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Cineradiographic System Design

F. ALLAN HOFMANN
Lancaster, Pennsylvania

The title of this paper suggests that cineradiographic and associated equipment should be designed to create a total system to meet a particular diagnostic need or to serve a specialized research purpose. For example, a recent study of the height of soft palate closure required a specific *system* in order to evaluate this velopharyngeal phenomenon (*9*). Fortunately, in that case, the demands of diagnostic rationale for cleft palate patients plus on-going research projects in temporomandibular joint function and palatal dynamics had resulted in a cineradiographic system which met the needs for that specific project (*1, 2, 5*) (Figures 1 and 2). A minor change in the system readout section was the only change necessary to accommodate the new project. Usually, however, one begins by drawing design specifications based on the basic research requirements.

Instrumentation Design

When considering instrumentation, professional investigators are aware that scientific advance is not based upon the Rube Goldberg concept of instrumentation, but rather upon the engineering approach oriented to the research thesis. This is an improvement over the plan where the investigator must force his proposal to fit existing equipment design. For the project requiring special instrumentation, one might consider this primary rule: the underlying overall institutional program plus the individual research priori should be the dictum of system development. The burden of this approach to cineradiography is borne by the biomedical engineer for the research team in the dental-medical environment.

The importance of this design phase is emphasized by Littleton (*7*) who states

> The total effectiveness of any given radiologist depends upon a multitude of factors, but there can be no doubt that a primary part is played by the

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Mr. Hofmann is research associate at the University of Pennsylvania School of Dental Medicine. He was formerly Director of Technical Research, Lancaster Cleft Palate Clinic, Lancaster, Pennsylvania.

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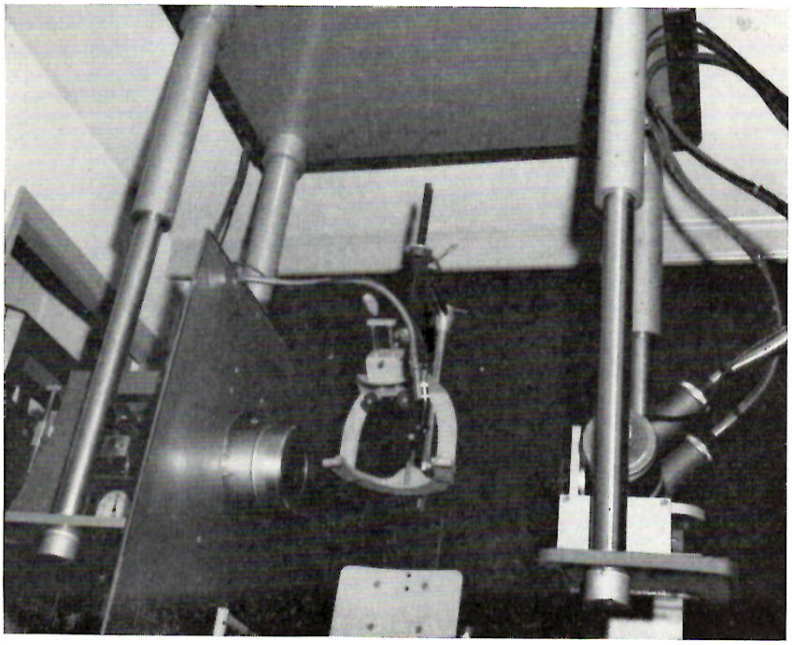


FIGURE 1. Cineradiographic system records both x-ray motion pictures and speech of the patient. The author designed this ceiling mounted radiographic apparatus that supports the x-ray tube, cameras, radiation time, and image intensifier. The intensifier reduces the x-radiation to the patient while increasing picture screen brilliance 1,000 times. The unit is used to study dynamics of soft palate, tongue, throat wall function during speech and is a valuable aid to surgical techniques or prosthetic speech bulb location, diagnosis and treatment planning.

> character and quality of performance of the equipment at his command. No other medical specialty influences such a broad spectrum of the medical profession, from general practitioner to specialist. (p. 662)

He concludes his editoral as follows:

> A more complete appraisal of current research expenditures will probably point out the extent to which the development of roentgen equipment is being retarded and might lead to one logical conclusion: . . . how to divert additional funds to basic research in roentgen methods and, in particular, more basic research in fluoroscopic amplification technics.

The Thrust of Radiology

Robbins (*8*) emphasizes the role of radiology in medical groups. He states

> Radiology . . . cuts across all Medicine and Surgery more than any other specialty. What happens in this field, therefore, whether it be in relation to research, methods of practice, or education is very likely to happen to all other branches of Medicine. (p. 485)

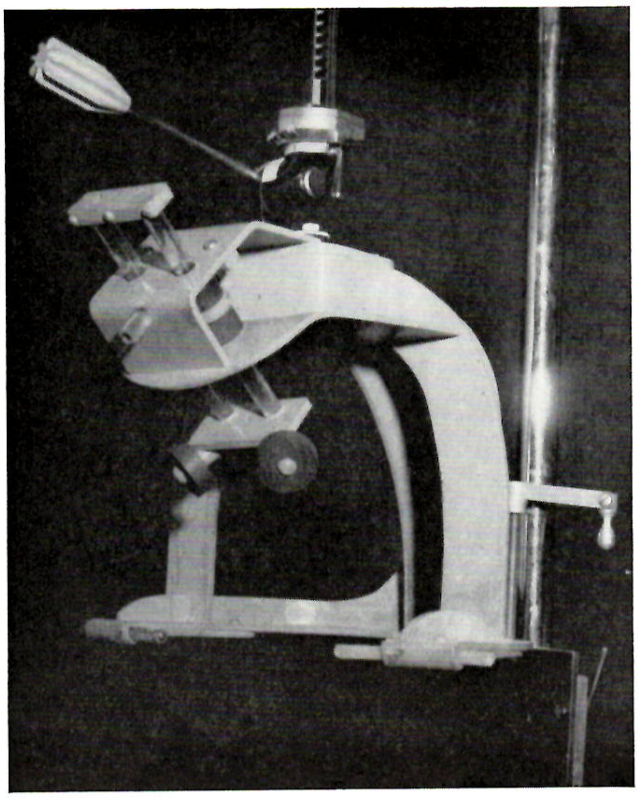


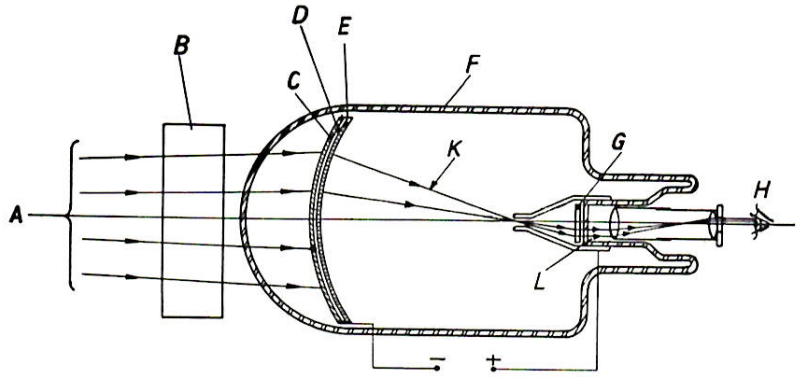
FIGURE 2. A special head position was developed that is attached to the back of a modified dental chair. Complete freedom of movement for adjustment in all planes is possible. The headpiece is constructed of plastic with two ear rods and brace which can be fitted tightly over the frontal area. It is used to maintain the mid-sagittal plane of the patient's head, perpendicular to the central ray of the x-ray beam and also perpendicular to the floor.

Since most of the group practices involve the radiologist, it follows that radiology can exert a leading influence and make a scientific contribution to the group effort in diagnosis, treatment, and research in cleft palate rehabilitation.

Today, in velopharyngeal studies, we see the astute prediction regarding cineradiography made by Cooper (*4*) come to fruition. It was as follows:

> It is believed that this method of cinefluorography with image intensification and sound accompaniment will prove invaluable to plastic surgeons, dentists, speech therapists, anatomists, research scientists, and others in investigating some of the problems connected with cleft palate, speech and movements of the tongue and temporomandibular joint. (p. 137)

Cineradiography, in current usage, depicts the production of x-ray



A. *Incident X-rays*
B. *Patient*
C. *Aluminum Screen Carrier*
D. *Fluorescent Screen*
E. *Photocathode*
F. *Glass Envelope*
G. *Viewing Screen*
H. *Eye of Observer*
L. *Visible Light*

FIGURE 3. Typical x-ray image intensifier—Courtesy of North American-Philips Co., Inc.

motion pictures by means of an electronic image intensifying device (Figure 3). In its broad sense, it must also include the analysis of the resulting films. Therefore, a system of cineradiography, to be complete, should include provisions for the observation, recording, and reduction of data to a form amenable to thorough analysis (*3, 6*) (Figure 4).

It would be very difficult to compile a complete listing of instrumentation currently in use. However, although the observation, recording, and reduction components and techniques may differ in any particular Vidicon, Orthicon, Televex, or cineradiographic system, the overall purpose of each design remains the same: to provide the best means to study roentgen-physiology in addition to roentgen-anatomy with a minimum amount of exposure to the humans involved.

Conclusions

What is cineradiography's unique contribution to cleft palate rehabilitation? Of all the diagnostic sciences, radiology alone produces for the team a graphic image of the area under diagnostic surveillance. This is, in itself, significant for it improves communications among members of the group, but the ultimate value of radiology is realized only when one records and correlates to the radiograph all other physiological phenomena that have occurred during the same interval of time as re-

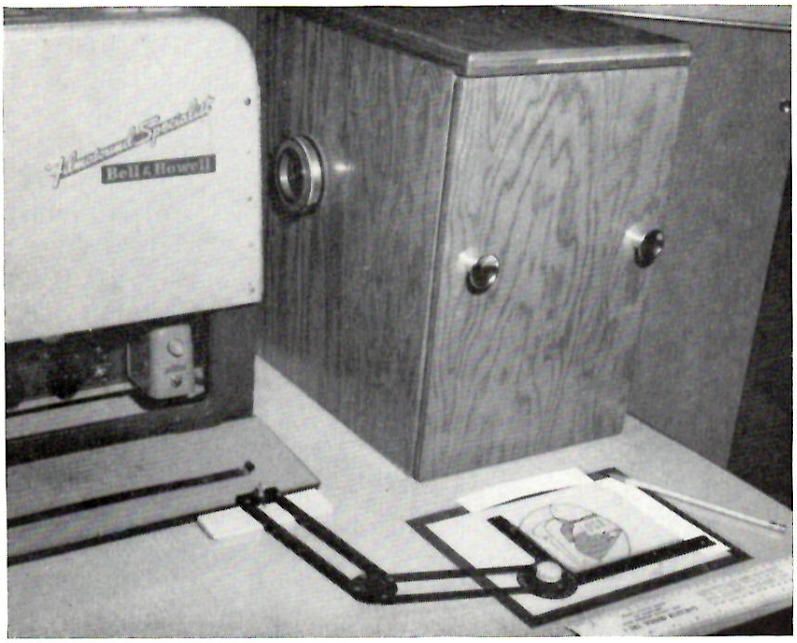


FIGURE 4. After reviewing the 16 mm x rays as continuous motion, they are studied frame by frame. Optical-mechanical plotter was constructed for single frame projection, tracing, and analysis of film strips.

corded on the x-ray film. Taking this fact as a premise, the importance of cineradiography logically follows, for if properly designed, the cineradiographic system will record, store, display, and define not only the body part movement under surveillance in space coordinates, but also will relate the movement of the area in time relationships. The cineradiographic equipment with selectable number of x-ray pictures per second, per foot of motion picture film, provides a built-in time base for diagnostic analysis of the motion recorded.

Devices for simultaneous recording of speech related bio-medical activity are synchronized to this time base. Therefore, I would consider cineradiographic system design a coordinating scientific specialty that presents not only a dynamic display of body function, but also contributes to the interpretation of associated physiological data recorded by other team members in providing a diagnostic verdict.

A real challenge facing those who utilize cineradiographic data analyzing devices in velopharyngeal studies is the need for straightforward simplified input systems for computer reception of biological material directed toward mathematical description of cineradiographic syndromes of speech abnormalities.

(In presentation, the author used several transparencies to demonstrate the details of a cineradiographic system developed at the Lancaster

Cleft Palate Clinic. He also projected a pilot study film taken at 400 frames per second. Further descriptions of high speech technique will be reported at a later date.)

School of Dental Medicine
University of Pennsylvania
Philadelphia, Pennsylvania 19104

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