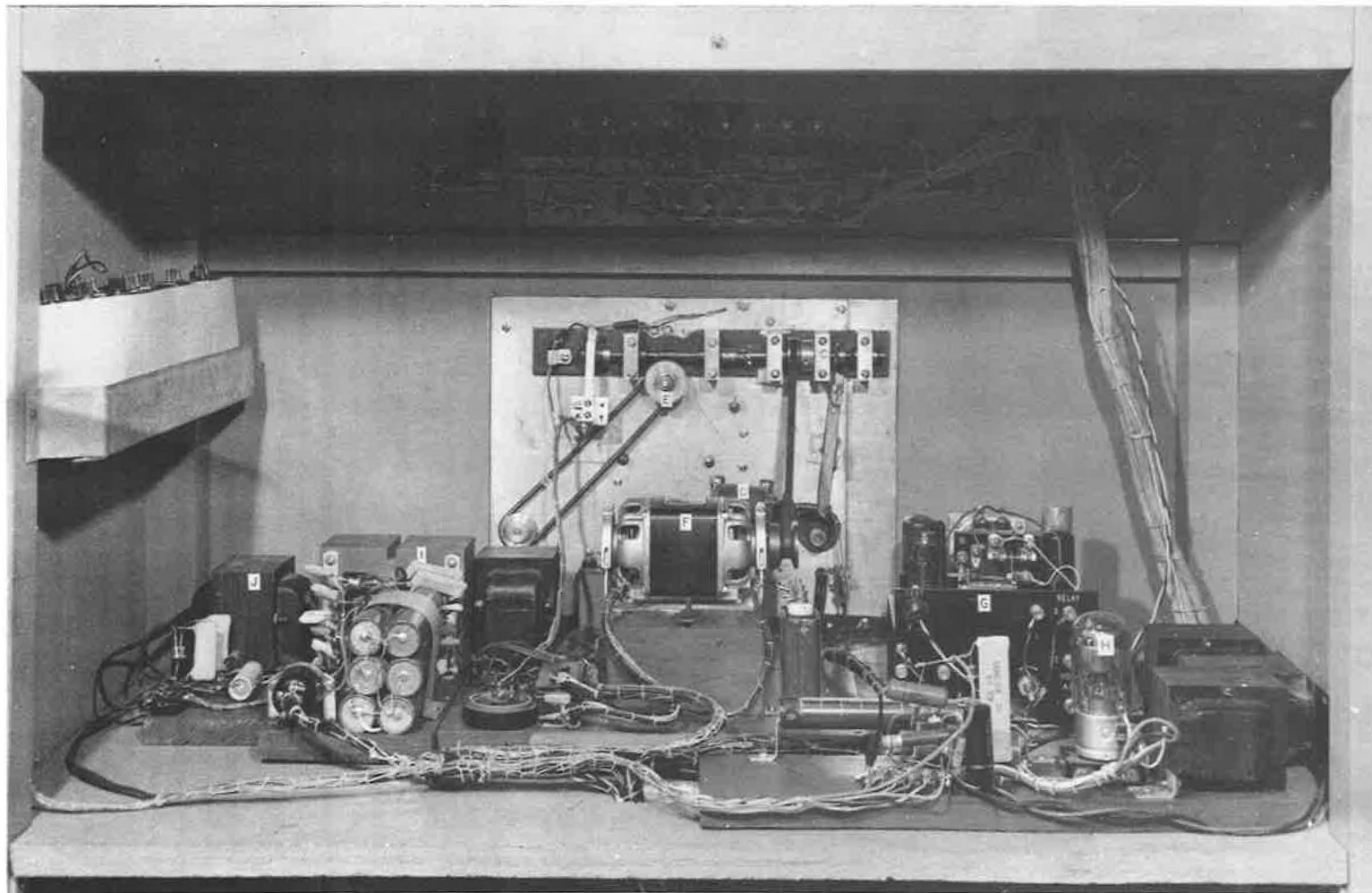


Figure 12. Rear view, tape reading unit: tape drive mechanism (E); drive motors (F); photo cell amplifier (G); stepping relay electronic switch (H); stepping relay power supply (I); program relay power supply (J).

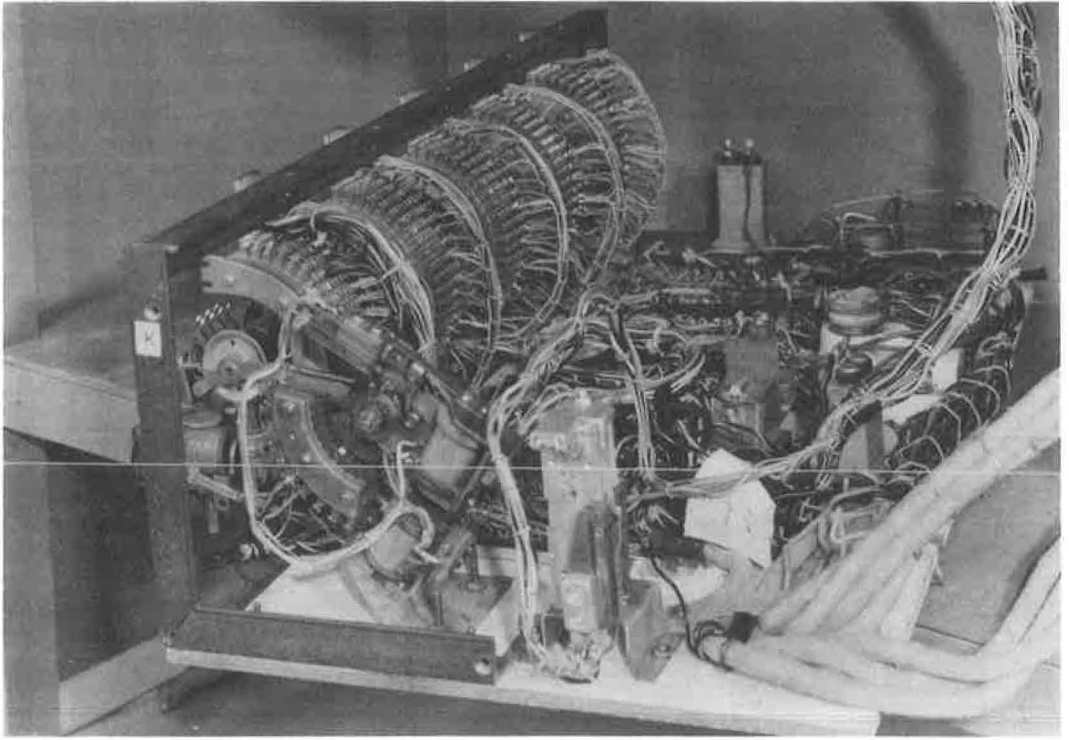


Figure 13. Stepping relays: rear view, stepping relay bank (K).

shown on the hour counter, are marked on the tape. From this information on the tape the interpreter operator can set up the equipment through the control panel (Fig. 11) to match this last recorded hour. The tape is then fed into the interpreter beginning with this last recorded hour or backwards. Doing this eliminates the need of rewinding or matching the previous month's tape.

The tape is fed through the interpreter by the same type of equipment as controlled its movement in the traffic counter. Because each vehicle passing the traffic counter caused the tape to be moved $\frac{1}{30}$ in., the interpreter reading head must interpret each tape movement of this amount as a vehicle and give a signal that can be recorded. This

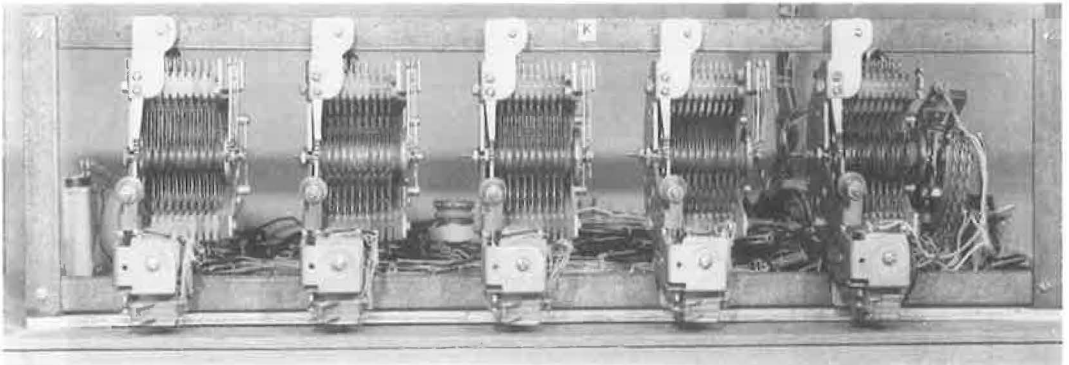


Figure 14. Counter or memory bank: front view, stepping relay bank (K).

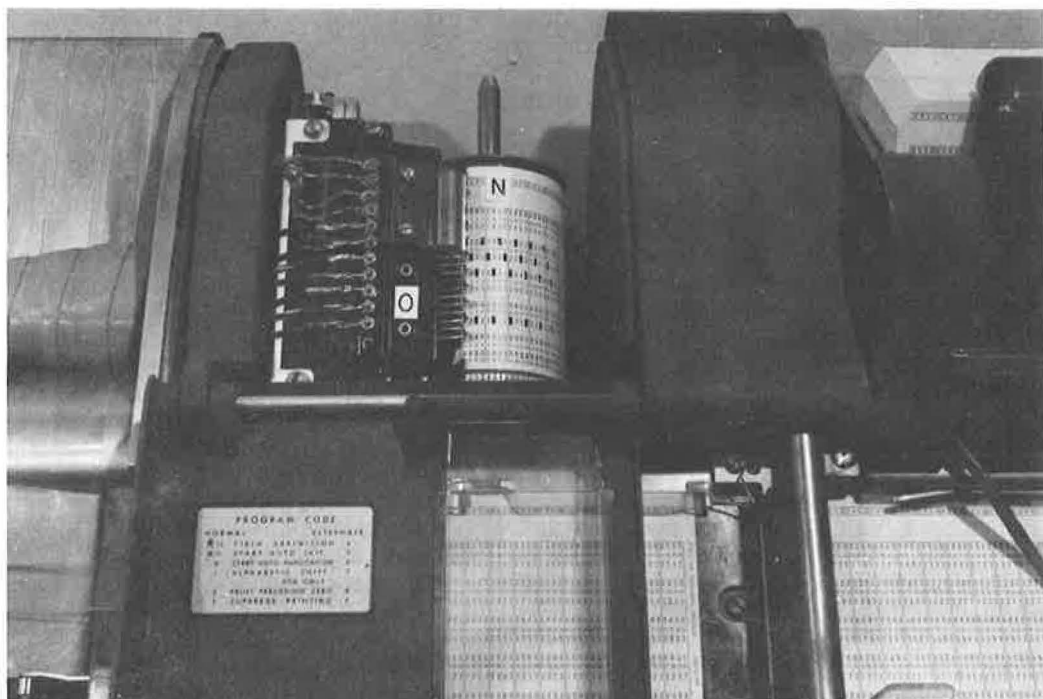


Figure 15. IBM card punch: program card (N); program contact assembly (O).

is done by the equipment shown in Figure 12. The signal is an electrical impulse that is transmitted to the stepping relays (Fig. 13), which advance one unit for each impulse. Each unit of advance of the stepping relays is therefore the equivalent of a vehicle passing the station.

As previously stated, four counts were induced to separate the hour holes at zero traffic and they must now be eliminated. This is done by shunting the reading impulses to a special stepping relay (Fig. 13) that is not a part of the memory bank. When this relay has received four impulses, it removes itself from the circuit and the balance of the impulses for that hour go to the stepping relays that compose the counter or memory bank (Fig. 14).

This summation of impulses continues in these stepping relays until the next hour hole in the tape intersects the photo cell light. This energizes a circuit that stops the tape.

These stepping relays are wired to the 10-punch interposer magnets in the IBM card punch, the time and sequence of punching is controlled by the program card (Fig. 15) and power is supplied through the relay bank (Fig. 10).

When the program card arrives at the last column in the field, a relay is energized that closes the stepping relay reset circuit. This relay holds until the stepping relays have all returned to zero. When in this position a series circuit is energized which closes a relay to de-energize the clutch solenoid. The tape then starts moving again and the cycle is repeated.

There is one tabulating card for each day. The first 72 holes are for the hour counts. This allocates three spaces for each volume and will allow for 999 vehicles. In North Dakota there are only a few counter locations where the hour volume ever exceeds this amount and then only in rare instances. These instances are readily recognized by the interpreter operator and are handled manually. Volumes requiring four card spaces could easily be handled by using two cards for each day instead of one. The remaining columns are used to show station number, day, month, and year. After the hour counts for one day have been punched, the date is punched on the card through

stepping relays controlled by the program card. The balance of the identification is punched by duplication from the previous card.

ANALYSIS

Planned Revisions

At the present time, the State has no planned revisions for the traffic counter. There may be some minor mechanical changes if better parts are found at a reasonable price. As an example, the tape punch is not giving completely satisfactory service in all instances. The failures to date have been of little significance, but they have occurred.

The counters have all been built in the Planning Survey shop, with relatively inexperienced help, but with technically competent supervision and it was expected that certain construction errors would occur that would not be found until after installation. So far, comparatively few have been found.

Some changes in the interpreter are planned. Most are of little importance. It is recognized that the stepping relays have certain limitations. First, they are relatively slow, as they will only cumulate about 19 units or vehicles per second. They are also subject to excessive wear. To overcome these disadvantages, an electric counting circuit has been built which has a speed about five times greater than does the stepping relays. This counting circuit was used in other North Dakota equipment during the summer of 1962 and has been very satisfactory. It is expected that this circuit will be installed in the interpreter shortly.

The speed of this circuit is much greater than is that of the clutch and brake assembly and possibly that of other parts. Improvement of these items must be made if the benefits of the electric counting circuit are to be realized. It is the intention of the State to continually up-grade the equipment.

Advantages and Disadvantages

This equipment has many direct advantages. It has met all the requirements previously set out in this report and they were all advantages. This applies to both the traffic counter and the interpreter. These advantages were nearly all mechanical in nature. Also of great value are the more complete and accurate data that are available at a much earlier date. There is also a considerable savings in salaries previously paid for work now done by the equipment.

It is the opinion of the State that this equipment has its greatest advantage over the previously used method when the ADT does not exceed 5,000 vehicles per day. When the ADT approaches 10,000, it appears that the original advantage has about been eliminated. If the present efforts to increase the speed of the interpreter are successful, then the comparative ADT just referred to will be materially increased.

There are also disadvantages. The disadvantages, however, generally center around personnel. This equipment requires greater skills on the part of the maintenance and operating personnel than did the equipment previously used.

SUMMARY

1. This paper describes a new method of counting traffic with automatic traffic counters and mechanical interpretation of that record.
2. This method is essentially a linear measurement procedure.
3. Further refinements that will improve the service of the equipment are being developed.
4. This method provides much greater accuracy in the data obtained from automatic traffic counters at a much earlier date.
5. This method has produced savings in operations that are now estimated at more than \$100 per year per field counter.